KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

Vadose Zone Investigation Work Plan
Part 1: Field Investigation Activities
Bulk Fuels Facility Spill
Solid Waste Management Units ST-106 and SS-111

November 2010

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Kirtland AFB, New Mexico 87117-5270

KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

VADOSE ZONE INVESTIGATION WORK PLAN
PART 1: FIELD INVESTIGATION ACTIVITIES
BULK FUELS FACILITY SPILL
SOLID WASTE MANAGEMENT UNITS ST-106 AND SS-111

November 2010

Prepared for
U.S. Army Corps of Engineers
Albuquerque District
Albuquerque, New Mexico 87109

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This Vadose Zone Investigation Work Plan, Part I: Field Investigation Activities, was developed to address vadose zone contamination at the Bulk Fuels Facility (BFF) Spill at Kirtland Air Force Base. The work plan demonstrates the Air Force's commitment to addressing fuel contamination resulting from past practices and events at the BFF Spill. The work plan outlines previous investigations performed at the BFF Spill and provides the sampling rationale and decision logic for defining the nature of fuels contamination of soil and vapor within the vadose zone. Vadose zone investigation activities described include subsurface geophysical investigations, soil and soil-gas vapor sampling, and installation of vapor monitoring points throughout the vadose zone. The geophysical investigation will provide information on subsurface geology and contaminant location and migration. Soil and vapor sampling will provide immediate, as well as long-term, sampling data on subsurface contaminant distribution in the vadose zone. The vadose zone investigation will be integrated with groundwater, interim measures, and light non-aqueous phase liquid (LNAPL) containment investigations to provide the data necessary to supplement and optimize remedial efforts currently underway. Enhancement of current remedial operations will increase the contaminant mass removed from the vadose zone and groundwater, thus reducing the time required for cleanup.

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For

LUDIE W. BITNER, JR.
Chief, Restoration Section

This document has been approved for public release.

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377 ABW Public Affairs

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PREFACE

This Groundwater Investigation Work Plan, Part I, Field Investigation Activities was prepared by Shaw Environmental and Infrastructure, Inc. (Shaw) for the U.S. Army Corps of Engineers (USACE), under contract W912DY-10-D-0014, Delivery Order 0002. It pertains to the Kirtland Air Force Base (Kirtland AFB) Bulk Fuels Facility Spill, Solid Waste Management Units ST-106 and 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, New Mexico Hazardous Waste Management Regulations, Resource Conservation and Recovery Act, regulatory correspondence between the New Mexico Environment Department Hazardous Waste Bureau and the Air Force, dated April 2 and August 6, 2010; and *Base-Wide Plans for Investigations Under the Environmental Restoration Program*, Kirtland AFB, 2004.

This Groundwater Investigation Work Plan is being completed in two parts, Part I: Field Investigation Activities and Part II: Nature and Extent Investigation. Part I, presented in this work plan, describes all activities associated with the installation of 78 monitoring wells including locations, well installation method, well development, initial sampling and testing, handling of investigation-derived waste, and borehole geophysical investigation. Part II will consist of the evaluation of all existing and new data, and development of the risk assessment (including the conceptual site model), and the Groundwater Investigation Report (including cross sections and plan views).

Part I provides:

- Construction details, locations, and depths of proposed groundwater monitoring wells,
- Field procedures, sampling and analysis, and related quality control protocols for soil and groundwater analysis, and
- A proposed project schedule.

This work was performed under the authority of the USACE, Contract No. W912DY-10-D-0014, Delivery Order 0002. All work was conducted in October and November 2010. Mr. Walter Migdal is the Project Manager for the USACE Albuquerque District. Mr. Wayne Bitner, Jr. is the Kirtland AFB Restoration Section Chief, and Mr. Tom Cooper is the Shaw Project Manager. This plan was prepared by Mr. Andrew Ellison and Mr. Tom Cooper.

Tom Cooper, PG, PMP
Shaw Environmental & Infrastructure, Inc.
Project Manager

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A 2010 Regulatory Correspondence between the NMED HWB and the Air Force regarding the Kirtland AFB, BFF Spill

Attachment 1: April 2, 2010 Correspondence from the NMED HWB to Colonel Michael S. Duvall, Base Commander, 377 ABW/CC, Re: SWMUs ST-106 and SS-111, BFF Spill, Kirtland, AFB

Attachment 2: August 6, 2010 Correspondence from the NMED HWB to Colonel Robert L. Maness, Base Commander, 377 ABW/CC, Re: SWMUs ST-106 and SS-111, BFF Spill, Kirtland, AFB

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ACRONYMS AND ABBREVIATIONS

^{o}C	degrees Celsius
^{o}F	degrees Fahrenheit
ADR	automated data review
AFB	Air Force Base
AFCEE	Air Force Center for Engineering and Environment
Air Force	U.S. Air Force
AmBe-241	americium-beryllium-241
API	American Petroleum Institute
APP	Accident Prevention Plan
ARCH	air rotary casing hammer
AST	aboveground storage tank
ASTM	ASTM International
AvGas	aviation gasoline
BFF	Bulk Fuels Facility
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
COPC	contaminant of potential concern
CRP	Community Relations Plan
CSM	conceptual site model
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
DQCR	daily quality control report
DQO	data quality objective
DTIC	Defense Technical Information Center
EDB	ethylene dibromide
EIMS	Environmental Information Management System
ELAP	Environmental Laboratory Accreditation Program (DoD)
EM	electromagnetic
EM	Engineer Manual
EPA	U.S. Environmental Protection Agency
EPH	extractable petroleum hydrocarbons
ERP	Environmental Restoration Program
ERPIMS	Environmental Resource Program Information Management System
FCR	Field Change Request
FFOR	Former Fuel Offloading Rack
ft	foot/feet
ft/day	feet per day

ACRONYMS AND ABBREVIATIONS (continued)

GIS	Geographic Information System
GRO	gasoline range organics
He-3	helium-3
HWB	Hazardous Waste Bureau (NMED)
ID	identification
IDW	investigative-derived waste
JP-4	Jet Propellant-4 fuel
JP-8	Jet Propellant-8 fuel
KAFB	Kirtland Air Force Base
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LDC	Laboratory Data Consultants, Inc.
LNAPL	light non-aqueous phase liquid
MA DEP	Massachusetts Department of Environmental Protection
mg/kg	milligrams per kilogram
mm	millimeter
MS	matrix spike
MSD	matrix spike duplicate
NAD83	North American Datum, 1983
NMED	New Mexico Environment Department
NTIS	National Technical Information Service
O.D.	outside diameter
PID	photoionization detector
PPE	personal protective equipment
ppm	parts per million
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QC	quality control
RCRA	Resource Conservation and Recovery Act
RPD	relative percent difference
SEDD	Staged Electronic Data Deliverable
Shaw	Shaw Environmental & Infrastructure, Inc.
SOP	standard operating procedure
SEDD	Staged Electronic Data Deliverable
Shaw	Shaw Environmental & Infrastructure, Inc.

ACRONYMS AND ABBREVIATIONS (concluded)

SOP	standard operating procedure
SPR	standard penetration resistance
SSHP	Site Safety and Health Plan
SVE	soil vapor extraction
SVM	soil-vapor monitoring
SVMW	soil-vapor monitoring well
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TPH	total petroleum hydrocarbons
UFP-QAPP	Uniform Federal Policy - Quality Assurance Project Plan
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
USF	Santa Fe Group
UTM	Universal Transverse Mercator
V.A.	Veterans Administration
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbons

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EXECUTIVE SUMMARY

This Vadose Zone Investigation Work Plan, together with the Groundwater Investigation Work Plan, the Interim Measures Work Plan, and the Light Non-Aqueous Phase Liquid (LNAPL) Containment Interim Measure Work Plan, were developed in response to April 2, 2010, and August 6, 2010 correspondence from the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB)to the U.S. Air Force (Air Force). In these letters, the NMED HWB required the Air Force to develop and submit work plans to address soil and groundwater contamination at the Bulk Fuels Facility (BFF) Spill at Kirtland Air Force Base (AFB), New Mexico. The work plans will be implemented concurrently to reduce the time required to address each item. Submittal of these work plans demonstrates the Air Force's commitment to addressing fuels contamination resulting from past practices and events at the BFF at Kirtland AFB.

This Vadose Zone Investigation Work Plan provides the sampling rationale and decision logic for defining the nature of the contaminants and delineating fuels contamination of soil and vapor within the vadose zone. The specific goals of the work plan are to:

- Estimate the amount of fuel that exists within the vadose zone as absorbed or residual liquid, or as soil gas;
- Identify the probable source of the LNAPL fuel plume; and
- Characterize the vadose zone geology, hydrology, hydrogeology, and soil/soil vapor contamination in sufficient detail to prepare an updated conceptual site model, which incorporates current and potential soil and groundwater contamination pathways, vadose zone sources, and the distribution, fate, and transport of contaminants.

Vadose zone investigation activities include subsurface geophysical investigations, soil and soil-gas vapor sampling, and installation of vapor monitoring points throughout the vadose zone. The geophysical investigation will provide information on subsurface geology and contaminant location and migration.

Soil and vapor sampling will provide immediate, as well as long-term, sampling data on subsurface contaminant distribution in the vadose zone.

The vadose zone investigation will be integrated with the groundwater investigation to provide data necessary to supplement and optimize remedial efforts currently underway at the BFF Spill. Enhancement of current remedial operations will increase the contaminant mass removed from the vadose zone and groundwater, thus reducing the time required for cleanup.

1. INTRODUCTION

This Vadose Zone Investigation Work Plan, Part I, was prepared by Shaw Environmental and Infrastructure, Inc. (Shaw) for the U.S. Army Corps of Engineers (USACE) under contract W912DY-10-D-0014, Delivery Order 0002. This work plan pertains to vadose zone investigations at the Kirtland Air Force Base (AFB) Bulk Fuels Facility (BFF) Spill, Solid Waste Management Units (SWMUs) ST-106 and SS-111 (collectively known as the “BFF Spill”). The BFF Spill site is located at Albuquerque, New Mexico (Figure 1-1).

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;
- New Mexico Hazardous Waste Management Regulations;
- Resource Conservation and Recovery Act (RCRA);
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA);
- April 2, 2010, and August 6, 2010 regulatory correspondence between the NMED HWB and the Air Force regarding the BFF Spill at Kirtland AFB (Appendix A, Attachments 1 and 2); and
- *Kirtland AFB, Base-Wide Plans for Investigations Under the Environmental Restoration Program, 2004 Update*

The vadose zone investigation is being completed in two parts, Part I: Field Investigation Activities and Part II: Nature and Extent Investigation. Part I, presented in this work plan, describes the geophysical investigation, borehole and soil-vapor well installation, as well as soil and soil-vapor sampling.
Part II will consist of the evaluation of all existing and new data, development of the risk assessment (including the conceptual site model), and preparation of cross sections and plan views.

The U. S. Department of Defense (DoD) Kirtland AFB is conducting an investigation of contaminated groundwater at the BFF Former Fuel Offloading Rack (FFOR) (SWMU ST-106) and the associated light non-aqueous phase liquid (LNAPL) plume (SWMU SS-111, also known as the Phase-Separated Hydrocarbon BFF Remediation), collectively known as the BFF Spill. Previous investigations show that contamination caused by the BFF Spill represents a significant threat to human health and the environment, particularly public water supply wells adjacent to Kirtland AFB. The contamination also threatens Kirtland AFB and the Veterans Administration (V.A.) Hospital water-supply wells. This release of hazardous constituents was first discovered 10 years ago, however a complete characterization of the BFF Spill has not been completed. The large extent of this contamination and its proximity to water supply wells requires that action be taken.

This work plan describes the actions to investigate the vadose zone hydrology and geology of the affected area, to identify and characterize the source of the releases at the BFF Spill, and to identify the extent of soil and soil-gas contamination in the vadose zone from the surface to groundwater to complete the characterization of the vadose zone. The area covered under this work plan includes the tank farm, the ancillary piping between the farm, the FFOR, and the area east of the FFOR. This work plan describes in detail all research, locations, depths and methods of exploration, field procedures, sampling and analysis of soil and soil gas, related quality control procedures, and a schedule for implementation of the work.

Per the direction of the NMED HWB (Appendix A), a characterization will be performed of the soil and soil gas in the vadose zone at the FFOR. Additional characterization and field investigation is also needed at the east side of the BFF Spill to determine the full extent of petroleum hydrocarbons and hazardous constituents in soil and soil vapor beneath Tanks 2422 and 2420. Additional investigation will determine whether release(s) associated with this tank are the source of adsorbed-phase and vapor-phase petroleum hydrocarbons previously indentified in distal soil-vapor monitoring well (SVMW)-13 and SVMW-15.

Additional characterization is also needed to complete the design and implement an appropriate final remedy.

The sampling rationale and decision logic for delineating the nature and extent of fuels contamination from past operations at the BFF Spill at Kirtland AFB are defined in this work plan. Activities described in the work plan are designed to define the nature of the contaminants and delineate fuels contamination of soil and vapor within the vadose zone at the following areas: the Tank Farm, pipeline, fuel offloading rack, fuel percolation area, and far field area north of the BFF Spill.

The objectives of implementing this work plan are as follows:

- Determine the amount of fuel that exists within the vadose zone as sorbed or residual liquid, or as soil gas.
- Identify the probable source of the LNAPL fuel plume.
- Describe the vadose zone hydrology, its relationship to groundwater contamination as it is encountered, and the potential for continuing groundwater contamination by the vadose zone.
- Characterize the vadose zone geology, hydrology, hydrogeology, and soil/soil vapor contamination in sufficient detail to prepare an updated conceptual site model, which incorporates current and potential soil and groundwater contamination pathways, vadose zone sources, and the distribution, fate, and migration of contaminants.

To achieve the stated objectives, nested soil-vapor monitoring (SVM) wells and geophysical investigation data will be used to:

- Estimate amount of residual fuel adsorbed to soil, as soil gas and as residual liquid in the soil.
- Determine the source of the LNAPL remaining in the vadose zone.
- Characterize the vadose zone hydrogeology in terms of LNAPL retention and migration pathways and the potential for long-term sources to groundwater contamination.
- Characterize the geology and extent of contamination in the soil and soil gas to determine distribution, fate, and migration of contaminants sufficient to support the selection of additional soil vapor extraction (SVE) wells in the shallow, intermediate, and deep vadose zone that will be protective of human health and the groundwater.
- Modify the operation and evaluate the performance of SVE wells.

A total of 35 nested SVM wells will be installed to a total depth of 450 feet(ft) below ground surface (bgs) within the BFF Spill area at Kirtland AFB. Nested wells consist of six small-diameter (0.75-inch) wells screened at intervals of 25, 50, 150, 250, 350, and 450 ft bgs as specified in the NMED regulatory correspondence (Appendix A).

This work plan will be implemented concurrently with the Groundwater Investigation Work, the Interim Measures Work Plan, and the LNAPL Containment Interim Measure Work Plan for the BFF Spill at Kirtland AFB. Together, implementation of these work plans will complete the delineation of fuels contamination, address continuation of existing interim measures, initiate LNAPL plume containment, and evaluate the potential of augmented or additional interim measures at the site.

1.1 Identification of Contaminants of Potential Concern

Petroleum contamination associated with the BFF Spill has been identified in subsurface soil, soil gas, and groundwater. Contamination appears to be a result of various releases that occurred over the operational history of the facility. Information is available on some of the releases whereas other releases are not well-documented and are inferred to have been ongoing for unknown periods of time. All contaminants of potential concern (COPC) at the BFF Spill are constituents of refined petroleum products and include, but are not limited to, the following: benzene, toluene, ethylbenzene, xylenes (BTEX), ethylene dibromide (EDB), and lead.

1.2 Scope of Activities

This Vadose Zone Investigation Work Plan is being completed in two parts, Part I: Field Investigation Activities and Part II: Nature and Extent Investigation.

1.2.1 Vadose Zone Investigation Work Plan, Part I

The Vadose Zone Investigation Work Plan, Part I, presented in this work plan, describes all activities associated with the soil boring/soil vapor monitoring wells, including locations, borings, soil sampling, and the borehole geophysical investigation to support the actions that Kirtland AFB is taking to begin the remediation at SWMUs ST-106 and SS-111, collectively called the BFF Spill, at Kirtland AFB. Part I describes investigation requirements of the June 2, 2010 and August 6, 2010 the NMED letters (Appendix A, Attachments 1 and 2).

1.2.2 Vadose Zone Investigation Work Plan, Part II

In order to prioritize field activities to meet the outlined aggressive schedule, Part II will provide a comprehensive, site-specific conceptual site model (CSM) using regional and site-specific information from previous investigations. Part II will contain all CSM data, including geologic, hydrologic, and contaminant conditions. During Part II, a current understanding of the sources, contaminants, and media that have been impacted by the activities at the BFF Spill will be provided in the updated CSM, with particular emphasis on LNAPL migration and transport. Part II will include the approach for conducting the risk assessment. The CMS will address concerns stated in the June 2, 2010, and August 6, 2010 NMED letters (Appendix A, Attachments 1 and 2).

1.3 Data Gaps

Following previous investigations at the BFF Spill, data gaps related to the nature of the fuels contamination and the extent of contaminations resulting from past operational history at the BFF Spill were identified. The intent of the BFF Spill vadose zone investigation is to address the data gaps for the lateral and vertical delineation of vadose zone contamination and to provide data of sufficient quality to characterize the nature and extent of fuels-related soil and soil-vapor contamination and to support the development of a Corrective Measures Evaluation.

Implementation of Part I: Field Investigation Activities of this work plan will function as the first phase of the BFF Spill vadose zone investigation and will accelerate implementation of the overall investigation. A second portion of this work plan (Part II: Nature and Extent Investigation) detailing the complete BFF Spill vadose zone investigation will be issued following approval of Part I of the work plan and the completion of the geophysical logging effort. The BFF Spill vadose zone investigation will be performed in conjunction the groundwater investigation and evaluation of interim measures for the BFF Spill.

1.4 Report Organization

This report is organized into thirteen major sections:

- Section 1: Introduction
- Section 2: Background Information
- Section 3: Site Conditions
- Section 4: Data Quality Objectives Process
- Section 5: Investigation Methods and Approach
- Section 6: Monitoring and Sampling
- Section 7: Project Schedule
- Section 8: Organizational Plan
- Section 9: Data Management Plan
- Section 10: Quality Assurance/Quality Control (QA/QC)
- Section 11: Waste Management
- Section 12: Accident Prevention Plan(APP)/Site Safety and Health Plan (SSHP)
- Section 13: Community Relations Plan

Figures and tables are provided in separate tabs following the body of the work plan.

Appendices to this work plan include:

- Appendix A: 2010 Regulatory Correspondence between the NMED HWB and the Air Force regarding the Kirtland AFB BFF Spill
- Appendix B: Project Schedule
- Appendix C: Waste Management Plan
- Appendix D: Field Forms
- Appendix E: Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP)

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 and the Albuquerque International Sunport (Figure 1-1). The approximate area of the base is 52,287 acres.

2.2 Operational History

The BFF Spill site is located in the northwestern corner of Kirtland AFB (Figure 1-1). Historical aerial photography has revealed that the area was used for fuel storage and processing as early as 1951 (CH2M HILL, 2001). At that time, the fueling area was separated into a distinct tank holding area where bulk shipments of fuel were received (near the location of existing well Kirtland AFB-1066) and a separate fuel loading area where individual fuel trucks were filled. The truck loading area appears to have been approximately 250 feet (ft) north of the tank area.

Subsequent aerial photographs indicate that construction of the facility and associated infrastructure took place from 1951 until 1953. Once completed, the facility operated until it was removed from service in 1999, as a result of below grade line leakage along the offloading rack. Bulk storage for Jet Propellant-8 fuel (JP-8), diesel fuel, and aviation gasoline (AvGas) was managed in the eastern portion of the facility. A 250-gallon underground storage tank was located near the Pump House (Building 1033) (CH2M HILL, 2001). The three types of fuel handled by the BFF Spill were AvGas, Jet Propellant Fuel-4 (JP-4), and JP-8. Use of AvGas and JP-4 at Kirtland AFB was phased out in 1975 and 1993, respectively. JP-8 was handled through the FFOR until the leak was discovered in 1999.

The exact history of releases is unknown. Conceptually, releases could have occurred when fuel was transferred from railcars, through the FFOR, to the pump house and then to the bulk fuel storage containers on the south end of the site (Tanks 2420 and 2422). The probable release points have been investigated. Fuel transfer from railcars to the pump house was done under vacuum transfers. Transfer of fuel from the pump house to the bulk storage containers was performed under pressurized conditions. Fuel transfer infrastructure for vacuum transfers was exempt from pressure testing, whereas fuel infrastructure for pressurized transfer did undergo regular pressure testing. Only when the vacuum portion of the fuel system underwent pressure testing in 1999 was any problem noted in the fueling system.

At present, jet fuel is stored in two aboveground storage tanks (ASTs) (2.1 and 4.2 million gallons), diesel fuel is stored in two ASTs (one 5,000- and one 10,000-gallon), and unleaded gasoline is stored in one 10,000-gallon AST. The site currently has one temporary JP-8 offloading rack located in the southwest corner of the facility, west of the fuel loading structure (Building 2404). This rack was placed into service following the piping failure at the FFOR (SWMU ST-106). A second small offloading rack (Building 2401) is used for delivery of diesel and unleaded gasoline motor vehicle fuels.

Fuel delivered to the temporary JP-8 offloading rack is conveyed to the Pump House (Building 1033) via subsurface transfer lines. The fuel is then pumped to the JP-8 ASTs by piping of varying sizes that runs above ground for approximately 750 ft and runs belowground for approximately 300 ft. Figure 2-1 presents the infrastructure present at the eastern portion of the BFF Spill.

3. SITE CONDITIONS

This section describes site conditions, including regional and site-specific geology, hydrogeology, and geochemistry. In addition, it presents the known extent of contamination, summarizes previous investigative results, and describes contaminants of potential concern and potential receptors.

3.1 Regional Geology

The geology of the Kirtland AFB area varies in accordance with the regional geology. The eastern portion of the base is mountainous, with elevations reaching 7,900 ft above mean sea level. These mountains are composed of Precambrian metamorphic and 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 structural basin that contains the through-flowing Rio Grande. The basin is approximately 90 miles long and 30 miles wide. The deposits within the Albuquerque Basin consist of interbedded gravel, sand, silt, and clay. The presence of clay has significant implications for bulk hydrocarbon migration in the vadose zone. The thickness of basin-fill deposits in most of the basin exceeds 3,000 ft, though the thickness varies considerably because of the large amount of faulting in the basin.

Geologic materials of primary importance within the basin are the Santa Fe Group (USF) and the piedmont slope deposits. The USF consists of beds of unconsolidated to loosely consolidated sediments and interbedded volcanic rocks. The materials range from boulders to clay and from well-sorted stream channel deposits to poorly sorted slope wash deposits. Coalescing alluvial fans of eroded materials from the surrounding mountains were deposited unconformably over the Santa Fe Group, extending westward from the base of the Sandia and Manzano mountains to the eastern edge of the Rio Grande floodplain. The fan sediments range from poorly sorted mud flow material to well-sorted stream gravel; the beds consist of channel fill and interchannel deposits. The fan deposits range in thickness from 0 to 200 ft and thicken toward the mountains. The USF under the BFF Spill is further broken down into two depositional facies called the USF-1 and USF-2 (Hawley et al, 1995). As shown on Table 3-1, USF-1 is present from ground surface to approximately 86 ft bgs, then a transition occurs where USF-1 and USF-2 are interfingered to a depth of 117 ft bgs, under which USF-2 is present to a depth of greater than 500 ft bgs (CH2M HILL, 2008).

3.2 Site-Specific Geology

Soil types at the BFF Spill range from lean clays, silts, and sands to minor silty or sandy gravels. These soil can be correlated into several litho-stratigraphic zones discussed below.

- From the surface to approximately 85 ft bgs, the soil primarily consists of thick, discontinuous intervals of silt and silty or sandy clays.
- From approximately 86 to 144 ft bgs, two 3- to 25-ft-thick units of poorly graded fine-grain sands alternate with two silty, sandy, and lean clay units that are up to 25 ft in thickness.
- From approximately 144 to 270 ft bgs poorly graded fine-grained sands combine with well-graded fine- to coarse-grained sands.
- A significant 15-ft-thick clay zone occurs within the lower sandy zone at about 270 ft bgs.

Soils at the BFF Spill range from wet to dry. The finer-grained upper soil is generally moist while the coarser-grained deeper soil could be moist or dry. Several minor perched water-bearing zones are present in the vadose zone above the regional groundwater table at the BFF Spill. None of these water-bearing zones is substantial enough to merit the installation of a groundwater monitoring well. Some of these water-bearing zones below 400 ft bgs are probably remnants of the regional aquifer left behind as the water table has dropped. The regional water table varies with location within the Kirtland AFB and ranges from approximately 485 to 500 ft bgs.

3.3 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 USF. The unit consists of unconsolidated sediments that thin toward the basin boundary. Edges of the basin are marked by normal faults. Overlying the USF are the Pliocene Ortiz gravel and Rio Grande fluvial deposits.

Generally, the upper unit of the USF contains the most productive portion of the regional aquifer that supplies groundwater to the City of Albuquerque and Kirtland AFB. The unit is characterized by piedmont slope, river, and floodplain deposits. The ancestral Rio Grande formed a large aggradational plain in the central basin, depositing a mix of coarse- to fine-grained sands, silts, and clays with variable bed thickness.

Basin-fill deposits make up the aquifer in the Albuquerque Basin. Hydraulic conductivity values range from 0.25 ft per day (ft/day) to 50.0 ft/day due to large variations in the lithology of the basin-fill deposits. Clay layers have relatively low hydraulic conductivity, whereas gravel and cobble deposits have relatively high hydraulic conductivity. Deposits of interbedded gravel, sand, silt, and clay have intermediate hydraulic conductivity.

This principal aquifer underlies Kirtland AFB, with the basin fill in this area consisting of unconsolidated and semi-consolidated sands, gravels, silts, and clays of the USF; alluvial fan deposits associated with erosion of upland areas; and valley alluvium associated with stream development. The alluvium varies in thickness from a few feet near the mountains on the east side of the base to greater than 2,100 ft bgs at a location 5 miles southwest of the airfield. (Tetra Tech, 2004).

3.4 Geochemistry

Geochemical conditions are one factor that influences the transport and transformation of chemical compounds in the environment. Biodegradation often is a major transformation process for petroleum hydrocarbons and related compounds, and in general requires sufficient electron acceptors for microbial metabolism of petroleum hydrocarbons. In the presence of a carbon source (including fuels-related aromatic and aliphatic hydrocarbons), naturally occurring bacteria can use the fuel as food for growth and numerous naturally occurring compounds nitrate, iron, manganese, sulfate, carbon dioxide, etc. as electron acceptors, producing carbon dioxide, methane, and water (National Research Council [NRC], 2000). Microbial testing for soil was performed in 2009 and the results were that significant microbial action was detected at the location with high fuel contamination. (CH2M HILL, 2009).

3.5 Previous Investigations

3.5.1 Contaminant Sources

In November 1999, three known discharges occurred as a result of pressure testing of the lines that transfer fuel from the JP-8 offloading rack (Building 2405) to the pump house at the facility (Figure 2-1):

- Failure of one of the 14-inch-diameter belowground transfer pipelines (pipeline #22) during a hydrostatic pressure test;
- Failure of a cam-lock coupling during pressure test of the second belowground transfer pipeline (pipeline #23), and

- Failure of the second belowground transfer pipeline (pipeline #23) during a hydrostatic pressure test after the cam-lock coupling problem had been corrected.

Testing revealed that the primary belowground transfer pipeline (pipeline #22) had been in a state of failure for an unknown duration; therefore, the total amount of fuel released is unknown. The volumes of the second two discharges were estimated to be approximately 200 to 400 gallons and 30 gallons, respectively. For all discharges documented in November 1999, the product released was JP-8. However, due to the presence of multiple types of fuel contamination on the water table and the size of the LNAPL plume it is likely that the primary pipeline had been in a state of failure for many years. The presence of LNAPL fuel hydrocarbons on the water table also indicates that substantial releases have occurred and that a range of fuel types may have been released. Possible fuel types include AvGas, JP-4, and JP-8.

In 1951, the U. S. Government specified JP-4 (for Jet Propellant) as a 50-50 kerosene-unleaded gasoline blend (MIL-J-5624E). JP-4 was the primary Air Force jet fuel between 1951 and 1995. JP-4 is a mixture of aliphatic and aromatic hydrocarbons with a low flash point (0 degrees Fahrenheit [°F]/-18 degrees Celsius [°C]), if a lit match is dropped into JP-4, ignition does not occur.

JP-8 was specified by the U. S. Government in 1990 as a lower volatility replacement for JP-4. JP-8 is kerosene-based and has been used in nearly all jet aircraft, tactical ground vehicles, and electrical generators since 1996. Based on historical Air Force fuel usage, AvGas would have been in use from approximately the 1940s to 1975. EDB was added to the fuel as a lead scavenger and serves as a useful tracer of time frames. Likewise, the transition from JP-4 to JP-8 in 1993, it serves as another potential marker.

Over the past several years, potential sources in addition to the offloading rack were evaluated as possible contributors to LNAPL on the water table. These previously investigated potential sources include the pump house, a fueling island, underground piping, an evaporation pond, and areas where water from the bottom water holding tanks was released.

3.5.2 Past Investigative Results

As previously mentioned, in November 1999, three known discharges occurred as a result of pressure testing of the lines that transfer fuel from the JP-8 offloading rack (Building 2405) to the pump house at the facility. Subsequent investigations were conducted and the results are provided in the following reports:

- *Stage 1 Abatement Plan Report for the Bulk Fuels Facility (ST-106)* (CH2M HILL, 2001);
- *Stage 2 Abatement Plan Report for the Soil Vapor Extraction and Treatment System, Bulk Fuels Facility (ST-106), Kirtland AFB, New Mexico* (CH2M HILL, 2006a);
- *Stage 1 Abatement Plan Report, East Side of the Kirtland AFB Bulk Fuels Facility* (CH2M HILL, 2006b);
- *Semi-Annual Summary and Performance Report, October 2007 through March 2008, Bulk Fuels Facility* (CH2M HILL, 2008); and
- *Remediation and Site Investigation Report for the Bulk Fuels Facility* (CH2M HILL, 2009).

In the reports, soil data collected during the BFF Spill investigations are compared to the NMED's total petroleum hydrocarbon (TPH) Screening Guidelines to aid in defining extent of contamination (NMED, 2006). The petroleum product subgroup containing kerosene and jet fuel was selected as applicable for the BFF Spill site. The TPH toxicity for jet fuel is based on the weighted sum of the toxicity of the hydrocarbon fractions, which is reported as 30 percent for C11-C22 aromatics and 70 percent for C9-C18 aliphatics (NMED, 2006). Based on this assumed composition, the documented TPH screening guideline for potable water industrial direct exposure for jet fuel is 1,810 milligrams per kilogram (mg/kg) (NMED, 2006). The TPH screening guideline for vapor migration and inhalation of groundwater industrial direct exposure is 2,350 mg/kg (NMED, 2006).

Findings of these investigations are summarized below.

Stage 1 Abatement Plan Report (CH2M HILL, 2001)

In the soil investigations initiated immediately after the 1999 discovery of the fuel line leak, contamination was detected along the JP-8 offloading rack that supplies the 300-foot-long belowground pipeline. The horizontal extent of shallow contamination less than 40 ft bgs was delineated during the June 2000 direct push investigation portion of the Phase 1 investigation. This contamination appeared to be limited to within 50 ft lateral to the location where the pipelines went belowground.

The site investigations conducted during 2000 also included soil characterization at depth, extending down to the water table at select locations. Regional hydrostatic units and corresponding site-specific units are presented in Table 3-1. Contamination was identified in two deep soil borings (SB-25 and SB-26) installed during July 2000 using hollow stem auger drilling. These two borings were located on the eastern and western ends of the offloading rack. The maximum concentration detected in soil from boring SB-25 was 81,000 parts per million (ppm) TPH in the sample from 105 ft bgs, which is just below the Transition Zone between USF-1 and USF-2. The maximum concentration detected in boring SB-26 was 114,000 ppm TPH in the sample from 270 ft bgs, which is just above the Clay Zone that divides the USF-2 hydrostratigraphic unit.

Additional borings were installed to determine the horizontal extent of the soil that has TPH concentrations greater than 100 mg/kg. Based on data from the additional borings, soil contaminated in excess of the NMED TPH Screening Guidelines are limited to within approximately 310 ft of the surface; and within the area 65 ft south, 280 ft north, 400 ft east, and 175 ft west of the FFOR. The total area of soil affected by the petroleum hydrocarbon contamination is estimated to be 6.5 acres with depths of contamination extending to 310 ft bgs.

Stage 2 Abatement Plan Report (CH2M HILL, 2006a)

Additional borings were advanced in 2003 as part of a pilot test for SVE. All four soil vapor monitoring wells included both soil and vapor sampling capabilities and were completed to depths of approximately 450 ft bgs. In addition to the anticipated intervals of petroleum-related contamination, two locations were found to have detections at the lowest sampling depth of 60 ft bgs.

Stage 1 Abatement Plan Report, East Side of the Kirtland AFB Bulk Fuels Facility, (CH2M HILL, 2006b)

In 2005, a shallow soil investigation of potential source areas on the east side of the BFF Spill was conducted. Soil samples were collected from the following areas:

- Former Wash Rack Drainfield
- Three fuel-storage ASTs
- Former Fuel/Water Evaporation Pond
- Recovered Liquid Fuel Collector Tank
- Primary fuel-storage ASTs and tank bottom water-holding tanks

The investigation included excavating test pits (TP-07, TP-08, and TP-09) and advancement of a direct-push borehole (SB-04) to 50 ft bgs. Additionally, a temporary soil vapor monitoring point was installed in the direct-push borehole and monitored for hydrocarbon concentrations with field monitoring equipment for several quarters. Based on the visual observations, analysis of soil samples from the test pit and shallow soil sampling at this location and soil vapor samples, substantial hydrocarbon impacts were not identified in the interval from the ground surface to 50 ft bgs. The only area where the NMED TPH guideline was exceeded was in the vicinity of the primary fuel storage ASTs and tank bottom water-holding tanks. The maximum petroleum hydrocarbon concentration was 2,400 mg/kg detected in the 15-ft bgs sample. None of the detections suggested that the area was a contributor to the soil vapor profile at the BFF Spill.

Semi-Annual Summary and Performance Report (CH2M HILL, 2008)

In 2007, groundwater monitoring well KAFB-1066 was installed in the general vicinity of the east side of the BFF Spill. This monitoring well was installed between the presumed area of the storage tank associated with the 1951 rack operations and the location of the filling rack itself where tanker trucks would have been fueled. Well KAFB-1066 is roughly 75 ft north of the storage tank area associated with the 1951 operations. Additionally, 15 groundwater monitoring wells were installed between 2007 and 2008. These monitoring well installations are reported on in their respective Semi-Annual Summary and Performance Reports. Soil sampling was conducted at 20-ft intervals during advancement of the KAFB-1066 borehole, from 20- ft bgs to 480-ft bgs. The soil sample results did not suggest the presence of a large surface release of fuel in this area. However, there were detections of limited petroleum hydrocarbon concentrations (< 100 mg/kg) throughout much of the borehole length; and isolated, higher concentration detections of other fuel compounds such as toluene, benzene, xylenes, etc. at individual shallower depths of 40-ft and 140-ft bgs in the borehole. While the individual fuels-related detections in the borehole were not extremely high, the pattern of detections may be indicative of a predominantly stair-step lateral and vertical migration of near surface releases of fuel through the vadose zone.

Remediation and Site Investigation Report (CH2M HILL, 2009)

In 2009, soil boring investigations were conducted and four additional groundwater monitoring wells were installed at the BFF Spill to further evaluate other potential source areas. The soil data are consistent with previous sampling results and the effectiveness of the SVE system was indicated. LNAPL was not detected in samples collected from any of the newly installed wells.

3.5.3 Vadose Zone and Soil Vapor Contaminant Distribution

Previous TPH vapor data suggest the movement of LNAPL through the vadose zone was offset to the east and north, presumably by fuel migration along dipping clay layers. The pathway will be refined/tested during the upcoming characterization effort. Conceptually, the TPH vapor results at 450 ft show the effect and correlate well with the distribution and orientation of LNAPL on top of the water table and groundwater contamination.

3.5.4 Light Non-Aqueous Phase Liquid Distribution

Previous investigations suggest that the greatest thickness of LNAPL occurs in the area to the east of the FFOR, and is consistent with vadose zone migration of bulk LNAPL migration along east dipping clay beds, and then following the groundwater table toward the north and east. The pathway will be refined/tested during the upcoming characterization effort. Measurements of LNAPL were made on monitoring wells that have historically had or potentially have measurable thickness of LNAPL again on May 14, 2010.

Measured LNAPL was detected on wells:

- KAFB-1068 3.8-ft SVE
- KAFB-1066 2.45-ft SVE
- KAFB-1065 3.33-ft SVE
- KAFB-10614 0.23-ft
- KAFB-1069 0.79-ft
- KAFB-10610 1.18-ft
- KAFB-10618 (sheen)

Measured thicknesses are greater at monitoring wells where active SVE is ongoing, possibly producing a mounding effect. The LNAPL plume extends approximately 2,600-ft long and is approximately 1,000-ft wide trending along the groundwater flow direction.

3.5.5 Dissolved-Phase COPC Distribution

The distribution of dissolved-phased contaminants forms a halo around the LNAPL plume. As expected, concentrations of dissolved COPCs are detected at high concentrations very close to the LNAPL plume due to the dissolution of petroleum products into the groundwater and lower concentrations further from the LNAPL plume. The dissolved-phase COPC distribution is within the groundwater zone of saturation, and not within the soil-water unsaturated zone. The dissolved-phase plume extends approximately 4,500-ft along the axis of the plume trending along the groundwater flow direction. EDB is the most widely distributed COPC. The footprint of the dissolved-phase plume downgradient is elongated as the more mobile contaminants, such as benzene and EDB, are more quickly transported along with groundwater movement downgradient.

3.5.6 Site-Specific Fate and Transport

(To be included in Part II of the Vadose Zone Investigation Work Plan.)

3.5.7 Potential Receptors

(To be included in Part II of the Vadose Zone Investigation Work Plan.)

3.5.8 Site-Specific Conceptual Model

The specific CSM will be included as Part II to this Vadose Zone Investigation Work Plan, which will also address data gaps as applicable. The CSM will include an in-depth discussion of the site geology; it will encompass the source areas, fuel percolation area, LNAPL plume floating on groundwater, and the dissolved-phase contaminant plume in groundwater. The applicable models will be illustrated through the liberal use of detailed, accurate, scaled geologic cross-sections; maps in plan view; and other figures to clearly and accurately show geologic features, hydrologic features, and contamination levels.

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4. DATA QUALITY OBJECTIVES PROCESS

4.1 Data Quality Objectives

Data quality objectives (DQOs) are the basis for design of the data collection plan. DQOs specify the type, quality, and quantity of data to be collected and how the data are to be used to make the appropriate decisions for the project. They are qualitative and quantitative statements that specify the quality of data generated to support decision making. DQOs are scoping and planning tools applicable to every data generation effort, and developing DQOs is a necessary step for project-specific plans. For each data collection task, DQOs were developed during project scoping and include a description of the purpose of the task, the specific activities to be performed, the intermediate and end-uses of the generated data, and the resultant data quality that is required.

The DQO development process includes the following steps:

1. Statement of the problem
2. Identification of a decision that addresses the problem
3. Identification of inputs that affect the decision
4. Specification of the domain of the decision
5. Development of logic statement
6. Establishment of constraints on uncertainty
7. Optimization of design for obtaining data

The DQO process is an iterative process that occurs at every stage throughout the project to ensure that stakeholders obtain sufficient quantity and quality of data to provide the basis for decision making. DQO development is consistent with U.S. Environmental Protection Agency (EPA) guidance, *Guidance on Systematic Planning Using the Data Quality Objectives* (EPA, 2006) and *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual, Final, Version 1,* worksheets 10, 11, and

17 (EPA, 2005a). DQOs specific to the vadose zone investigation are presented in Table 4-1. Details are provided below.

4.1.1 Borehole Logging and Geophysics Data Quality Objectives

DQOs for borehole logging and geophysics logging include the objective of refining the interpretation of subsurface geology and identification of the presence of silt and clay layers that affect the migration of the LNAPL from the source area to the water table. Thirty-five newly installed wells will be geophysically logged to aid in the determination of geology in the vadose zone and will also help in delineating the presence and extent of fine grained units. LNAPL plume within soil and groundwater. DQOs for geophysical data collection are summarized in Table 4-1.

4.1.2 Soil Sample Data Quality Objectives

DQOs for soil samples from soil borings to be installed as part of this work plan, where soil sample analytical results exceed the NMED TPH screening criteria (guidelines) or the NMED Soil Screening Levels (NMED, 2009), are summarized in Table 4-1.

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5. INVESTIGATION METHODS AND APPROACH

Following previous investigations at the BFF Spill, data gaps were identified regarding the nature and extent of fuels contaminations as the result of past operational history at the BFF Spill. This work plan was developed to address the data gaps for the soil and vapor in the vadose zone, provide sufficient data and quality of data to adequately characterize the nature and extent of fuels-related contamination, and support the development of a Corrective Measures Evaluation.

This work plan will be implemented in conjunction with the BFF Spill Groundwater Investigation Work Plan, Interim Measures Work Plan, and LNAPL Containment Interim Measure Work Plan. Intrusive investigation, including drilling and sampling of soil and vapors, will determine the nature and extent of soil and vapor contamination at the BFF Spill and will provide insight into the chemical makeup and distribution of contaminants within the vadose zone. The Groundwater Investigation Work Plan and Interim Measures Work Plan will provide similar information and insight for the saturated zone and remedial measures.

5.1 Project Coordination

Prior to the commencement of work, a kickoff meeting will be held at Kirtland AFB, as appropriate. Invitees will include representatives from the USACE, Air Force Center for Engineering and the Environment (AFCEE), Kirtland AFB, NMED personnel, and the contractors conducting the work. The meeting will outline roles and responsibilities of all participants; review scope, schedule and procedures; and discuss base rules and security requirements. During the field implementation kick off meeting, a list of critical contacts within the field team, USACE, Kirtland AFB, and AFCEE will be compiled. This contact list will be used should immediate input be needed to any decision process critically impacting field work. This list will be reviewed and revised, as needed, on a monthly basis during the monthly conference call to account for future personnel absences.

A monthly conference call status meeting will be held among the field team, USACE, AFCEE, Kirtland AFB, and NMED to discuss the progress of the field effort, upcoming field work, and consider any problems or issues that require resolution. Minutes of the meeting and action items will be documented by the field team managers, and circulated to the participants within 24 hours of the meeting. Conference calls will be implemented as deemed necessary.

During field investigation activities, daily quality control reports (DQCRs) will be completed by the field lead and provided to the project manager, and the USACE. DQCRs summarizes field activities and quality control (QC) activities that will occur each day. In compliance with the established *Base-Wide Plans for Investigation under the Environmental Restoration Program* (Tetra Tech, 2004), Field Change Request (FCR) forms will be filled out if there are any changes to the awarded scope of work approach. If the FCR represents a major change, such as moving a well or boring location, the USACE, AFCEE, and Kirtland AFB will be notified for approval and submittal to the NMED for approval prior to commencement.

5.2 Field Activities

The areas identified that need further investigation to characterize the full extent of lateral and vertical contamination in the vadose zone are:

- Tank Farm
- Pipeline
- Former Fuel Offloading Rack
- Fuel Percolator Area
- Farfield Area of Soil-Vapor Plume

Table 5-1 summarizes information about the soil borings/soil vapor sampling wells and Table 5-2 presents the coordinates and purpose of the soil borings/soil vapor wells. Figure 5-1 shows the soil borings/soil vapor sampling wells locations and Figure 2-1 presents the layout of the area. The number, locations, and depths of soil borings/soil vapor wells are in accordance with Table 4 of the NMED letter from the Hazardous Waste Bureau, dated August 6, 2010 (Appendix A, Attachment 2). Sections 5.2.1 (Soil Borings/Drilling) and 6.1 (Soil Sampling) provide further discussion of the vadose zone investigation in these areas.

Field activities associated with this work plan include geophysics, soil borings/drilling activities, installation of soil-vapor monitoring wells, soil sampling and soil-vapor sampling. Soil and soil-vapor sampling are discussed in Section 6. Geophysics, soil borings/drilling activities, and installation of soil-vapor monitoring wells are discussed below.

5.2.1 Utilities Clearance

A utilities clearance will be conducted to locate all underground and suspended utilities both on Kirtland AFB property and off base. Onbase utilities clearance activities will be conducted as prescribed by and in accordance with the Kirtland AFB site representative policies and procedures. Utilities clearance activities at adjacent residential neighborhoods and City of Albuquerque right-of-ways will be prescribed by and in accordance with State of New Mexico and City of Albuquerque utilities regulations.

All underground utilities will be clearly marked prior to the start of any intrusive activities. All intrusive activities will take into account any existing utilities, and will be located to avoid these utilities. The State of New Mexico's "New Mexico One Call" utility excavation clearance system will be utilized for all off-base drilling and excavation locations. Each well boring will be tested for utility clearance to 5 feet with a hand-auger or post-hole digger.

5.2.2 Site Survey

Land surveying activities may occur before, during, and after well installation activities. The survey will be conducted at locations on Kirtland AFB, adjacent residential neighborhoods, and City of Albuquerque right-of-ways. The survey will establish northings, eastings, and elevations at all locations. All survey points will be verified, determined, marked, and documented per all requirements as outlined in the Kirtland AFB Base-Wide Standard Operating Procedures (SOPs). A State of New Mexico registered professional land surveyor or licensed Professional Engineer will be utilized for well location verification and determination, excavation extents, temporary benchmarks as required for site controls, and as-built determination surveys,

Elevations for each survey point will be determined to the nearest 0.01 foot. The horizontal coordinates of each survey point will be determined to the nearest 0.01 foot and referenced to the New Mexico State Plane Coordinates. Horizontal coordinates will be based on the New Mexico State Plane Coordinate System, central zone (North American Datum, 1983 [NAD83]), as published by the National Geodetic Survey. Survey points will also be provided in Universal Transverse Mercator (UTM) coordinate system. Elevations will be determined to the nearest 0.01 foot and referenced to the 1988 National Geodetic Vertical Datum, as obtained from permanent benchmarks.

There will be two survey points for new and existing monitoring wells installed at the BFF Spill. The first survey point will be on north side of the well casing. The second survey location will be on the ground surface adjacent to steel protective casing or concrete well pad. Survey points at all other points, lines, and features will be have both horizontal and vertical control.

Daily reports will consist of the following: a tabulation of the location, identification, coordinates (both State Plane and UTM), and elevations of each point surveyed that day.

5.2.3 Borehole Geophysical Investigations

Borehole geophysics, consisting of induction, neutron, and gamma logging, will be conducted on 35 newly installed nested SVM wells (six individual polyvinyl chloride [PVC] soil vapor monitoring wells installed in the same borehole, one 2-inch diameter and five 3/4-inch diameter) to be installed as described in this work plan. Geophysical logging will aid in fully characterizing the nature and extent of the vadose contamination and geology. The ultimate goal of geophysical borehole logging investigations is to use the data to refine the conceptual site model of the potential source location(s) and the extent of the LNAPL contamination, in order to optimize placement of remedial SVE and groundwater extraction wells and potential future monitoring wells. For this objective, it is expected that the characterization of fine-grained clay and silt units in the vadose zone will be mapped with a vertical accuracy of less than 1 foot.

Borehole logging will follow standard industry practices, and those presented in the ASTM International (ASTM) D5753 *(Standard Guide for Planning Borehole Geophysical Logging)*, ASTM D6274 (*Standard Guide for Conducting Borehole Geophysical Logging – Gamma)*, ASTM D6127 (*Standard Guide for Conducting Borehole Geophysical Logging: Neutron)*, and ASTM D6726 (*Standard Guide for Conducting Borehole Geophysical Logging: Electromagnetic Induction).*

5.2.3.1 Downhole Geophysical Logging

Geophysical techniques have proven to be valuable tools in determining lithology, porosity, and moisture condition of various stratigraphic units. Downhole geophysical logging will be conducted using a suite of induction (deep, medium), neutron, and gamma (large-crystal) tools. The objective of this effort is to characterize the fine-grained clay and silt units in the vadose zone with a vertical accuracy of less than 1 foot.

The logs will be run from the groundwater table (approximately 500 ft bgs) to ground surface through the well casing. Equipment will be decontaminated at each well location before conducting logging activities. The logs will be evaluated /interpreted along with soil boring logs, well construction reports, and proposed seismic survey results.

All logging equipment will be calibrated in accordance with manufacturer's specifications. "Shop" calibrations will be performed within 30 days of the logging event. Before-and-after calibrations will also be conducted for each logging tool run in the borehole. A rat hole may be required at the bottom of the borehole to accommodate the logging tools(s) and ensure that the bottom zone can be evaluated.

A minimum of 100 ft of repeat log will be made after the initial logging effort and the initial and repeat logs provided to the USACE Onsite Representative in hardcopy form for review. After completion of the borehole, a paper copy of the strip logs will be provided to the USACE Onsite Representative for review and approval. Digital data files for all logs also will be provided by the logging contractor at the end of the field day.

Geophysical logs submitted to the NMED will show results of induction logging (medium and deep) in milliohms per meter, neutron logging in American Petroleum Institute (API) neutron units, and gamma logging in API calibrated counts per second. The results of each method will be plotted versus depth from the surface to total depth of the borehole for which the log represents. The name of the borehole, location of the borehole, the date(s) that the borehole was completed, the drilling method, and the elevation of the top of the borehole also will be noted on the boring log. Data will be provided to the NMED in hard copy and in digital format.

Borehole logging will follow standard industry practices, and those presented in the ASTM 5753 (*Standard Guide for Planning and Conducting Borehole Geophysical Logging*), ASTM D 6274 (*Standard Guide for Conducting Borehole Geophysical Logging–Gamma*), ASTM D 6727 (*Standard Guide for Conducting Borehole Geophysical Logging–Neutron*) and ASTM D 6726 (*Standard Guide for Conducting Borehole Geophysical Logging– Electromagnetic Induction*).

5.2.3.2 Induction Logging

Electromagnetic (EM) induction logging provides detailed stratigraphic information from dry, cased, or uncased holes. The slimhole EM induction probe's high-frequency magnetic field transmitter induces an alternating electrical current into the surrounding formation and the induced voltages in the receivers are indicative of the electrical conductivity of soil adjacent to the borehole in PVC-cased or uncased holes. The probe is designed to focus EM energy away from the borehole so that materials immediately adjacent to the casing, such as well completion materials, have minimal effect on the measurements. A dual focused probe, where a "medium" and "deep" radii of investigation will be used. The probe diameter is 38 millimeters (mm) and is 2.15 meters long.

EM-induction logs record electrical conductivity or resistivity of the rocks and water surrounding the borehole. Conductivity and resistivity are dependent on the porosity, permeability, and clay content of the rocks and the dissolved-solids concentration of the water within rocks. The electromagnetic-induction probe is designed to maximize vertical resolution and depth of investigation and to minimize the effects of the borehole fluid.

A small transmitter coil in the borehole probe induces eddy currents in the surrounding geologic material. The eddy currents generate a secondary magnetic field in the geologic materials. The strength of the magnetic field is controlled by the electrical properties of both geologic materials and groundwater. A receiver coil in the borehole measures the strength of the quadrature component of the secondary magnetic field, and electronics in the instrument console convert the magnetic field strength to values of conductivity. A focusing coil in the borehole probe causes measurement sensitivity to peak about 12 inches away from the borehole axis; consequently, borehole effects are minimized and the measured electrical conductivity responds to formation and groundwater changes.

Drift and noise are typically less than 1 millisiemen per meter and conductivity changes of a few percent are easily resolved. The intercoil spacing resolves conductivity layers 20 inches thick. The system may detect layers that are thinner than 20 inches; however, the measured value is the product of conductivity contrast times layer thickness.

The borehole induction system measures bulk conductivity resulting from the electrical properties of geologic materials and contained groundwater. In general, conductivity will increase as clay content increases and as ionic strength of groundwater increases.

The borehole induction system can be used in boreholes that range from 2 to 8 inches in diameter without significant borehole effects. Conductivity measurements may be acquired in both the vadose and saturated zones, in open holes or through PVC casing. Measurements may not be taken through steel or black iron casing. The maximum depth of measurement for the most induction logging systems is 650 ft (200 meters).

A general procedure for the information recorded for a borehole geophysics survey will include:

- Record all information necessary to correctly interpret the log including:
  - Well identification number
  - Project number
  - Client bit size (or borehole diameter)
  - Casing size
  - Location of the zero-depth of the log, which may be the top of the casing, ground level, or some other specified point
  - Height of the top of the casing above ground level
  - Depth of the bottom of the casing(s)
  - Total depth drilled
  - Date of logging
  - Logging engineer
  - Logging speed
  - Sensitivity range setting(s)
  - Calibration and standardization data
  - Logging tool serial numbers
  - Any additional pertinent information

- Record the source-to-detector distance for nuclear radiation tools and the focusing width for focused resistivity tools.
- In resistivity logging, sample the drill hole fluid and record its resistivity so that true resistivity for the strata can be calculated.
- Clearly record calibration and standardization marks on all logs to demonstrate the relationship between the log scale and standard calibration procedures.
- Assemble the downhole logging tool.
- Decontaminate logging tool and cable if necessary.

Electromagnetic-induction logs record the electrical conductivity or resistivity of the rocks and water surrounding the borehole. The conductivity and resistivity are dependent on the porosity, permeability, and clay content of the rocks and by the dissolved-solids concentration of the water within the rocks. The electromagnetic-induction probe is designed to maximize vertical resolution and depth of investigation and to minimize the effects of the borehole fluid.

A calibration certificate for the induction logging will be provided.

5.2.3.3 Gamma Logging

Gamma logs detect the amount of natural gamma radiation emitted by the rocks surrounding the borehole. Naturally occurring sources of gamma radiation are potassium-40 and daughter products of the uranium- and thorium-decay series. Clayey and shaley rocks typically have higher gamma radiation due to their composition of weathering products of potassium feldspar and mica.

The natural gamma probe utilizes a sodium-iodide, thallium activated crystal to measure gamma-ray emissions from soil or rock. The method can be used in uncased, steel-cased, or PVC-cased holes and is used for stratigraphic correlation between boreholes. The instrument continuously measures, in counts per second, gamma-rays emitted primarily from uranium, potassium-40 and thorium.

This sensor is integrated in both the EM induction and neutron probes.

Natural gamma measurement detects natural gamma radiation occurring in lithology and is recorded in counts per second. This log, which exhibits relative changes in natural (or man-made) radiation, is used for general lithologic identification and stratigraphic correlation. Natural occurring radiation comes from three principal areas: potassium-40, which occurs with all potassium minerals; uranium-238; and thorium-232, which is associated primarily with biotite. The typical radius of investigation for the natural gamma log is approximately 10 to 12 inches from the borehole wall.

Gamma logs detect the amount of natural gamma radiation emitted by the rocks surrounding the borehole. Naturally occurring sources of gamma radiation are potassium-40 and daughter products of the uranium- and thorium-decay series. Clayey and shaley rocks typically have higher gamma radiation due to their composition of weathering products of potassium feldspar and mica.

Gamma (natural radiation) measurement units, such as counts per second, inches of deflection, or standard units will be noted on the log scale. A calibration certificate for the gamma will be provided.

5.2.3.4 Neutron Logging

Neutron logs map porosity by emitting high energy neutrons. The compensated neutron measurement uses two helium-3 (He-3) proportional detectors and a detachable, sealed neutron source. Fast neutrons emitted by the source are scattered and slowed by light elements (and principally hydrogen in the formation) until they reach thermal energy levels. The ratio of the flux of thermal neutrons reaching the near and far detectors depends on the formation's Hydrogen Index and porosity. The porosity can be calculated in real-time or post- logging. The probe is 60 mm in diameter and 1.94 meters long.

Neutron logging is typically used to identify porous formations and lithology, identifying perched layers and evaluating water saturation in vadose zones.

Note that neutron logging uses an active radioactive source.

The neutron measurement is a single function radiation probe which detects thermal neutrons using a He-3 detector. An americium-241 (beryllium-activated americium-beryllium-241 [AmBe-241]) neutron source emits high energy (fast) neutrons into the formation. These neutrons diffuse through the formation and collide with the atoms present. Collisions with atoms nearest the mass of neutrons, such as hydrogen, results in an exchange of energy. Thus, these neutrons are slowed down to thermal energies which can be detected by the He-3 detectors. Since slowing is primarily due to collisions with hydrogen, neutron count rates represent the hydrogen content of the formation and can be interpreted in terms of porosity. This measurement can be compensated by using two different source-detector spacings and taking the ratio of these measurements.

The neutron measurement uses a 1 or 3 curie AmBe-241 radioactive source. The neutron log can be presented in counts per second or porosity units. A casing collar locator measurement is a standard addition to the neutron log for well work.

Neutron logging is based on formation porosity and liquid filled pores. The necessary containers and safeguards for the transportation, storage, and use of nuclear source(s) will be provided. The operator will be properly trained, certified, and maintain the required licenses to handle nuclear source(s). Work will complete with all federal and state requirements for the use of active-source tools.

5.2.3.5 Logging System

A Mount Sopris MGX digital logger will be used. This facilitates interchanging probes as well as allowing the data to be collected on a DOS-based field notebook as the winch raises and lowers the probe. The logging system will be equipped with a 0.1- or 0.125-inch steel, armored, single conductor cable long enough to log 600-ft depths.

5.2.4 Pre-Logging Requirements

Pre -logging activities include drilling and mobilization of the logging unit by the logging contractor to the borehole locations.

The following are basic pre-logging requirements:

- Boring logs will be prepared for each borehole during drilling for instantaneous comparison to the wireline logs. Zones of extensive circulation, lost circulation, suspected washouts, or drilling problems will be noted for anticipation of possible log response.
- Hole deviations will be recorded on the appropriate form(s) if directional surveys were run.
- A diagram will be drawn or one will be available from the logging contractor with the dimensions of every tool going into the hole. This will be provided at the beginning of the field program. A tool status report will be onsite for all tools plus spares.
- All logging equipment will be properly decontaminated before arrival onsite, between wells, and before leaving the site. The equipment will be decontaminated according to Section 5.3.7 of this work plan.
- If the logs are to be run in cased holes, it may be useful to sound the boring or cased hole with a dummy (of the same dimensions as the logging tool) to make sure the tool will not stick in the casing. This is especially useful for small-diameter PVC casing, which may flex when it is set in the borehole.
- For open-hole logging, the drilling contractor will circulate and condition the borehole appropriately to aid the geophysical logging of the hole. Such requirements will be discussed with the driller in the briefing.
- Just prior to logging, a mud sample will be circulated from the bottom of the hole and measured for the resistivity of the drilling mud, mud cake, and mud filtrate. The geophysical logging subcontractor will supply the mud meter and conduct the measurements.

5.2.5 Logging Requirements

The basic borehole geophysical logging process consists of the following:

1. After mobilization to the borehole and decontamination of the equipment, the contractor connects the first tool to be run to the cable.
2. The contractor then checks to ensure the equipment is functioning properly and conducts the "before" logging calibration check. The calibration results are checked to ensure that they are within appropriate tolerances.
3. The tool is attached to the cable and then suspended over the borehole. (Note: sometimes the calibration is conducted while the tool is suspended over the hole.) The contractor checks to ensure that all equipment is still functioning properly and then lowers the logging tool into the borehole/casing.
4. While the tool is lowered to the bottom of the hole, a down-log is generated.
5. Once the tool is at the bottom of the hole, the down-log is checked; the instruments are appropriately adjusted, the scales are set for proper response, and the logging speed is adjusted, as necessary.
6. The logging tool is then run up the hole at the proper speed and the up-log is generated.
7. Once the up-log is completed, the tool is run back down the hole for 100-ft intervals and a repeat log will be run for QC purposes.
8. Field copies of the main and repeat logs are generated. The repeat log is checked for appropriate quality and repeatability.
9. If the main log is of appropriate quality and if the repeat and main log are in required agreement, the "after" calibration of the logging tool is then run. The calibration results are checked to ensure that they are within appropriate tolerances.
10. The tool is then removed from the cable.

- If another tool is to be run, the process above is repeated. If not, then the logging unit and associated tools and equipment are rigged down. The tools and equipment are decontaminated before leaving the site.

The following required items are necessary for effective implementation of the logging process and generation of useful logs of appropriate quality:

- The pullout strength of the cable socket, which connects the tool to the cable, will be known before entry into the hole.
- Calibration procedures, both in the shop and in the field, must be performed. The time and results of the last shop calibration for each tool must be documented.

- Field calibrations are run just prior to logging and recorded on the log tails or header.
- When logging tools are run in combination, all curves are to be on the same depth.
- A thermometer will be used on the first logging run of each logging trip, to record the maximum hole temperature, or a temperature probe will be run to the bottom of the borehole.
- Depth control must be used on each run. For multiple (i.e., successively deeper) logging runs in the same borehole, the later (deeper) run will be tied into the previous run. Accuracy will be within 1 foot. If there is a discrepancy, tie into the previous run and note the discrepancy on the log heading. When the tie-in is behind casing, run a gamma-ray log to overlap the tie-in. Never tie into the driller's reported casing depth.
- If logging tools are run in combination, make sure that all curves are on the same depth. If sand or gravel is present at the base of the well, make sure the driller drills a rat hole deep enough so as to provide enough depth for the log's first readings to be in the sand or gravel.
- Down-logs will be recorded as each tool is run down the hole. This will provide an opportunity to properly adjust the instruments and provide for proper scaling of the up-log responses. Logging speed will be selected to give good thin bed resolution and proper log quality.
- Repeat sections will be run on all logging runs. The repeat sections will be chosen to cover zones of particular interest or at least 100 ft. The curves from the repeat and original logs will then be checked. Electrical curves will overlay exactly, while nuclear logs will have statistical variations (usually no more than one chart division).
- For multiple logging runs (i.e., successively deeper runs in the same borehole), the later (deeper) runs will be logged up into the casing. Overlay at least 100 ft of all previous logging runs and compare. Reproducibility should result.

Attention to detail during borehole geophysical logging, including equipment setup, calibration, and monitoring, is required for obtaining accurate and reliable data. Borehole geophysical logs are subject to a number of potential tool problems and operational errors. The QC geophysicist will be present during the entire logging operation to provide constant monitoring of the logs and subcontractor and keep consistent, accurate records. Any and all problems (including tool malfunction and significant downtime) and associated corrective actions will be recorded by the geophysicist conducting oversight on the appropriate form(s) according to the project work plans.

A field copy of the log will be provided to the rig geologist immediately after completion of the logging run. The geophysicist will review the log and check the cures for excessive drift, spikes, or noise; lack of completeness; and any other potential problems. Borehole washouts (identified on the boring logs and/or caliper log) will be identified and compared with the log curves. Any problems observed on the logs will be brought to the attention of the contractor and corrected.

The logs will be completed to the satisfaction of the Site Supervisor before the logging contractor is allowed to rig down. Final approval for acceptance of the quality of the log will rest with the QC geophysicist.

For field logs (and final logs), all off-scale readings, drift adjustments, and first curve readings will be marked on the logs, and all curves identified and labeled. All after (post-logging) field calibrations must be run for each tool and recorded on the log tails or headers. These will be checked with the pre-log calibrations, noting any changes.

Heading information will be thoroughly filled out, including equipment and calibration date. Type, temperature, and resistivity of any fluids and other associated measured parameters will be recorded. All scales and scale changes will be clearly identified. Any unusual conditions, problems, or concerns regarding the logging run are to be included in the remarks section. Logging speeds, time constants, and tool numbers are to be correctly recorded.

5.2.6 Post-Logging Requirements

A predetermined number of final log prints will be provided within 2 weeks of completing the final logging run, including the final composite logs. Any and all information required for entry on the field logs above will be included on the final log prints.

5.2.7 Reporting

5.2.7.1 Daily Field Reports

Field record of the operation of site activities, including boreholes logged and support activities such as equipment decontamination will be available to the Site Supervisor at the completion of each day's work.

As a minimum, the following data will be included in the daily reports:

- Dates and times of beginning and completion of work;
- A list of employees at the site and their work locations (borehole number);
- The number and location of boreholes logged, including depth or total logging footage performed;
- A list of major onsite equipment and location (borehole or equipment decontamination location); and
- Any problems encountered, including standby time recorded.

5.2.7.2 Final Report

Three copies of the paper strip logs and report and digital (MSWord [text], PDF [figures], ASCII [logging data]) copies, on compact disk, will be provided. Each log title block will include as a minimum the borehole number, probe type, module adjustments, logging speed, depth footage (vertical scale), horizontal units and scale, depth to groundwater and calibration(s). The report will include field and data processing procedures, figures representing the data, and an interpretation minimally identifying relatively more permeable zone, stratigraphy, and structure as applicable.

5.2.8 Technical Review

All borehole geophysical logging plans, scopes-of-work, field procedures, field quality control documentation, logs, and associated reports will undergo technical review by a geophysicist.

The technical review, at a minimum, will consider and evaluate the following pre-logging items:

- Data collection objectives and requirements
- Site geology
- Scope-of-work
- Vendor qualifications and equipment
- Field procedures

The post-logging technical review will consider and evaluate the following minimum items:

- Field documentation, including problems encountered and corrective actions taken,
- Equipment calibration/certification,
- Review and quality of the logs relative to the requirements and the project work plans, and
- Calculations and data interpretation.

Any issues raised during the pre-logging technical review will be resolved between the reviewer and staff planning the program before conducting the logging. Issues raised during the post-logging review will be resolved before external submission of the results. The technical review comments and issues, and corresponding resolution, will be documented and filed with the project records.

5.2.9 Borehole Geophysics Equipment Decontamination

All downhole logging equipment and materials will require decontamination before use, between each borehole, and before demobilization. Equipment will be thoroughly decontaminated between boreholes. All equipment will be cleaned before mobilization.

5.2.10 Soil Borings/Drilling

A total of 35 soil borings will be advanced to approximately 450 ft bgs. Each boring at each location will be drilled from the surface to the water table, and completed as a permanent soil-gas monitoring well. Figure 5-1 shows the locations. The following is a summary of the soil borings for each area:

- **Tank Farm -** Eight deep and five shallow soil borings/soil-vapor wells will be completed in the tank farm area. Depending on what is found, additional soil borings/soil-vapor wells may be needed. Eight deep soil borings to 450 ft and five shallow soil borings to a depth of at least 20 ft will be completed at Tank Farm locations (Figure 5-1).
- **Pipeline -** The pipeline that runs between the tank farm, the pump house, and the FFOR has not been investigated. Five deep soil borings/soil-vapor wells will be completed along the buried and exposed portions of the pipeline. Five deep soil borings/soil-vapor wells will be completed to 450 ft. Figure 5-1 shows locations of soil boring/soil-vapor wells.

- **Former Fuel Offloading Rack -** Six deep soil borings/soil-vapor wells will be completed at the FFOR to determine the full extent of contamination. Soil borings/soil-vapor wells will be completed at the locations shown on Figure 5-1.
- **Fuel Percolation Area -** Eight deep soil borings/soil-vapor wells will be completed in order to significantly improve characterization of this area. The eight soil borings/soil-vapor wells locations are shown on Figure 5-1.
- **Farfield Area of Soil-Vapor Plume -** Eight soil-vapor wells will be completed at locations north of the Fuel Offloading Rack and the fuel percolation area to investigate the concentrations of hazardous constituents in soil gas that overlies groundwater in these areas. Soil-vapor well locations are shown on Figure 5-1.

Each well boring will be tested for utility clearance to 5 ft with a hand-auger or post-hole digger. Borehole advancement (drilling) will be performed using the air-rotary casing hammer (ARCH) method. The ARCH method uses steel insulator casing, advanced with drill bit/rod, to prevent borehole collapse. Deep vadose zone wells will be installing a nest of 6 wells screened at different intervals (25, 50, 150, 250, 350, and 450 ft bgs). The deepest well (450 ft bgs) will to be a 2-inch PVC well and the remaining will be ¾ inch wells. Each borehole will be drilled as a 10 ¾ outside diameter (O.D.) casing that telescopes down to 9 5/8 O.D. casing at 200 ft.

Borehole drilling equipment will be thoroughly decontaminated between boreholes. All soil cuttings will be placed into the provided roll-offs. All soil and solid wastes resulting from drilling and sampling activities will be contained in roll-off bins and all liquid will be contained in U.S. Department of Transportation (DOT) approved, 55-gallon drums. All drums containing wastewater will be transported to a central location on Kirtland AFB.

Geologic logs will be prepared for each borehole showing relative to borehole depth the rock types, thickness of rock units, and water-bearing zones (including that at and below the water table). The name of the borehole, location of the borehole, the date(s) that the borehole was completed, the drilling method, and the elevation of the top of the borehole will also be noted on the boring log. The data will be provided to the NMED in both hard copy and in digital format. See Section 5.2.8.1 for details regarding logging.

The following elements regarding soil borings will be followed:

- All drilling will conform to state and local regulations. Permits, applications, and other documents required by state and local authorities will be obtained.
- Locations of all borings will be approved in writing by the NMED before drilling begins.
- The drill rig will be decontaminated in accordance with SOP B1.11 (Equipment Decontamination). Use of disposable equipment is preferred. If disposable equipment is unavailable, use of decontaminated equipment is allowed. Equipment will be decontaminated per the requirements of SOP B1.11. All sampling equipment which may not be decontaminated will be disposed of in accordance with the project-specific addenda to the Waste Management Plan (Appendix C).
- 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.
- Surface water and extraneous materials will not enter the boring.
- All trash and drill cuttings will be disposed.
- Before digging begins a digging permit, the 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. The work clearance request is processed just before 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

Activities associated with borehole advancement (drilling), equipment decontamination, handling of investigative-derived waste (IDW), and borehole abandonment (if required) will be performed in accordance with the *Base-Wide Work Plans for Investigation under the Environmental Restoration Program* (Tetra Tech, 2004) and is discussed in the following sections.

5.2.10.1 Borehole Logging

Each boring will be fully described on a boring log similar or equivalent to that shown in Appendix D, Form 1 and in accordance with ASTM D5434 *(Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock*). The rig geologist will log the boring as it is being drilled by recording relevant data, listed below, on either the boring log.

Data to be included in the logs, as applicable, are:

- The identifying number and location of each boring will be noted.
- All measurements will be accurate to one-tenth of a foot.
- Drilling logs and other scaled drawings will be drawn at a scale of 1 inch = 1 ft. (Note: for wells deeper than 200 ft, 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).
- Soils will be classified in accordance with the Unified Soil Classification System (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.
- A full description of soil samples will be made. 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 and the type and number of each sample taken will be indicated. 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 will be indicated, as well as hammer weight and length of fall for split-spoon or driven samplers; and 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 will be noted, 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, will be noted. Any distinct water-bearing zones below the first zone also will be noted. Other observations during drilling will 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 will be provided. 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 will be indicated.
- The names of the contractor, driller, and rig geologist will be noted.
- The size and length of casing or auger used in each borehole will be noted.
- Observations of visible contamination for each sample or from contaminated cuttings will be made.
- Field instrument readings will be noted.

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 soil that 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 soil 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 will develop and record an appropriate description for each defined stratigraphic unit. Each description will 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 will be written directly on the boring log (if there is enough space) or in a field logbook. The method of deriving the classification will be described, or reference to this guideline or other manuals will be made. Handling of samples during soil classification will be coordinated with chemical sampling activities, if appropriate.

USCS Classification

Soils are to be classified according to the USCS (ASTM D2488-09a, *Standard Practice for Description and Identification of Soils [Visual-Manual Procedure]*). This method of classification is detailed in Appendix D, Form 2. This classification method 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 soil, or fines, are classified as those which will pass through a No. 200 U.S. standard sieve (0.074 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 a common component of soil but has no size range, and is recognized by its composition.

Gravely soil is identified by a “G” as the first letter in the two-letter symbol, whereas sandy soil is identified with an “S.” The term, “rock fragments,” will 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 will 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 will 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 soil, or the plasticity characteristics of fine-grained soil. 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 will be described using 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 used 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 will 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 D1535-08e1 (*Standard Practice for Specifying Color by the Munsell System*), 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 soil contains predominantly sands and gravels and are generally non-cohesive (particles do not adhere well when compressed). Finer-grained soil (silts and clays) is cohesive (particles will adhere together when compressed).

The density of non-cohesive, granular soil is classified according to standard penetration resistances obtained from split-spoon sampling methods that are in accordance with ASTM D1586-08a (*Standard Test Method for Standard Penetration Test [SPT] and Split-Barrel Sampling of Soils*) and are detailed in SOP B2.3 (Subsurface Soil Sampling, 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 O.D., 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 the number of blows is recorded for each 6-inch increment. The density designation of granular soil 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 will be noted on the log and referenced to the sample number.

The consistency of cohesive soil is determined by performing field tests and identifying the consistency as shown in Appendix D, Form 2. The consistency of cohesive soil is determined either by blow counts or most accurately by a pocket penetrometer or field Torvane device in accordance with ASTM D2573-08 (*Standard Test Method for Field Vane Sheer Text in Cohesive Soil*). The SPR can be applied to cohesive soil 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 will 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 conjunction with blow counts to determine cohesive soil consistency.

Soil Component

In nature, soil is comprised of particles of varying size and shape and are combinations of the various soil types. Appendix D, Form 2 lists grain size classifications to be used in describing soil 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
Most	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 D2216-10 (*Standard Test Methods for Laboratory Determination of Water [Moisture] Content of Soil and Rock by Mass*) or field tests for water content will 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 Approximate English(Metric) Equivalent Classification

Metric	**English**	**Classification**
>1 meter	> 3.3 ft	Very thick
30 centimeter (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

5.2.11 Soil Vapor Monitoring Wells

Thirty-five “nested” soil vapor monitoring wells will be installed in soil borings. Soil boring/soil-vapor monitoring well locations are shown on Figure 5-1. Each nested well location will include six individual (one 2-inch diameter and five 3/4-inch diameter), schedule 80, PVC soil vapor monitoring wells installed in the same borehole. The nested wells will include a 10-ft length of machine slotted (0.050-inch) screen. Anticipated depths of the nested wells will be 25-, 50-, 150-, 250-, 350-, and 450-ft bgs. Actual well depths may vary and are dependent on lithology observed during the advancement (drilling) of each borehole (e.g., screens will be placed in transmissive zones). Clays will be avoided. If proposed vapor monitoring points are screened in zones determined to be fine grained lithologic, the screen vapor monitoring point will be adjusted up or down to the nearest coarser grained unit if the unit is located within 20 feet of the proposed screened interval. If there is no coarser grained interval located within the 20 feet of the proposed screened interval, the screen vapor point will be installed as originally proposed. (Fine grained units are defined as units coarser than ML or CL as presented in the United Soils Classification System.) If a large deviation is required, the NMED will be notified in writing of the deviation. Filter pack (sand) will be placed around the lowest nested well screen followed by a fine sand seal. A bentonite chip seal will extend from the top of the fine sand seal to just below the screen for the next lowest well. This process will be completed for each nested well screen/riser pipe. Surface completions of the nested wells will be within steel flush-mount protective covers (manholes) with gasketed bolt-down covers. The bentonite seal for the highest well will extend to the base of the protective cover skirt. Bentonite chip seals will be hydrated in lifts using a “clean” water source. A typical SVM well installation is shown on Figure 5-2.

The SVM nests will be constructed using ¾-inch diameter, flush threaded, Schedule 80, PVC casing and 10 ft of 0.050- inch factory slotted screen. An engineered filter 8/10 graded pack will be installed in the annular space between the riser/screen and the borehole from 1 ft below to 1 ft above the screened interval. The filter pack will be slurried with clean potable water and tremied into place to prevent bridging and to ensure continuous placement, while the drive casing is slowly removed. A 10-ft hydrated bentonite seal will be emplaced above the sand filter pack and incrementally hydrated with potable water in 1-ft lifts. After the last lift has hydrated for 2-hours, a high solids bentonite grout will be emplaced by tremie pipe to 1 ft below the next higher point, except for the 25-ft sample point. The 25-ft sampling point will have a bentonite-cement grout placed above the seal extending to within 1.5 ft of the surface. Each sampling string will be marked to identify the screen depth as it has been emplaced. The nest will be completed as a surface completion with a 4- x 4-ft concrete pad, sloped to direct runoff away from the well. Surface completions of the nested wells will be within steel flush-mounted. protective covers (manholes) with gasketed bolt-down covers, and each sample string will be fitted with an adaptor and push-to-connect for ¼-inch tubing for connection to the vapor sampling device.

Activities associated with soil vapor monitoring well installation will be performed in accordance with the *Base-Wide Plans for Investigations Under the Environmental Restoration Program, Kirtland Air Force Base* (Tetra Tech, 2004), the site-specific UFP-QAPP, and other pertinent site documents.

If a soil vapor well is installed as a permanent monitoring point, the well will not be sampled before the expiration of the 24-hour equilibration period following completion of installation. Information on the design and construction of SVM wells will be recorded as with groundwater monitoring wells as applicable.

SVM wells will be designed and constructed in a manner that will yield high quality samples. The design and depth of installation will be approved by the NMED.

5.2.12 Borehole Abandonment

If needed, all borehole abandonment procedures will be performed in accordance with all federal, state, and local regulations. Well abandonment will be supervised by a qualified geologist or hydrogeologist and the details recorded on the Well/Borehole Abandonment Form as shown in Appendix D, Form 3.

Unless otherwise specified, monitoring wells will be abandoned as described below:

- Prior to abandonment, the borehole or well will be probed to determine the total open depth of the hole or well casing, respectively. Water level measurements will also be measured and recorded.
- All stainless steel or steel existing well casings will be completely removed or drilled out to the total depth of the well to avoid groundwater contamination due to corrosion. PVC casings may remain in place.
- A plugging material consisting of one or a combination of the following materials will be used:
  - Neat cement with not more than 5 percent by weight of bentonite;
  - Bentonite slurry (which can include polymers designed to retard swelling);
  - High solids grout ; or
  - Pelletized medium grade or crushed bentonite.
- Cement and bentonite slurries will be pumped into place in a continuous operation with a grout pipe introducing the plugging material at the bottom of the well and moving the pipe progressively upward as the well is filled. This method will be repeated to within 2 ft bgs unless otherwise specified.
- The well casing will be severed at least 2-ft bgs, if not required to be completely removed, and a cement plug larger in diameter than the well bore will be constructed over the well bore and completed flush with the ground surface.
- When using pelletized or crushed bentonite, the bentonite will be poured down the hole in 3- to 5-ft lifts and hydration using clean potable water between lifts. This method will be repeated to within 2 ft bgs unless otherwise noted.

5.3 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. Kirtland AFB Base-

Wide SOP B.1-11 (Equipment Decontamination) will be used by field personnel 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.

5.3.1 Handling and Containers for Cleaning Solutions

Improperly handled cleaning solutions may easily become contaminated, thereby jeopardizing the validity of the sample data. Containers will be constructed of the proper materials to ensure their integrity.

The following containers will be used for storing the specified cleaning materials:

- Soap—Keep in clean containers until use. It will 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.

5.3.2 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 will 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 an 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 that come in direct contact with the media being sampled also will be washed as described above. Specific decontamination instructions will be included in project-specific addenda.

- Rinse with potable water.
- Perform this decontamination procedure before equipment is used and between each well or other sampling locations.

5.3.3 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 Waste Management Plan (Appendix C). Personnel directly involved in equipment decontamination will wear appropriate personal protective equipment (PPE) as specified in the SSHP.

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

5.3.4 Construction of a Decontamination Pad

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

- The pad will be constructed in an area known or believed to be free of surface contamination.
  A temporary pad will be lined with a water impermeable material with no seams within the pad. The material will be either easily replaced (disposable) or repairable.

- The location of the pad will be out of the work zone and situated not to interfere with other work in progress.
- The pad will not leak excessively. Any sump or pit will be lined.
- Sawhorses or racks constructed to hold equipment while being cleaned will be high enough above the ground surface to prevent equipment from 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.

5.3.5 Personal Protective Equipment

Personnel directly involved in equipment decontamination will wear appropriate PPE as specified in the SSHP, which was provided under separate cover (Shaw, 2010). Appropriate PPE will be selected based on the level of contamination present or suspected at the site. Care will be taken so the selected PPE protects decontamination workers from unnecessary contact with soil 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 will also be worn.
- No eating, smoking, drinking, chewing, or any hand-to-mouth contact will be permitted during cleaning operations.
- Field equipment decontamination will be conducted in accordance with ASTM D5088-02(2008) (*Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Site*) requirements and ASTM D5608-10 (*Standard Practices for Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites*) as applicable.

5.4 Investigation-Derived Waste

All IDW will be handled in accordance with the project-specific Waste Management Plan provided in Appendix C. In general, all soil cuttings generated by the drilling of soil borings will be containerized in roll-off containers at the drilling location. Composite soil samples will be collected from each roll-off for waste disposal characterization. Water produced from sampling will be containerized and characterized for waste disposal. All PPE (e.g., sampling gloves) will be disposed with municipal waste.

6. MONITORING AND SAMPLING

All soil and soil gas samples and geophysical data collected during the field effort will support delineation of lateral and vertical distribution of volatile organic compounds (VOCs) that volatize from LNAPL in the subsurface, either as residual masses in the soil or from the floating pool at the water table. This information will be used to refine the conceptual site model and to determine the requirements of the shallow/intermediate SVE system.

The USACE will notify the NMED no less than 15 days before field sampling or other field activities and will provide the NMED the opportunity to collect split samples upon request. In addition, the NMED will be notified in writing a minimum of 15 days before implementation of this Vadose Zone Investigation Work Plan.

6.1 Soil Sampling

Soil samples collected during the drilling of SVM wells will be analyzed to estimate the amount of residual fuel adsorbed to soil, as soil gas and as residual liquid in the soil. The following bullets summarize soil sampling that will be performed to further characterize the vadose zone in areas needing further investigation. See Table 5-1 for details on sampling and Figure 5-1 for location.

- **Tank Farm** - Soil samples from the five shallow borings will be collected at depths of 0, 5, 10, 15, and 20 ft. Soil samples from eight deep borings will be collected at a frequency of at least one sample every 10 ft for the first 50 ft, and at least one sample thereafter every 50 ft to total depth, and at least one sample at total depth in each boring. These samples will be analyzed for VOCs, semivolatile organic compounds (SVOCs), volatile petroleum hydrocarbons (VPH) and extractable petroleum hydrocarbons (EPH) (Massachusetts Department of Environmental Protection [MA DEP], 2004a, 2004b), and lead.
- **Pipeline** - Soil samples from five deep borings will be collected and analyzed for VOCs, SVOCs, VPH, EPH, and lead. Soil samples from the deep borings will be collected at a frequency of one sample every 10 ft for the first 50 ft, and one sample thereafter every 50 ft to total depth, and at least one sample at total depth in each boring.

- **Former Fuel Offloading Rack -** Soil samples from six deep borings will be collected and analyzed for VOCs, SVOCs, VPH, EPH, and lead. Soil samples from the deep borings will be collected at a frequency of one sample every 10 ft for the first 50 ft, and one sample thereafter every 50 ft to total depth, and at least one sample at total depth in each boring.
- **Fuel Percolation Area -** Soil samples from eight deep borings will be collected and analyzed for VOCs, SVOCs, VPH, EPH, and lead. Soil samples from the deep borings will be collected at a frequency of one sample every 10 ft for the first 50 ft, and one sample thereafter every 50 ft to total depth, and at least one sample at total depth in each boring.
- **Farfield Area of Soil-Vapor Plume -** Soil samples from eight deep borings will be collected and analyzed for VOCs, SVOCs, VPH, EPH, and lead. Soil samples from the deep borings will be collected at a frequency of one sample every 10 ft for the first 50 ft, and one sample thereafter every 50 ft to total depth, and at least one sample at total depth in each boring.

In addition, soil samples containing LNAPL will be sent to the laboratory and analyzed for TPH, VOCs, SVOCs, and lead.

Soil samples will be collected using split-spoon samples at 10-ft intervals to 50 ft and at 50-ft intervals, and at changes in lithology to the total depth and at least one sample at total depth in each boring. The soil samples, and soil samples (drill cuttings) collected from the drill rig “cyclone”, will be lithologically logged and field screened for VOCs using a photoionization detector (PID) as specified in the Kirtland AFB Base-Wide SOP B3.1, *Photoionization Detectors and Organic Vapor Analyzers*. “Drill cutting” samples will be collected at 5-ft (minimum) intervals and at changes in lithology and/or color. PID readings will be used for health and safety purposes and will be submitted to the laboratory with samples for chemical analysis, as an indicator of relative contaminant levels for use by the lab.

For soil samples collected for VOC analysis, the samples will be collected from the sampler before lithologic logging and any disturbance to the sample core. Sample collection for VOC analyses will be in accordance with EPA SW-846 Method 5035 and the NMED requirements. Samples will be collected using EnCore (or similar type) 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) then discrete grab samples will be collected in a 4-ounce jar and prior to homogenization with as little disturbance as possible.

6.1.1 Split-Spoon Sampling Procedure

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

- Samplers will wear appropriate PPE as outlined in the SSHP. In addition, samplers will don new sampling gloves at each location.
- Boreholes will be drilled to the desired sampling depth. Split-spoon will be driven into the undisturbed soil that is to be sampled.
- A stainless-steel, 2-inch (or 3-inch) O.D. split-spoon sampler will be driven with blows from a 140 pound (or 300-pound) 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 D1586-08a, Standard Test Method for Standard Penetration Test [SPT] and Split-Barrel Sampling of Soils). 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 in accordance with ASTM 1557-09 (Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort). Shelby tubes can be used when cohesive materials are encountered, and when an undisturbed sample is required for testing.
- The number of blows required for each 6 inches of penetration or fraction thereof will be recorded.
- 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 will be entered on the log.
- The sampler will be brought to the surface and both ends and one-half of the split-spoon removed so that the recovered soil rests in the remaining half of the barrel. The split-spoon will be placed on clean polyethylene sheeting. The approximate recovery (length), USCS classification, composition, color, moisture, etc., of the recovered soil will be described thoroughly. A copy of a typical bore log form is shown in Appendix D, Form 1.
- NOTE: If soil samples are being collected for VOC analysis, those samples will be collected from the sampler before lithologic logging and any disturbance to the sample core.
- Sample collection for VOC analyses will be in accordance with EPA SW-846 Method 5035 and the NMED requirements. Samples will be collected before homogenization from the split-spoon core, using EnCore (or similar) samplers.

- The remaining contents of the split-spoon will be entered into a disposable sample tray/pan or decontaminated stainless-steel pan. Samples will be homogenized according to procedures specified in Kirtland AFB Base-Wide SOP B2.5, Sample Homogenization. The remaining jars will be filled with soil using stainless-steel spatulas or spoons.
- The split-spoon sampler will be decontaminated in accordance with the procedures outlined in Kirtland AFB Base-Wide SOP B1.11 Equipment Decontamination.
- Analytical samples will be placed in a sample cooler and chilled to 4°C. Samples will be shipped to the laboratory within 24 hours.
- The field logbook, sample log sheet, labels, custody seals, and chain-of-custody forms for analytical samples will be filled out.
- Work will be conducted in accordance with other applicable requirements such as:
  - ASTM D1452-09 (Practice for Soil Exploration and Sampling by Auger Borings);
  - ASTM D1586-08a (Standard Test Method for Standard Penetration Test [SPT] and Split-Barrel Sampling of Soils); and
  - ASTM D4220-95(2007) (Standard Practices for Preserving and Transporting Soil Samples).

Soil samples collected for the purpose of analyzing for VOCs and TPH-gasoline range organics (GRO) will not be mixed to homogenize samples for any reason. All collected soil samples will be analyzed by a DoD Environmental Laboratory Accreditation Program (ELAP)-certified laboratory. The remaining portions of the sample will be used for field screening and logging.

Activities associated with soil sampling, equipment decontamination, handling of IDW, lithologic logging, and field screening will be performed in accordance with the Kirtland AFB *Base-Wide Plans for Investigations Under the Environmental Restoration Program, 2004 Update,* as discussed in Section 5.

Soil samples (drill cuttings) will be collected from the ARCH drill rig “cyclone” on representative 5-ft centers, and at changes in lithology/color, during advancement of each of the 40 boreholes. A geologist will lithologically log the samples and field screen them for VOCs using a PID. Because the ARCH drilling method uses air to lift cuttings from the borehole and creates varying amounts of friction heat, some of the VOCs will be driven off before field screening. Therefore, PID readings will primarily be used for health and safety purposes. These readings may also distinguish areas of no/low contaminant concentrations from those of gross/higher concentrations on a qualitative basis, but will not be used in any decision making process.

Table 6-1 lists sample requirements for analytical testing, including sample containers, preservation, and holding time for each parameter.

Activities associated with soil sampling, equipment decontamination, lithologic logging, field screening, and IDW handling will be performed in accordance with *Base-Wide Plans for Investigations Under the Environmental Restoration Program, 2004 Update* and other pertinent site documents.

6.1.2 Sampling Equipment Decontamination

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 on to 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 (Appendix C). Personnel directly involved in equipment decontamination will wear appropriate PPE as specified in the SSHP.

6.2 Standards for Subsurface Soil Sampling

Soil samples being collected for VOC analysis, those samples will be collected from the sampler before lithologic logging and any disturbance to the sample core.

Sample collection for VOC analysis will be in accordance with U.S. EPA SW-846 Method 5035 and the NMED requirements. Samples will be collected using EnCore (or similar type) 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), then a discrete grab samples will be collected in a 4-ounce jar, and before homogenization with as little disturbance as possible.

6.2.1 Split-Spoon Sampling Procedure

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

- Samplers will wear appropriate PPE as outlined in the SSHP. In addition, samplers will don new sampling gloves at each location.
- Boreholes will be drilled to the desired sampling depth. Split-spoon will be driven into the undisturbed soil that is to be sampled.
- A stainless-steel, 2-inch (or 3-inch) O.D. split-spoon sampler will be driven with blows from a 140 -pound (or 300-pound) 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 D1586-08a, *Standard Test Method for Standard Penetration Test [SPT] and Split-Barrel Sampling of Soils*). 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 in accordance with ASTM 1557-09 (*Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort)*. Shelby tubes can be used when cohesive materials are encountered, and when an undisturbed sample is required for testing.
- The number of blows required for each 6 inches of penetration or fraction thereof will be recorded.
- 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 will be entered on the log.

- The sampler will be brought to the surface and both ends and one-half of the split-spoon removed so that the recovered soil rests in the remaining half of the barrel. The split-spoon will be placed on clean polyethylene sheeting. The approximate recovery (length), USCS classification, composition, color, moisture, etc., of the recovered soil will be described thoroughly. A copy of a typical bore log form is shown in Appendix D, Form 1.
- NOTE: If soil samples are being collected for VOC analysis, those samples will be collected from the sampler before lithologic logging and any disturbance to the sample core.
- Sample collection for VOC analyses will be in accordance with EPA SW-846 Method 5035 and the NMED requirements. Samples will be collected before homogenization from the split-spoon core, using EnCore (or similar) samplers.
- The remaining contents of the split-spoon will be entered into a disposable sample tray/pan or decontaminated stainless-steel pan. Samples will be homogenized according to procedures specified in Kirtland AFB Base-Wide SOP B2.5 (Sample Homogenization). The remaining jars will be filled with soil using stainless-steel spatulas or spoons.
- The split-spoon sampler will be decontaminated in accordance with the procedures outlined in Kirtland AFB Base-Wide SOP B1.11 (Equipment Decontamination).
- Analytical samples will be placed in a sample cooler and chilled to 4°C. Samples will be shipped to the laboratory within 24 hours.
- The field logbook, sample log sheet, labels, custody seals, and chain-of-custody forms for analytical samples will be filled out. Example copies of these forms are included in the UFP-QAPP prepared for this investigatory work (Appendix E).

6.2.2 Field Quality Control

Field QC samples will be collected throughout field investigation activities to ensure the integrity and reproducibility of the vadose zone investigation data. Field QC samples include duplicates, trip and field blanks for VOC analysis, and equipment blanks for non-dedicated sampling equipment. Field duplicates will be collected at a frequency of 10 percent of total number of environmental samples or a minimum of one per each event. Trip blank samples will accompany each shipment of water samples to the laboratory for VOC analysis. One field bank will be collected per day for groundwater sampling. Sampling equipment rinse blanks will be collected for soil and groundwater at a rate of 5 percent of the total number of environmental samples, when non-dedicated sampling equipment is being utilized. A temperature blank will be included with each shipment of soil and water samples from the field to the offsite laboratory.

6.2.3 Data Reporting

Results of the soil gas survey will be used to qualitatively describe the areal extent of volatile contamination. They will also be used to determine the locations of subsequent soil borings and monitoring wells. For overall characterization of the site, soil gas results are secondary to the soil and groundwater results. In addition, soil gas results cannot be used to describe the extent of semivolatile or heavy metals contamination.

6.2.4 Sample Packaging and Shipping

The primary objective of sample packaging and shipping requirements is to maintain sample integrity from the time a sample is collected until it is received at the analytical laboratory. Chain-of-custody forms, sample labels, custody seals, and other sample documents will be completed as specified in the UFP-QAPP, provided in Appendix E. Specific procedures for packaging and shipping of environmental samples are presented below.

- A sample label is attached to the sample bottle and completed with indelible ink.
- A picnic cooler (such as a Coleman or other sturdy cooler) is typically used as a shipping container. In preparation for shipping samples, the drain plug is 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 and packing material, such as bubble wrap, or Styrofoam beads, will be placed in the bottom of the liner.
- The containers are placed in the lined picnic cooler. Cardboard separators may be placed between the containers at the discretion of the shipper.
- Unless indicated in project-specific requirements, all samples for chemical analysis must be shipped cooled to 4 degrees °C with ice. All samples will require icing prior to shipping.
- 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 is closed and taped shut with strapping tape (filament-type).
- Custody seals are placed on the cooler. Placing clear tape over the custody seals can help to prevent them from being accidentally torn or ripped off.

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

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7. PROJECT SCHEDULE

The project schedule is provided in Appendix B of this work plan.

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8. ORGANIZATIONAL PLAN

8.1 Overall Project Organization

The organizational structure of our team is shown in Figure 8-1.

8.2 Responsibilities, Qualifications, and Authority of Key Personnel

Table 8-1 summarizes the responsibilities, qualifications, and authorities of project team members.

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9. DATA MANAGEMENT PLAN

Environmental laboratory services will be provided only by laboratories compliant with the *DoD Quality Systems Manual for Environmental Laboratories, Version 4.1* (DoD, 2009) or a most recent version and that hold a current DoD ELAP accreditation for all appropriate analytical methods (DoD, 2009). Three laboratories will provide analytical results in support of the BFF Spill project. Each laboratory will provide electronic data in both Staged Electronic Data Deliverable (SEDD) and the Environmental Resources Program Information Management System (ERPIMS) format. The SEDD deliverable will be used for applying the electronic data review process. The ERIPMS deliverable will be validated for upload to the Air Force data repository. All analytical data generated in support of the BFF Spill remediation will be uploaded to the Air Force Data Repository.

9.1 EPA Level III Data Review

Analytical data generated in support of the Kirtland BFF Spill project will undergo an EPA level III data review by a project chemist. An automated data review (ADR) software, developed by Laboratory Data Consultants, Inc. (LDC), will be used to perform 100 percent EPA Level III data review. The data review will be performed for groundwater and soil vapor analytical data obtained from each of the pre-remedy quarterly monitoring events. In addition, the project chemist will use the ADR software to conduct 100-percent, EPA Level III data review of the analytical data collected during the vadose zone and groundwater investigations, and Interim Measure field sampling activities. The data review will be performed using the quality control criteria specified the following documents:

- The UFP-QAPP;
- *DoD Quality Systems Manual for Environmental Laboratories, Version 4.1* (DoD, 2009);
- *Test Methods for Evaluating Solids Waste, SW846 Physical/Chemical Methods* (EPA, 2007 and updates);

- USACE, *Guidance for Evaluating Performance-Based Chemical Data, Engineer Manual (EM) 200-1-10* (2005);

- *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review* (June 2008); and

- *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Inorganic Methods Data Review* (January 2010).

The following QC elements will be included in the EPA Level III data review:

- Laboratory method blanks,
- Sample extraction and analysis holding times,
- Surrogate spike recoveries,
- Laboratory control sample (LCS)/laboratory control sample duplicate (LCSD) recoveries,
- Matrix spike (MS)/matrix spike duplicate (MSD) recoveries,
- Relative percent difference (RPD) for duplicate samples,
- Initial calibrations,
- Continuing calibrations,
- Trip and field blank data (water samples for volatiles only), and
- Field duplicate samples.

Note that due to laboratory information system limitations, laboratories may not be able to provide initial and continuing calibration results in SEDDs. In this case, the project chemist will manually review the calibration data and document review findings in a database and data review worksheets.

Data will be validated and flagged with the following data qualifiers as applicable:

- ***J+ qualifier*** denotes the analyte was positively identified, but the associated numerical value is estimated with a potential high bias.

- ***J- qualifier*** denotes the analyte was positively identified, but the associated numerical value is estimated with a potential low bias.

- ***U qualifier*** denotes the analyte was analyzed for, but was not detected.

- ***R qualifier*** denotes the data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria and data quality objectives.

As a result of the ADR process, EPA qualifiers will be electronically generated and assigned to the sample results that were outside of established control criteria. The qualified data will then be exported to a contractor database for data users and for report tables and figure preparations. EPA level III data review findings will be summarized and documented with each Quarterly Monitoring Report and in other reports containing analytical data.

An Environmental Information Management System (EIMS) will be used for sample planning, data loading, data management, and data reporting. This system supports all aspects of the project from the planning stages throughout the project lifecycle and ultimately data archiving, and thus maintains the integrity of all project-related data. Each step of the data management process will be performed in accordance with the site-specific UFP-QAPP (Appendix E) and applicable *Base-wide Plans for Investigation under the Environmental Restoration Program, 2004 Update,* Kirtland AFB, New Mexico. All quarterly monitoring field data, including but not limited to water level data, survey data, boring logs, and well construction logs, will be uploaded into the contractor EIMS and will be linked with validated analytical results in order to generate output files that will be used to populate Environmental Restoration Program Tools and generate ERPIMS Version 5.0 submittals. ERPIMS data submittals will be reviewed for accuracy and completeness before submittal. ERPIMS submittals will be provided to the Air Force, at a minimum, every 6 months or as appropriate for data generation for uploading to the Air Force data repository. Submittals will be deemed complete upon receipt of the insertion letter from the Air Force.

Site characterization data will be mapped using a Geographic Information System (GIS). The GIS dataset will be accompanied by metadata conforming to the Federal Geographic Data Committee's Content Standard for Digital Geospatial Metadata and the Army Installation Geospatial Information and Services Metadata Standard , v1, which is compliant with Spatial Data Standards for Facilities, Infrastructure, and Environment v2.6. The horizontal accuracy of GIS data will be tested in accordance with the National Standard for Spatial Data Accuracy and results will be recorded in the metadata. All data will be provided in the Universal Transverse Mercator projection in the appropriate zone, and will have a datum of NAD83. The GIS effort will involve preparation, analysis, processing, and interpretation of data acquired from munitions constituent sampling and analysis, geophysical surveys, and intrusive investigations. The

GIS coordinator will register and process all survey and intrusive field data such that it can easily be incorporated into the Kirtland AFB and Army Mapper database. The GIS analysts will prepare maps depicting site-specific attributes for continuous updates to be provided to project stakeholders. No data will be released to project stakeholders without the approval of the USACE.

All project-related data will be maintained and archived in the electronic project files on the corporate server and will be made available to the government as necessary. All data generated in support of this contract will be maintained in accordance with the contract requirements.

10. QUALITY ASSURANCE/QUALITY CONTROL

A comprehensive UFP-QAPP document has been developed to be implemented in support of sampling and analysis activities for the BFF Spill. This document is presented in Appendix E.

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11. WASTE MANAGEMENT

All wastes generated during implementation of this work plan will be handled and disposed of according to the requirements as presented in the Waste Management Plan (Appendix C).

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12. ACCIDENT PREVENTION PLAN/SITE SAFETY AND HEALTH PLAN

The APP, including the SSHP (Attachment 10) for the Kirtland AFB BFF Spill investigation work, was submitted under separate cover (Shaw, 2010).

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13. COMMUNITY RELATIONS PLAN

A Community Relations Plan (CRP) is being developed and submitted under separate cover in accordance with contract No. W912DY-10-D-0014, Delivery Order 0002 and the Kirtland AFB Base-Wide Community Relations Plan. Community information meetings, including community outreach as well as presentations at neighborhood association meetings, are ongoing. Below is a general approach to supporting community relations. For details, see the CRP submitted under separate cover.

The CRP Update will designate activities designed to aid people working on the project in understanding community issues and concerns related to bulk fuels contamination associated with the Kirtland AFB BFF Spill. The CRP Update also will outline the types of information to be provided and how that information will be distributed to surrounding communities and other interested stakeholders. The CRP Update will include the following activities:

- Conduct in-person interviews with community representatives that reflect the spectrum of the impacted community;
- Analyze interview, local demographic, site historical, and technical data; and
- Develop appropriate and proactive communication strategies based on the compiled data.

An outreach strategy will be developed to meet current regulatory standards and Air Force communication needs and requirements. This strategy will also respond to community's needs and desire for information about the on going remediation field activities associated with the BFF Spill. Community relations work will be conducted in accordance with the appropriate regulatory guidance, including EPA's *RCRA Public Participation Manual, 1996 Edition, EPA530-R-96-007* (EPA, 1996), and *Superfund Community Involvement Handbook, EPA 540-K-05-003* (EPA, 2005b).

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FIGURES

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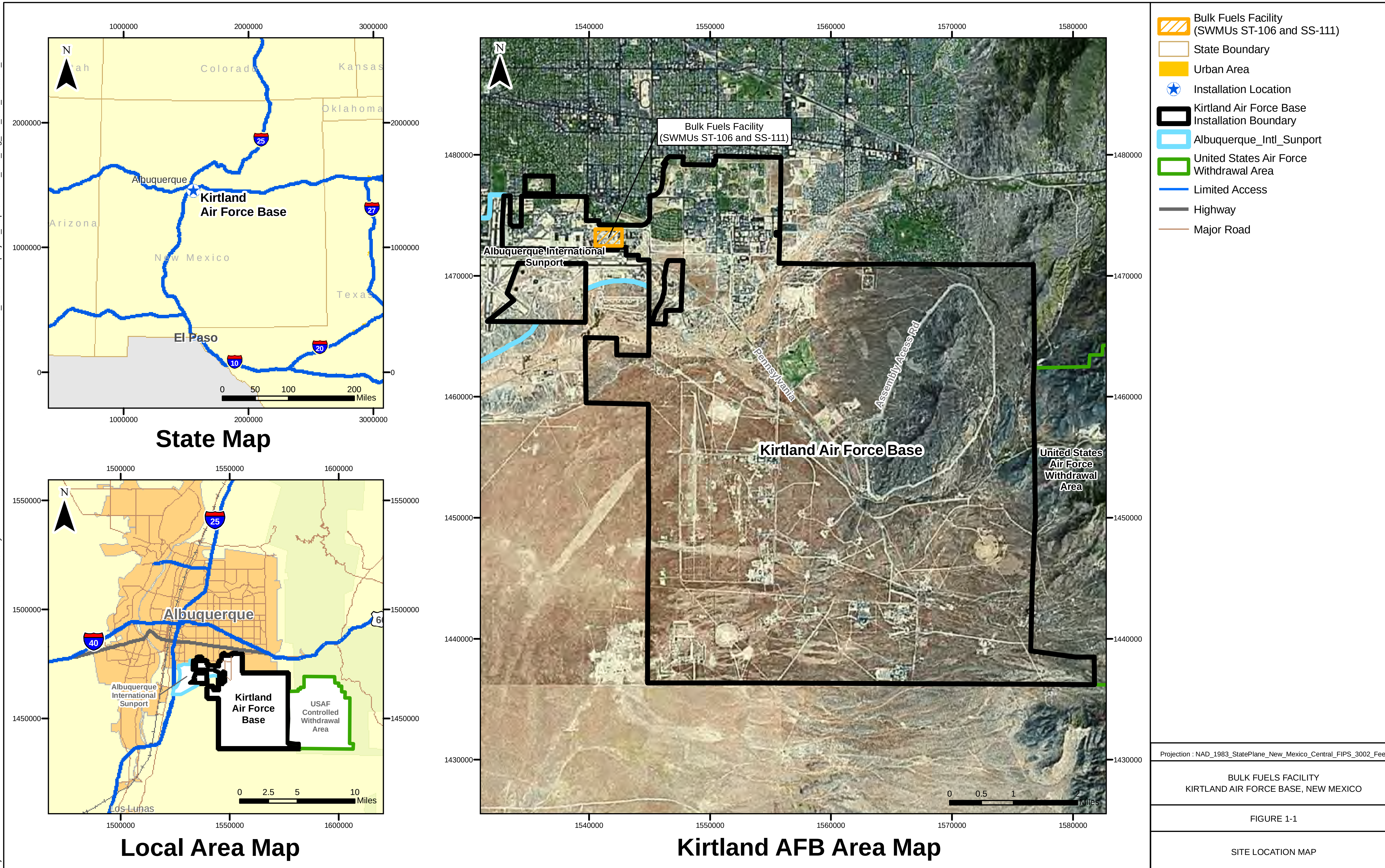

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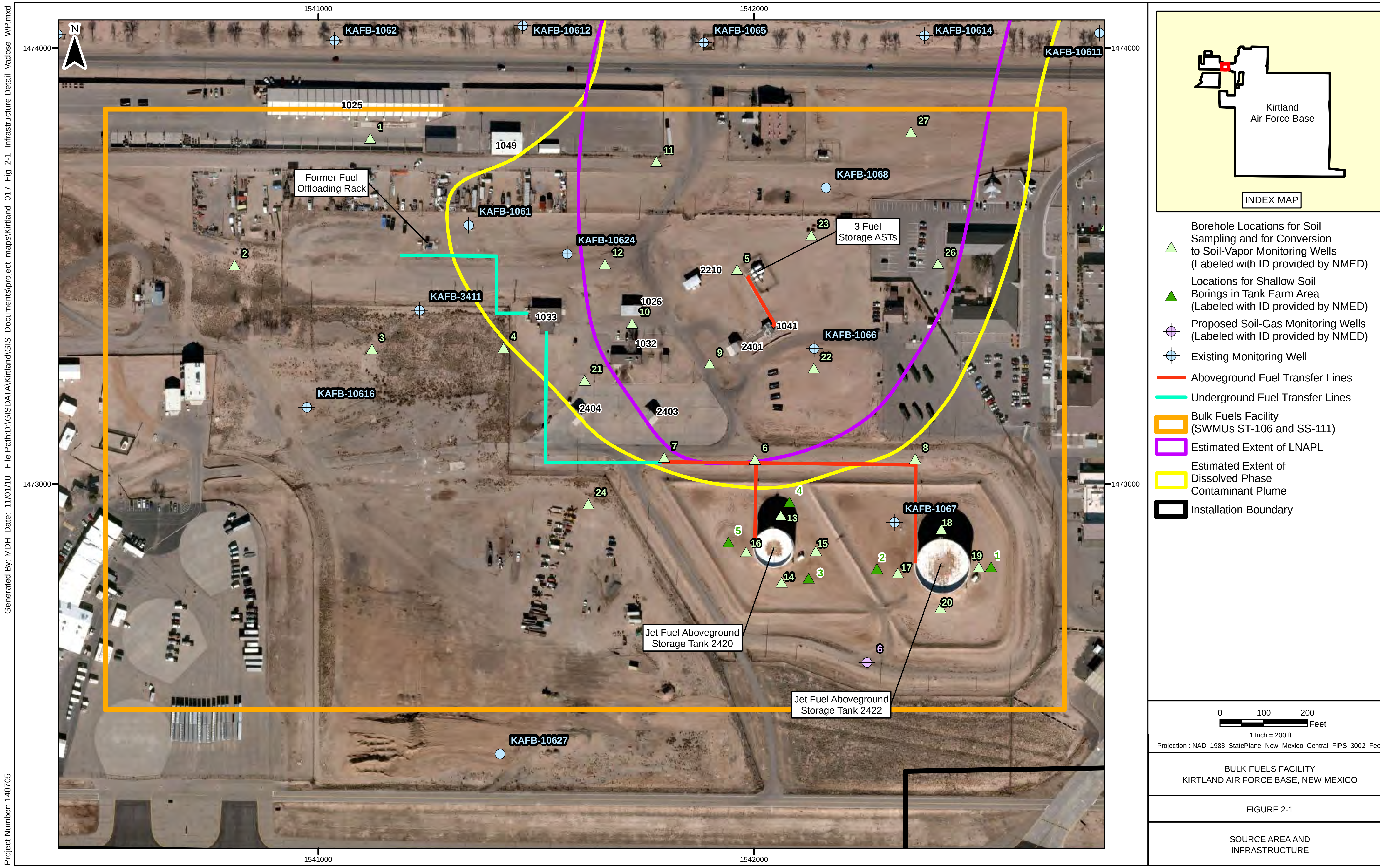

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KAFB-1067
KAFB-10627
1025
1049
1033
1026
1032
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1041
2401
2404
2403
Former Fuel Offloading Rack
3 Fuel Storage ASTs
Jet Fuel Aboveground Storage Tank 2420
Jet Fuel Aboveground Storage Tank 2422
Kirtland Air Force Base
INDEX MAP
Borehole Locations for Soil Sampling and for Conversion to Soil-Vapor Monitoring Wells (Labeled with ID provided by NMED)
Locations for Shallow Soil Borings in Tank Farm Area (Labeled with ID provided by NMED)
Proposed Soil-Gas Monitoring Wells (Labeled with ID provided by NMED)
Existing Monitoring Well
Aboveground Fuel Transfer Lines
Underground Fuel Transfer Lines
Bulk Fuels Facility (SWMUs ST-106 and SS-111)
Estimated Extent of LNAPL
Estimated Extent of Dissolved Phase Contaminant Plume
Installation Boundary
0 100 200 Feet
1 Inch = 200 ft
Projection : NAD_1983_StatePlane_New_Mexico_Central_FIPS_3002_Feet
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO
FIGURE 2-1
SOURCE AREA AND INFRASTRUCTURE

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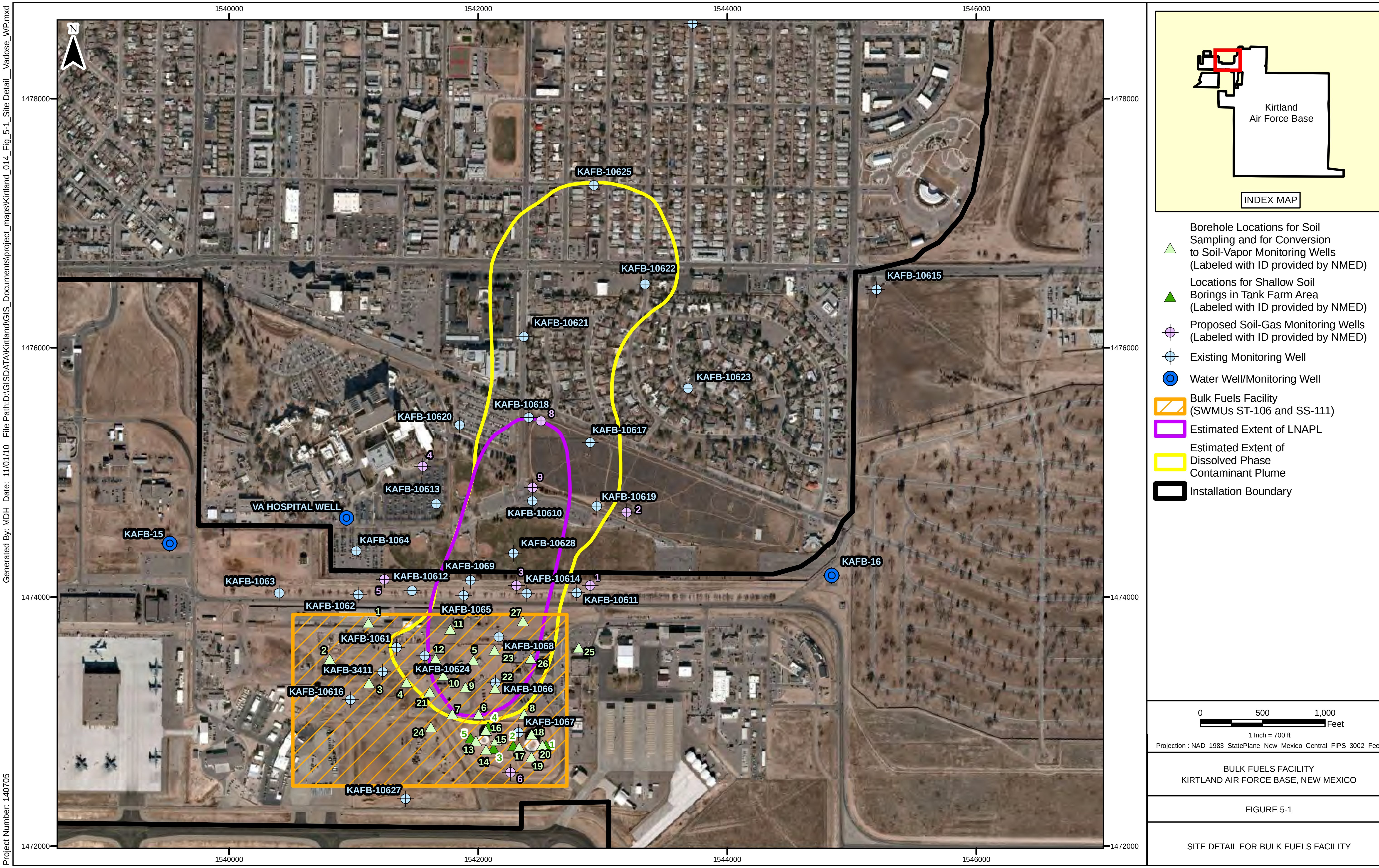

BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 5-1

SITE DETAIL FOR BULK FUELS FACILITY

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Figure 5-2. Typical Soil Vapor Monitoring Well Installation

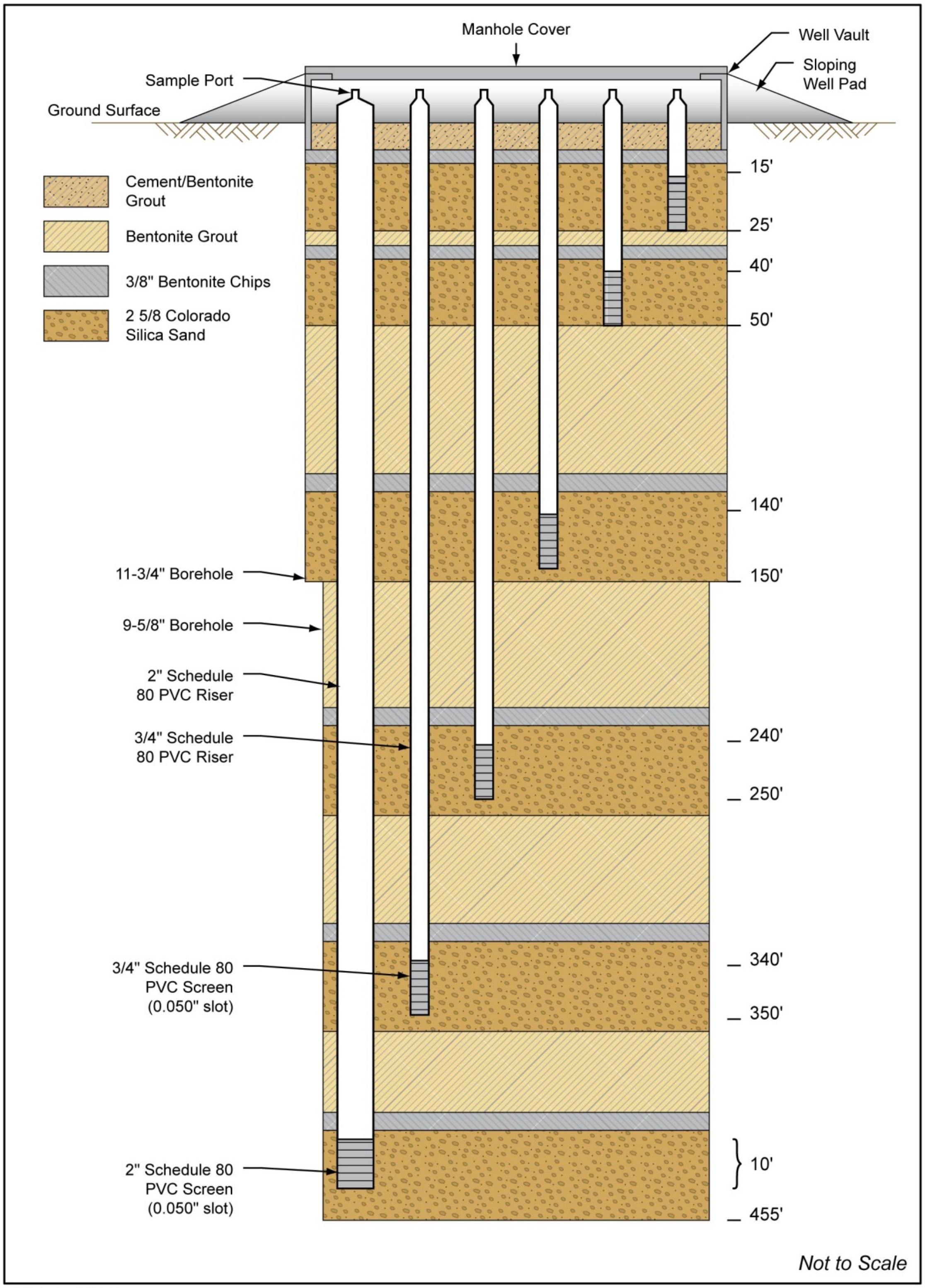

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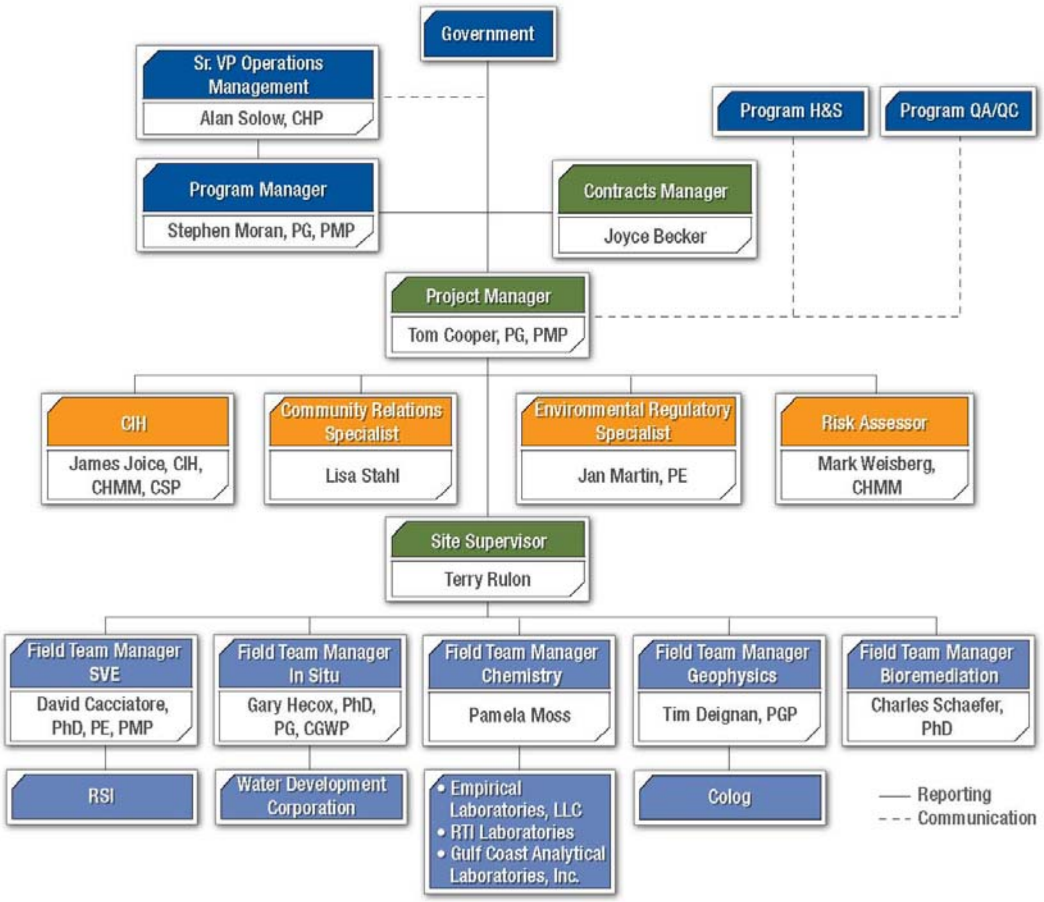
Figure 8-1. Project Organization



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TABLES

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Table 3-1. Hydrostratigraphic Units and Correspondence to Site-Specific Units

Regional Unit (Depositional Facies)	Site-Specific Zones	Description	Thickness	Approximate Depth Interval	SVMW Screened Intervals
USF-1 (Distal alluvial piedmont fan deposits from the Sandia uplift)		Thick discontinuous intervals of silt (ML) and silty or sandy clays (CL) w/minor lean clays (CL)	74’ to 94’	Surface to ≈86’ bgs	50’ to 52.5’ bgs
Transition Zone (Inter-tongued USF-1 and USF-2)	Upper transition sands (USF-2)	Poorly graded sand (SP) buff colored, fine-grained	15’ to 25’	≈86’ bgs to ≈107’ bgs	97’ to 102.5’ bgs
	Upper transition fines (USF-1)	Primarily silty, sandy, and lean clays (CL) with minor silt (ML) zones	13’ to 25’	≈107’ bgs to ≈125’ bgs	
	Lower transition sands (USF-2)	Poorly graded sand (SP) buff colored, fine-grained	3’ to 15’	≈125’ bgs to ≈140’ bgs	
	Lower transition fines (USF-1)	Primarily silty, sandy, and lean clays (CL)	0’ to 10’	≈140’ bgs to ≈144’ bgs	
USF-2 (Stacked sequence of braided river-channel deposits [Ancestral Rio Grande] and inter-bedded fine- to medium-grained sediments of diverse origin)	Upper Ancestral Rio Grande deposits	Poorly graded fine-grained sands (SP) and well-graded fine- to coarse-grained sands (SW) buff colored, w/trace of gravels.	117’ to 140’	≈144’ bgs to ≈270’ bgs	147’ to 152.5’ bgs, 229’ to 231’ bgs, 250’ to 252.5 bgs
	Clay Zone	Lean clay (CL) brown, moist to wet, very stiff w/minor sandy and silty clay (CL)	0’ to 15’	≈270’ bgs to ≈280’ bgs	
	Lower Ancestral Rio Grande deposits	Poorly graded fine-grained sands (SP) and well-graded fine- to coarse-grained sands (SW) buff colored, w/higher fraction of gravel (GW) and fine-grained (GM) zones	>137’	≈280’ bgs to >517’ bgs	287.5’ to 305’ bgs

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Table 4-1. DQOs for Vadose Zone Investigation Work Plan

DQO Step	Details of DQO Step per EPA DQO Guidance (2006)	BFF Spill Vadose Zone Investigation SVM Points	BFF Spill Vadose Zone Investigation Geophysics LNAPL	BFF Spill Vadose Zone Investigation Extent of LNAPL
1) State the Problem	Summarize the contamination problem requiring new data.	Optimal locations for vapor monitoring points.	Qualitative LNAPL extent within the vadose zone.	Nature and extent of soil contamination within the vadose zone.
2) Identify the Decision	Identify the decision that requires new environmental data to address the contamination problem.	Determine where fine grained lithologic units exert control on vapor and LNAPL migration pathways in the vadose zone at the BFF Spill - adjustment of vapor monitoring point screening locations to collect optimal data.	Define areas and depths where there is a likelihood of LNAPL being present.	Determine where contaminants exceed screening levels for the site and if further evaluation is required.
3) Identify Inputs to the Decision	Identify the information needed to support the decision and specify which inputs require new environmental measurements.	The geophysical down-hole logging including gamma, neutron and induction logs, run from the groundwater table (approximately 500 feet bgs) to ground surface through the well casing.	Borehole gamma, induction, and neutron logging measured in newly installed wells. Identify the limits of LNAPL using its chemical properties as a non conducting material.	Soil sampling in new boreholes.

Table 4-1. DQOs for Vadose Zone Investigation Work Plan (Continued)

DQO Step	Details of DQO Step per EPA DQO Guidance (2006)	BFF Spill Vadose Zone Investigation SVM Points	BFF Spill Vadose Zone Investigation Geophysics LNAPL	BFF Spill Vadose Zone Investigation Extent of LNAPL
4) Define the Study Boundaries	Specify the spatial and temporal aspects of the environmental media that the data must represent to support the decision.	Study boundaries are indicated on Figure 2-1.	Study boundaries are indicated on Figure 2-1.	During Soil Borings, soil samples will be collected at the midpoint of 10-foot depth intervals from ground surface to 50 ft bgs and from 50-foot depths thereafter, to the groundwater table, for a total of 14 depths per borehole.
5) Develop a Decision Rule	Develop a logical "if…then" statement that defined the conditions that would cause the decision maker to choose among alternative actions.	If proposed vapor monitoring points are screened in zones determined to be fine grained lithologic units adjust the screen location vapor monitoring points up or down to the nearest coarser grained unit if the unit is located within 20 feet of the proposed screened interval. If there is no coarser grained interval located within the 20 feet of the proposed screened interval install vapor point as originally proposed. Fine grained units are defined as units coarser than ML or CL as presented in the United Soils Classification System.	If vapor points being installed for the purpose of monitoring vadose zone contamination within the LNAPL plume are not within the plume, adjust location of these points or eliminate them.	If soil samples collected from the borings, used to establish the limits of soil contamination, exceed the criteria then the extent of contamination with the vadose zone has not been delineated and additional borings may be installed to complete the delineation.

Table 4-1. DQOs for Vadose Zone Investigation Work Plan (Concluded)

DQO Step	Details of DQO Step per EPA DQO Guidance (2006)	BFF Spill Vadose Zone Investigation SVM Points	BFF Spill Vadose Zone Investigation Geophysics LNAPL	BFF Spill Vadose Zone Investigation Extent of LNAPL
6) Specify Limits on Decision Errors	Specify the decision maker's acceptable limits on decision errors, which are used to establish performance goals for limiting uncertainty in the data.	Borehole geophysics measurements obtained are less than 1 ft.	Borehole geophysics measurements obtained are less than 1 ft.	Shaw's site specific UFP-QAPP will be utilized.
7) Optimized Design	Identify the most resource-effective sampling and analysis design for generating data that are expected to satisfy the DQOs.	Borehole geophysics measurements conducted following completion of each well prior to first sampling of well.	Borehole geophysics measurements conducted following completion of each well prior to first sampling of well.	Soil samples will be collected during installation of the soil borings followed by fixed lab analyses.

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Table 5-1. Kirtland AFB Vadose Zone Investigation - Field Sampling and Quality Control Sample Summary

Matrix	Analytical Group	No. of Primary Sampling Locations	No. of Field Samples	No. of Field Duplicates	No. of MS/MSDs	No. of Field Blanks	No. of Equipment Rinsates	No. of Trip Blanks	Total No. of Samples to Laboratory
Soil Sampling									
Soil	VOCs – SW846 8260B	35 deep/5 shallow(1)	515	52	26	0	26	0	619
Soil	VPH/EPH - MADEP	35 deep/5 shallow	515	52	26	0	26	0	619
Soil	SVOCs – SW846 8270C	35 deep/5 shallow	515	52	26	0	26	0	619
Soil	Lead – SW846 6010B	35 deep/5 shallow	515	52	26	0	26	0	619
Soil IDW Sampling									
Soil	Ignitability, Corrosivity, Reactivity – 40CFR Part 261	30	0	0	0	0	0	0	30
Soil	TCLP VOCs – SW846 1311/8260B	30	0	0	0	0	0	0	30
Soil	TCLP SVOCs – SW846 1311/8270C	30	0		0	0	0	0	30
Soil	TCLP Pesticides – SW846 1311/8081A	30	0	0	0	0	0	0	30
Soil	TCLP Herbicides – SW846 1311/8151A	30	0	0	0	0	0	0	30
Soil	TCLP Metals – SW846 1311/6010B/7470A	30	0	0	0	0	0	0	30
Soil	Metals – SW846 1311/6010B/7470A	30	0	0	0	0	0	0	30
Soil	BTEX – SW846 8260B/8021B (2)	30	0	0	0	0	0	0	30
Soil	TPH – SW846 8015M (2)	30	0	0	0	0	0	0	30

Notes:

1. 35 deep borings – 14 samples each; 5 shallow borings – 5 samples each

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Table 5-2. Soil Borings Locations and Correlation to NMED Letters Dated April 2, 2010, and August 8, 2010

Location #	Easting	Northing	Characterization Purpose	NMED April 2 Letter	NMED August 8th Letter
Deep Wells Soil Borings for Conversion to Soil Vapor Monitoring Wells					
1	1541119	1473793	Fuel Offloading Rack	Table 2, Location #1	Table 1, Location #1
2	1540808	1473503	Fuel Offloading Rack	Table 2, Location #2	Table 1, Location #2
3	1541123	1473310	Fuel Offloading Rack	Table 2, Location #3	Table 1, Location #3
4	1541425	1473313	Fuel Offloading Rack and Piping	Table 2, Location #4	Table 1, Location #4
5	1541961	1473492	Fuel Percolation Area	Table 2, Location #5	Table 1, Location #5
6	1542002	1473057	Piping	Table 2, Location #6	Table 1, Location #6
7	1541794	1473061	Piping	Table 2, Location #7	Table 1, Location #7
8	1541270	1473058	Piping	Table 2, Location #8	Table 1, Location #8
9	1541898	1473276	Fuel Percolation Area	Table 2, Location #9	Table 1, Location #9
10	1541720	1473369	Fuel Percolation Area	Table 2, Location #10	Table 1, Location #10
11	1541776	1473740	Fuel Offloading Rack	Table 2, Location #11	Table 1, Location #11
12	1541658	1473505	Fuel Offloading Rack	Table 2, Location #12	Table 1, Location #12
13	1542061	1472928	Fuel Tanks Farm	Table 2, Location #13	NA
14	1542063	1472775	Fuel Tanks Farm	Table 2, Location #14	NA
15	1542142	1472847	Fuel Tanks Farm	Table 2, Location #15	NA
16	1541982	1472845	Fuel Tanks Farm	Table 2, Location #16	NA
17	1542330	1472796	Fuel Tanks Farm	Table 2, Location #17	NA
18	1542430	1472897	Fuel Tanks Farm	Table 2, Location #18	NA
19	1542516	1472810	Fuel Tanks Farm	Table 2, Location #19	NA
20	1542428	1472716	Fuel Tanks Farm	Table 2, Location #20	Table 1, Location #20
21	1541611	1473238	Fuel percolation area	Table 2, Location #21	Table 1, Location #21
22	1542137	1473266	Fuel percolation area	NA	Table 1, Location #22

Table 5-2. Soil Borings Locations and Correlation to NMED Letters Dated April 2, 2010, and August 8, 2010 (Concluded)

Location #	Easting	Northing	Characterization Purpose	NMED April 2 Letter	NMED August 8th Letter
23	1542131	1473571	Fuel percolation area	NA	Table 1, Location #23
24	1541620	1472955	Far field	NA	Table 1, Location #24
25	1542807	1473592	Fuel percolation area	NA	Table 1, Location #25
26	1542422	1473506	Fuel percolation area	NA	Table 1, Location #26
27	1542360	1473808	Fuel percolation area	NA	Table 1, Location #27
1	1542900	1474092	Far Field	NA	Table 2, Location #1
2	1543194	1474680	Far Field	Table 3, Location #2	Table 2, Location #2
3	1542306	1474093	Far Field	Table 3, Location #3	Table 2, Location #3
4	1541555	1475049	Far Field	Table 3, Location #4	Table 2, Location #4
5	1541248	1474141	Far Field	Table 3, Location #5	Table 2, Location #5
6	1542259	1472591	Far Field	Table 3, Location #6	Table 2, Location #6
8	1542504	1475414	Far Field	NA	Table 2, Location #8
9	1542436	1474878	Far Field	Table 3, Location #9	Table 2, Location #9
Shallow Borings					
1	1542544	1472810	Tank Farm	NA	Table 3, Location #1
2	1542282	1471806	Tank Farm	NA	Table 3, Location #1
3	1542125	1472784	Tank Farm	NA	Table 3, Location #1
4	1542081	1472959	Tank Farm	NA	Table 3, Location #1
5	1541941	1472867	Tank Farm	NA	Table 3, Location #1

Table 6-1. Sample Requirements for Analytical Testing

Matrix	Parameter[1]	Container[2,3]	Preservation	Maximum Holding Times[4] Extraction	Analysis
Low-Concentration Samples					
Water	Volatiles	2 x 40-mL[5] G, Septa Vial	Ice to 4°C 4 drops conc. HCl or sodium bisulfate ($NaHSO_4$) to pH<2	---	14 days
Water	SVOCs	2 x 1-L[5,6] amber G	Ice to 4°C	7 days	40 days
Water	Metals[6]	1 x 1-L P	Nitric acid (HNO_3) to pH<2		6 months[7]
Water	TPH –gas TPH – diesel	2 x 40-mL[5] G, Septa Vial 2 x 1-L G	Ice to 4°C		14 days
Water	Common parameters	1 x 1-L[8] G	Ice to 4°C		28 days[8]
Soils/Sediments	Volatiles	3 – 5 gram Encore	Ice to 4°C		48 hr, 14 days frozen
Soils/Sediments	SVOCs, PCBs, pesticides	1 x 8-oz G	Ice to 4°C	14 days	40 days
Soils/Sediments	Metals, cyanide, TPH	1 x 8-oz G 5-gram Encore for TPH-gas	Ice to 4°C		6 months,[7] 14 days, 48 hr, 14 days frozen
Medium-Concentration Samples					
Water/Liquid	Volatiles	2 x 40-mL G	Ice to 4°C[5]		14 day
Water/Liquid	SVOCs[5]	2 x 32-oz wide-mouth jars, G	Ice to 4°C[5]	7 days	40 days
Water/Liquid	PCBs[5], pesticides	2 x 32-oz wide-mouth jar G	Ice to 4°C[5]	7 days	40 days
Water/Liquid	Metals	1 x 16-oz wide-mouth jar, G	HNO_3 to pH<2		6 months[7]
Water/Liquid	Explosives	2 x 1-L amber G	Ice to 4°C	7 days	40 days
Water/Liquid	Cyanide	1 x 1- L P	Sodium hydroxide (NaOH) to pH>12 Ice to 4°C		14 days
Soils/Sediments	Volatiles	3- 5 gram Encore	Ice to 4°C		48 hr, 14 days frozen
Soils/Sediments	SVOCs, PCBs, pesticides	1 x 8-oz wide-mouth jar, G	Ice to 4°C	14 days	40 days
Soils/Sediments	Metals, cyanide, TPH	1 x 8-oz wide-mouth jar, G 5-gram Encore for TPH-gas	Ice to 4°C		6 months,[7] 14 days, 48 hr, 14 days frozen
Liquid	All organic and inorganic analyses	1 x 8-oz wide-mouth jar, G		See comment 9	
Solids	All organic and inorganic analyses	2 x 8-oz wide-mouth jars, G		See comment 9	

Table 6-1. Sample Requirements for Analytical Testing (concluded)

1	B/N/A = base/neutral/acid extractables
2	All containers must have Teflon-lined seals (Teflon-lined septa for volatile organic analysis [VOA] vials).
3	L = liter; G = glass; P = high-density polyethylene. Sample preservation will be done in the field immediately upon sample collection. If water samples are filtered in the field, differential pressure methods using 45-micron filters will be used, and preservatives added after filtration. VOA samples should never be filtered.
4	When only one holding time is given, it implies total holding time from sampling until analysis.
5	Samples with residual chlorine present will be dechlorinated with sodium thiosulfate as specified in SW-846 (third edition).
6	Three bottles are required on at least 5 to 10 percent (but at least one) sample so that the laboratory can perform all method quality control checks for SW-846 method.
7	Total recoverable metals for water samples. Holding time for mercury is 28 days in glass; for hexavalent chromium is 24 hours.
8	Chlorine, bromine, fluorine, nitrate, nitrite, phosphate, sulfate; 1 L for each method; orthophosphate requires filtration. Holding time for extraction is 48 hours for nitrate, nitrite, and phosphate if not preserved with sulfuric acid to pH<2.
9	Holding times for medium-concentration samples are the same as those specified for low-concentration samples.

Table 8-1. Project Team Roles and Responsibilities

Position	Qualifications	Duties and Responsibilities	Authority Level
Project Manager	• Tom Cooper, PG, PMP • Mr. Cooper is a Professional Geologist (PG) and Project Management Professional (PMP) with 11 years of experience as a hydrogeologist on complex groundwater remediation projects and 5 years of experience as a project manager for firm-fixed-price, performance-based acquisition (PBA) projects including hybrid PBAs with options. He has expert knowledge of groundwater and soil sample collection/data evaluation and has extensive experience working proactively with clients and regulators to determine the best technologies to reach remedial performance objectives. • Mr. Cooper has served as the project manager for DoD projects at Former Air Force Plant PJKS, Pueblo Chemical Depot, and Vandenberg AFB. For these projects, he has established a strong and cooperative working relationship with his clients as well as the state and EPA regulators. At PJKS, he successfully negotiated with the regulators to implement an environmental covenant and technical impracticability waiver as opposed to a pump-and-treat system. The environmental covenant saved the Air Force millions of dollars. At Pueblo, Mr. Cooper developed ten remedy-specific work plans that were approved within the first year of the project. He and his team then completed installation of eight in situ bioremediation systems within the second year of the project.	• Manages task order (TO) deliverables, schedules, and budgets • Implements procedures to eliminate conflicts, errors, and omissions and ensure the accuracy of all output • Establishes and maintains close communication and coordination with the USACE for the duration of the project • Assigns scientists, engineers, and select subcontractors • Procures services, equipment, and supplies as needed • Ensures personnel follow approved work plans/specs • Tracks materials and resources and justify change orders • Coordinates subcontractors' work to ensure compliance with safety and health, quality, and contract procedures	• Full responsibility and authority to execute TOs • Approves subcontractor invoices, project charges, and deliverables • Implements corrective action • Stops work for non-compliance/safety violation
Site Supervisor	• Terry Rulon • Mr. Rulon has over 22 years as a site supervisor on restoration, remediation, demolition, and hazardous waste sites. His role has been primarily bid preparation, estimating, overall site management, and field work on numerous complex environmental projects throughout the U.S. • Mr. Rulon's experience includes, but is not limited to, management of contaminated soil remediation, in situ bioremediation of groundwater for chlorinated compounds, shock sensitive chemical packaging, and emergency response actions.	• Tracks progress of daily well installation production and soil excavation • Schedules manpower and balancing project resources • Schedules use of equipment • Manages sampling of environmental media and IDW, handling of IDW, and coordination of IDW disposal. • Manages operation and maintenance of all equipment • Addresses field issues to keep project on schedule • Communicates daily with project manager to keep project on schedule	• Supervises field TO engineering and design staff • Manages subcontractors • Implements corrective action • Stops work for non-compliance/safety violation

Table 8-1. Project Team Roles and Responsibilities (Continued)

Position	Qualifications	Duties and Responsibilities	Authority Level
Field Team Manager - SVE	• David Cacciatore, PhD, PE, PMP • Dr. Cacciatore is a registered Professional Engineer (PE) and PMP with 7 years of experience designing and implementing SVE/bioremediation systems for environmental remediation projects. He has designed and implemented a wide range of bioremediation technologies, including monitored natural attenuation (MNA). Dr. Cacciatore has served as the Designer of Record on plans and reports for several high-profile projects at sites including Hunters Point Naval Shipyard and Treasure Island in California. He has played an integral role in supporting negotiations with regulators to gain approval of the remedies and cleanup goals for these projects. Dr. Cacciatore has authored/co-authored 11 technical papers/ presentations at industry conferences on the design and implementation of bioremediation and other remedial methods.	• Identifies, trains, mentors, and assigns qualified engineering staff to tasks/projects • Ensures compliance and consistency of engineering and technical program execution across all TOs • Provides professional engineering certification of drawings, specifications, and documents as necessary • Ensures compliance with all applicable engineering and design codes, standards, and guidance	• Supervises field TO engineering and design staff • Defines qualifications and requirements of engineering and technical staff at TO level • Evaluates performance of engineering staff and provides feedback, including recommendations, to project manager • Stops work for non-compliance/safety violation
Field Team Manager – In Situ	• Gary Hecox, PhD, PG, CGWP • Dr. Hecox is a PG and certified groundwater professional (CGWP) with 32 years of experience in hydrogeology, GIS development and application, contaminant investigations, risk analysis, and remediation. He is a technical expert in non-aqueous phase liquid (NAPL) assessment and remediation, groundwater modeling, geostatistics, statistics, and error analysis. • Dr. Hecox has served as Shaw's senior scientist/engineer for federal remediation projects dealing with in excess of 5 million gallons of LNAPL contamination. He specializes in designing and implementing process treatment systems such as the chemical stabilization of soils and groundwater. He has provided technical input and strategy support in RCRA site remediation negotiations and technical impracticability waivers for various federal sites. Dr. Hecox has also developed and deployed new technologies and applications of GIS for hydrogeologic assessments.	• Prepares groundwater modeling to assist with the design of remediation systems • Executes the MNA evaluation study • Evaluates and documents all hydrogeologic data to confirm LNAPL and plume containment	• Supervises field TO design staff • Defines qualifications and requirements of technical staff at TO level • Evaluates performance of technical staff and provides feedback, including recommendations, to project manager • Stops work for non-compliance/safety violation

Table 8-1. Project Team Roles and Responsibilities (Continued)

Position	Qualifications	Duties and Responsibilities	Authority Level
Field Team Manager – Bioremediation	• Charles Schaefer, PhD • Dr. Schaefer has 14 years of experience with assessing the fate and transport of organic contaminants in soil and groundwater systems. His work has included design and performance of laboratory scale experiments, mathematical and numerical modeling, and conceptual design and evaluation of field-scale bioremediation systems. He has taught graduate-level courses in contaminant hydrogeology, and has been successful in attaining research funding from the EPA, DoD, and the U.S. Department of Energy (DOE). Dr. Schaefer's research has included development of experimental methods to evaluate new and emerging technologies including EDB degradation in Shaw's treatability study laboratories located in Lawrenceville, NJ and Knoxville, TN. As a result of his research, he has developed and published several conceptual and mathematical models that have been used to better understand, interpret, and predict contaminant fate and transport. • Dr. Schaefer has been the lead engineer and/or technical manager on several field projects, many of which have used innovative investigation and treatment technologies. His key contributions include the conceptual design and performance evaluation of an air sparging/soil vapor extraction Superfund site in New Jersey; development of a transport model to evaluate contaminant biodegradation in an engineered biocell at a Superfund site in Delaware; and development and implementation of an innovative cosolvent technology for investigation of dense, non-aqueous phase liquid (DNAPL) in bedrock.	• Identifies, trains, mentors, and assigns qualified engineering staff to tasks/projects • Ensures compliance and consistency of engineering and technical program execution across all TOs • Provides professional engineering certification of drawings, specifications, and documents as necessary • Ensures compliance with all applicable engineering and design codes, standards, and guidance	• Supervises field TO engineering and design staff • Defines qualifications and requirements of engineering and technical staff at TO level • Evaluates performance of engineering staff and provides feedback, including recommendations, to project manager • Stops work for non-compliance/safety violation

Table 8-1. Project Team Roles and Responsibilities (Continued)

Position	Qualifications	Duties and Responsibilities	Authority Level
Field Team Manager – Chemistry	• Pamela Moss • Ms. Moss has 32 years of experience in chemical QC, analytical chemistry, and project management in support of federal contracts. Ms. Moss has supported projects at Kirtland AFB from 1996 to 2010. During this time, she managed in excess of $5 million in analytical lab services. She has also participated in RCRA site investigations, remedial actions, long-term groundwater monitoring, compliance monitoring and sampling programs, which include hazardous wastes and routine and non-routine analytical parameters for groundwater, drinking water, soil, and air. • Ms. Moss has 14 years of experience at Kirtland participating in regular communications and negotiating with the NMED to ensure compliance with all applicable regulations. Ms. Moss also has extensive knowledge and experience implementing federal programs in accordance with the USACE; DoD Quality Systems Manual; and EPA requirements, protocols, and analytical methodologies.	• Approves project-specific DQOs that will meet the project-specific performance standards • Determines appropriateness of sampling procedures, analytical methods, and laboratory quality systems • Approves the final QAPP • Verifies the selection of appropriately qualified laboratories • Coordinates field and laboratory quality assurance surveillance per contract specifications • Notifies the project manager of any problems or nonconformance issues • Directs the performance of data review per contract specifications • Oversees data management and ERPIMS submittals	• Supervises field scientists and technical staff • Defines qualifications, requirements, and assigns engineering and technical staff at TO level • Evaluates performance of technical staff and provides feedback, including recommendations, to project manager • Stops work for non-compliance/safety violation
Field Team Manager – Geophysics	• Tim Deignan, PGP • Mr. Deignan is a registered PGP with more than 21 years of experience, which include executing multiple projects at Kirtland AFB. As a recognized subject matter expert, Mr. Deignan has also donated his time to serve as an archeological expert for efforts at Kirtland AFB. His experience includes design and management of integrated geophysical programs to investigate and assess sites and geotechnical, geologic, hydrogeologic, and cultural resource features. He specializes in high-resolution, integrated geophysical programs for environmental remediation and munitions investigations. • Mr. Deignan works with numerous state and federal agencies to increase the usability of results for geophysical and statistical sampling data, and is integral in developing more adequate and innovative sampling approaches. He is a two-time recipient of the Industry Recognition Award from the Interstate Technology and Regulatory Council.	• Functions in lead technical role for efforts requiring expert level support • Identifies, trains, mentors, and assigns qualified technical staff to tasks/projects • Ensures compliance and consistency of technical program execution • Ensures compliance with all applicable federal, state, and local regulations • Serves as the project geophysicist of record	• Supervises field scientists and technical staff • Defines qualifications, requirements, and assigns engineering and technical staff • Evaluates performance of technical staff and provides feedback, including recommendations, to project manager • Stops work for non-compliance/safety violation

Table 8-1. Project Team Roles and Responsibilities (Continued)

Position	Qualifications	Duties and Responsibilities	Authority Level
Environmental Regulatory Specialist	• Jan Martin, PE • Ms. Martin is a New Mexico-registered PE with more than 24 years of experience ensuring compliance on complex environmental investigation and remediation projects. Located in Shaw's Albuquerque office, Ms. Martin has executed a number of environmental remediation projects for DoD in New Mexico and other states, including active installations under the Installation Restoration Program at Wright-Patterson AFB, and Formerly Used Defense Sites (FUDS) at the Former Walker AFB in Roswell, New Mexico and at a FUDS adjacent to Kirtland. • She has worked with DoD clients, EPA regulators, and private and tribal stakeholders to ensure compliance on projects conducted under RCRA as well as various DoD programs, state statutes, and regulations. Ms. Martin has prepared remedial investigation, engineering evaluation/cost analyses, and feasibility study reports, various decision documents, land use control plans, Operating Properly and Successfully (OPS) documents, RCRA closure and corrective action documents, and design analysis documents including plans and specifications.	• Identifies regulatory requirements and oversees implementation of environmental regulatory requirements • Supports project manager in regulatory interaction • Works closely with the installation representatives to ensure that environmental policies and procedures are implemented • Stops work for non-compliance/safety violation	• Reports regulatory updates to project manager • Coordinates regulatory meeting in concert with project manager • Maintains list of team personnel who have authority to contact regulatory agencies • Stop-work authority
Risk Assessor	• Mark Weisberg, CHMM • Mr. Weisberg, a Certified Hazardous Materials Manager (CHMM), has prepared hundreds of risk assessments at more than 25 Army/DoD facilities, including Former Walker AFB in Roswell, New Mexico. At Walker, he prepared NMED-approved screening-level environmental risk assessments for sites throughout the base. He has more than 20 years of experience in ecology and environmental assessment, where he has been responsible for supervising and conducting risk assessments and RCRA facility investigations at numerous hazardous, toxic, and radioactive waste sites for the Army, Air Force, and Navy. His areas of expertise include ecological and human health risk assessment; toxicology; statistical analysis; water quality; site assessment; and federal, state, and local permit preparation.	• Functions in lead technical role for efforts requiring expert level support • Identifies, trains, mentors, and assigns qualified technical staff to tasks/projects • Ensures compliance and consistency of technical program execution • Ensures compliance with all applicable federal, state, and local regulations	• Supervises field scientists and technical staff • Defines qualifications, requirements, and assigns engineering and technical staff • Evaluates performance of technical staff and provides feedback, including recommendations, to project manager • Stops work for non-compliance/safety violation

Table 8-1. Project Team Roles and Responsibilities (Continued)

Position	Qualifications	Duties and Responsibilities	Authority Level
Certified Industrial Hygienist (CIH)	• James Joice, CIH, Certified Safety Professional (CSP), CHMM • Mr. Joice, Shaw's CIH for the Huntsville Worldwide Environmental Remediation contract, has 30 years of experience managing the health and safety for projects and programs at hundreds of environmental remediation sites. He has extensive experience establishing and maintaining health and safety plans and procedures where EPA Levels A, B, and C PPE were required. • He regularly supervises project safety personnel; monitors subcontractor activities; develops, implements, and enforces site-specific safety and health plans (SSHPs); audits sites for compliance with health and safety (H&S) program requirements; conducts personnel training, and verifies regulatory compliance. He has also prepared and implemented H&S programs for several PBA and firm-fixed-price contracts.	• Implements and oversees H&S program and plans • Develops, implements, and oversees APPs inclusive of SSHPs and directs/approves any changes • Notifies Contracting Officer of changes in the approved plan within 48 hours • Interfaces with the USACE on H&S program requirements • Assesses risk and ensures engineering controls and/or appropriate PPE are used for worker and public protection	• Approves APPs/SSHPs and all modifications before issuance to the USACE • Manages H&S Program and directs training and required attendance • Investigates safety concerns raised by staff • Investigates any accidents • Stops work for non-compliance/safety violation
Community Relations Specialist	• Lisa Stahl • Ms. Stahl is a senior community relations specialist/anthropologist with 17 years professional experience that includes active participation on projects in New Mexico. Ms. Stahl provided public involvement and social science support for efforts at both the Los Alamos National Laboratory as well as Pueblo of Isleta. • She has 17 years of experience working with a variety of assessment tools and information; establishing positive working relationships with multiple stakeholders; and preparing and distributing various bilingual outreach materials to a variety of end-users. • Ms. Stahl specializes in identifying and facilitating community perspectives into program and policy processes through active involvement and regular communication with members of the community. She is also skilled at writing innovative public participation strategies tailored and targeted to the specific needs and concerns of the community. • Her various experiences have included liaison activities between project staff and communities, conducting community assessments, evaluating various public programs, and providing community involvement support to a variety of government clients.	• Performs community outreach to facilitate offsite drilling program • Establishes and maintains regular communication regarding project and field efforts with the all members of community • Plans, organizes, and participates in public meetings regarding the project., including working with all applicable parties to prepare for public meetings • Prepares and advertises public notices as necessary • Prepares project fact sheets and facilitates distribution of fact sheets and other presentation materials • Performs research and community interviews to gather needed information	• Reports updates to project manager • Coordinates public meetings in concert with project manager • Maintains list of team personnel who have authority to conduct community interviews • Stops work for non-compliance/safety violation

Table 8-1. Project Team Roles and Responsibilities (Concluded)

Role	Subcontractor	Duties and Responsibilities	Authority Level
Driller	Water Development Corporation	• Installs groundwater, soil vapor monitoring, and soil vapor extraction wells • Uses direct push methods to advance soil borings • Collects continuous soil samples • Collects soil vapor samples	• Stops work for non-compliance/safety violation
Laboratory	Empirical Laboratories, LLC – groundwater sample analysis Gulf Coast Analytical Laboratories, Inc. – soil sample analysis RTI Laboratories – soil vapor sample analysis	• Conducts analytical services in accordance with the UFP-QAPP and DoD QSM • Provides analytical data in electronic PDF format • Provides ERPIMS-formatted deliverables	• Stops work for non-compliance/safety violation
Transportation and Disposal	Rhino	• Furnishes trucks, drivers, and all associated services required for transporting hazardous waste oil mixtures from Kirtland AFB to an offsite disposal facility • Ensures compliance with federal, state, and local environmental regulations • Provides all equipment and materials required for performing work at the disposal site	• Stops work for non-compliance/safety violation

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APPENDIX A

2010 Regulatory Correspondence between NMED HWB and the Air Force regarding the Kirtland AFB BFF Spill

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ATTACHMENT 1

April 2, 2010 Correspondence from NMED HWB
to Colonel Michael S. Duvall, Base Commander, 377 ABW/CC
Re: SWMUs ST-106 and SS-111, BFF Spill, Kirtland, AFB

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AR Doc # 3451

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CERTIFIED MAIL - RETURN RECEIPT REQUESTED

April 2, 2010

APR 19 2010

Colonel Michael S. Duvall
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Mr. John Pike
Director, Environmental Management Section
377 MSG/CEANR
2050 Wyoming Blvd., Suite 116
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RE: SOLID WASTE MANAGEMENT UNITS ST-106 AND SS-111, BULK FUELS FACILITY SPILL
KIRTLAND AIR FORCE BASE
EPA ID# NMD9570024423, HWB-KAFB-10-004

Dear Colonel Duvall and Mr. Pike:

As you are aware, the U. S. Department of Defense Kirtland Air Force Base ("Permittee") is conducting an investigation of contaminated groundwater at the Bulk Fuels Facility Former Fuel Offloading Rack (Solid Waste Management Unit ["SWMU"] ST-106) and the associated Light Non-Aqueous Phase Liquid ("LNAPL") plume (SWMU SS-111, or Phase-Separated Hydrocarbon Bulk Fuels Facility Remediation) (collectively, the "Bulk Fuels Facility Spill"). Data submitted by the Permittee show that the contamination caused by the Bulk Fuels Facility Spill represents a significant threat to human health and the environment, particularly to well water in urban neighborhoods adjacent to Kirtland Air Force Base ("KAFB"). Despite the fact that this release of hazardous constituents was first discovered 10 years ago, the Permittee has not completely characterized the Bulk Fuels Facility Spill, nor conducted adequate remediation.

As stated in the New Mexico Environment Department ("Department") Ground Water Quality Bureau ("GWQB") letter enclosed with this letter, the GWQB has transferred oversight of the Bulk Fuels Facility Spill to the Hazardous Waste Bureau ("HWB"), which will direct corrective action at the Bulk Fuels Facility Spill pursuant to the New Mexico Hazardous Waste Act ("HWA") NMSA 1978, §74-4-1 to 74-4-14 and the Hazardous Waste Management Regulations ("HWMR", 20.4.1 NMAC).

Releases of hazardous waste or hazardous constituents are subject to corrective action under Sections 3004(u) and (v) and 3008(h) of the Resource and Conservation Recovery Act "RCRA"; 42 U.S.C. §§ 6924(u) and (v) and 6928(h); Sections 74-4-4(A)(5)(h) and (i), 74-4-4.2(B), and 74-4-10(E) of the HWA; and the HWMR at 40 C.F.R. Part 264, Subpart F (incorporated by 20.4.1.500 NMAC).

Pursuant to 20.4.1 NMAC incorporating 40 CFR § 264.101(a), the Permittee must institute corrective action as necessary to protect human health and the environment for all releases of hazardous waste or constituents from any SWMU. Additionally, in accordance with 20.4.1 NMAC incorporating 40 CFR § 264.101(c), the Permittee must implement corrective actions beyond the facility boundary.

Section R.5 of the Hazardous and Solid Waste Amendments ("HSWA") Module IV of the Permittee's RCRA Permit states:

> The Permittee shall conduct those investigations of SWMUs previously identified with known or suspected releases of contamination as necessary to protect human health and the environment to: characterize the facility (Environmental Setting); define the source (Source Characterization); define the degree and extent of contamination (Contamination Characterization); and to identify actual or potential receptors.

Additionally, pursuant to Section R.5(b):

> The Permittee shall collect analytical data to completely characterize the waste and areas where waste have been placed, including: type, quantity, physical form, disposition (containment or nature of deposits), and the facility characteristics affecting releases.

And, in accordance with Section R.5(c):

> The Permittee shall collect analytical data on groundwater, soils, surface water, sediment, and subsurface gas contamination when necessary to characterize contamination from a SWMU. The data shall be sufficient to define the extent, origin, direction and rate of movement of the contaminant plumes.

Therefore, in accordance with Section K.1 of the HSWA Module IV of the Permittee's RCRA Permit, the Permittee is directed to immediately implement interim measures to remediate the LNAPL plume, to excavate and remove structures and contaminated soil in the vadose zone at and in the vicinity of the Former Fuel Offloading Rack, to install additional wells, and continue operation of the existing soil-vapor extraction units as directed below. Additionally, pursuant to Section R.5 of Module IV of the Permit, the Permittee is directed to immediately complete characterization of contaminated soil and soil-gas in the vadose zone, and to immediately complete characterization of the dissolved-phase contamination in groundwater. Furthermore, in accordance with Section M.1 of Module IV of the Permit, the Permittee will be directed by NMED to conduct one or more Corrective Measures Evaluations. The Permittee shall comply with the detailed instructions specified below by the indicated deadlines.

A. REQUIREMENT FOR COMPLETING CHARACTERIZATION OF CONTAMINATION IN THE VADOSE ZONE

The Department finds that contaminant characterization is inadequate at the tank farm, the piping extending from the tank farm to the Former Fuel Offloading Rack, and areas in the vicinity of the Former Fuel Offloading Rack. More specific details on this finding are presented in the next two paragraphs.

Based on information provided by the Permittee, only four soil borings have been completed at the fuel tanks and no borings have been completed along the ancillary piping leading from the fuel tanks to the Former Fuel Offloading Rack. The four soil borings at the tanks were completed to shallow depths ranging from 25-48 feet. Diesel Range Organics ("DRO") contamination was detected in all four boreholes, with the highest concentrations (1800-2400 mg/kg) found in borehole SB-09. A number of hazardous constituents were also detected in soil samples from SB-09 and SB-06. Despite these findings, the Permittee did not determine the extent of contamination near the tanks. The latter is particularly notable given that the Permittee's *Stage 1 Abatement Plan Report* (February 8, 2006) contains the following recommendation (in Section 4.4):

> It is recommended that additional field investigation at the east side of the Bulk Fuels Facility be conducted to determine the full extent of petroleum hydrocarbons in soil and soil vapor beneath Tank 2422...Additional investigation will also determine whether release(s) associated with this tank are the source of sorbed-phase and vapor-phase petroleum hydrocarbons previously indentified in distal monitoring wells SVMW-13 and SVMW-15.

To date, the Permittee has not conducted the additional field investigation to determine the full extent of petroleum hydrocarbons and hazardous constituents in soil and soil vapor around the Bulk Fuels Facility.

The Permittee has also not completed characterization of the contaminated soil in the vicinity of the Former Fuel Offloading Rack, as previous investigative efforts seem to have been arbitrarily terminated once Total Petroleum Hydrocarbons ("TPH") concentrations in soil were found to be less than 100 mg/kg. Additional soil borings should have been completed to investigate the full extent of soil contamination above background levels regardless of the concentration levels of the contaminants. Similarly, characterization of soil-gas contamination near the Former Fuel Offloading Rack is inadequate; investigative efforts appear to have been terminated once TPH concentrations were found to be below 1000 ppmv in the area. Additional soil-gas monitoring wells should have been installed to investigate the full extent of soil-gas contamination from the surface to groundwater, even in areas where the contamination is less than 1000 ppmv.

Thus, the Permittee has not adequately characterized LNAPL contamination in the vadose zone. Characterization must be complete to design and implement an appropriate final remedy. Accordingly, pursuant to the deadlines established below, the Permittee must:

1. Determine the amount of fuel that exists within the vadose zone as sorbed or residual liquid, or as soil gas.
2. Identify the source of the LNAPL fuel plume.
3. Describe the vadose zone hydrology, its relationship to observed and potential to-be-discovered groundwater contamination, and the potential for continuing contamination of groundwater by vadose zone contamination sources.
4. Characterize the geology and extent of contamination in the soil and soil gas to determine distribution, fate, and migration of contaminants.

Therefore, on or before **June 7, 2010**, the Permittee must submit to the Department for its review and approval a Vadose Zone Investigation Plan that describes the additional actions the Permittee will take to investigate the vadose zone hydrology and geology of the affected area, to identify and characterize the source of the releases at the Bulk Fuel Facility, and to identify the extent of soil and soil-gas contamination in the vadose zone from the surface to groundwater. The area covered under this Vadose Zone Investigation Plan must include the tank farm and the ancillary piping between the farm and the Former Fuel Offloading Rack. The Vadose Zone Investigation Plan must describe in detail all research, locations, depths and methods of exploration, field procedures, sampling and analysis of soil and soil gas and related quality control procedures. The Vadose Zone Investigation Plan shall also describe the results and the means (for example, cross-sections, plan views) by which these results will be reported after the investigation is completed, and a schedule for implementation of the work that complies with the compliance schedule in Table 1 of this letter.

Table 1. Compliance Schedule for Vadose Zone Investigation

Task	Date Due
Submit Vadose Zone Investigation Plan to the Department	June 7, 2010
Complete all subsurface-soil sampling and installation of all soil-gas monitor wells	Within 12 months after Department approval of Vadose Zone Investigation Plan

Report results for subsurface-soil sampling	Within 15 months after Department approval of Vadose Zone Investigation Plan
Complete first four quarters of soil-gas sampling and analysis	Within 24 months after Department approval of Vadose Zone Investigation Plan
Soil-gas sampling	Quarterly after well installations completed
Submit quarterly soil-gas monitoring reports to the Department	60 days after the quarter during which sampling occurred

Furthermore, in addition to any other locations the Permittee identifies, the locations listed in Table 2 of this letter shall be included in the Vadose Zone Investigation Plan and must be sampled for contaminants in soil and soil gas (all coordinates in this table are State Plane Coordinates in feet, NAD83). Soil samples shall be collected at a frequency of at least one sample every 10 feet for the first 50 feet, and at least one sample thereafter every 50 feet to total depth, and at least one sample at total depth in each boring. Each boring at each location shall be drilled from the surface to the water table, and each boring shall be completed as a permanent soil-gas monitoring well. All of the soil-gas monitoring wells shall be capable of yielding discrete samples of soil gas recovered from depths of 25, 50, 150, 250, 350, and 450 feet below the ground surface. While the Permittee shall continue to analyze samples for TPH and hazardous constituents, the investigation shall not be limited to only those areas containing or suspected to contain TPH at concentrations of greater than 100 mg/kg (100 ppm) in soil or 1000 ppmv in soil gas. Instead, investigation of the Bulk Fuels Facility Spill shall be designed to determine the full extent of contamination above background levels regardless of contaminant concentration levels.

Table 2. Borehole locations for soil sampling and for conversion to soil-gas monitoring wells.

Location #	Easting	Northing	Characterization Purpose
1	1541119	1473793	Step out from Fuel Offloading Rack beyond 100 mg/kg contaminated zone
2	1540808	1473503	Step out from Fuel Offloading Rack
3	1541123	1473310	Step out from Fuel Offloading Rack
4	1541425	1473313	Step out from Fuel Offloading Rack
5	1541961	1473492	Path from Fuel Offloading Rack to LNAPL Plume
6	1542002	1473057	Piping
7	1541794	1473061	Piping
8	1542370	1473058	Piping
9	1541898	1473276	Path from Fuel Offloading Rack to LNAPL Plume
10	1541720	1473369	Step out from Fuel Offloading Rack

11	1541776	1473740	Step out from Fuel Offloading Rack
12	1541658	1473505	Path from Fuel Offloading Rack to LNAPL Plume
13	1542061	1472928	Fuel tanks
14	1542063	1472775	Fuel tanks
15	1542142	1472847	Fuel tanks
16	1541982	1472845	Fuel tanks
17	1542330	1472796	Fuel tanks
18	1542430	1472897	Fuel tanks
19	1542516	1472810	Fuel tanks
20	1542428	1472716	Fuel tanks
21	1541611	1473238	Piping

In addition to any other location identified by the Permittee, the locations listed in Table 3 of this letter shall also be included in the Vadose Zone Investigation Plan to be sampled for contaminants in soil gas (all coordinates in this table are State Plane Coordinates in feet, NAD83). Each boring at each location listed in Table 3 shall be completed as a permanent soil-gas monitoring well. All of the soil-gas monitoring wells shall be capable of yielding discrete samples of soil gas recovered from depths of 25, 50, 150, 250, 350, and 450 feet below the ground surface.

Table 3. Locations for soil-gas monitoring wells.

Location #	Easting	Northing	Characterization Purpose
1	1543058	1474093	Characterize outside of LNAPL Plume
2	1543194	1474680	Characterize outside of LNAPL Plume
3	1542306	1474093	Characterize within LNAPL Plume
4	1541555	1475049	Characterize outside of LNAPL Plume
5	1541248	1474141	Characterize outside of LNAPL Plume
6	1542259	1472591	Characterize outside of LNAPL Plume
7	1540667	1472823	Characterize outside of LNAPL Plume
8	1542525	1475459	Characterize within LNAPL Plume
9	1542436	1474878	Characterize within LNAPL Plume

B. REQUIREMENT FOR COMPLETING CHARACTERIZATION OF DISSOLVED-PHASED CONTAMINANTS IN GROUNDWATER

The Permittee has not adequately characterized the dissolved-phase contamination in the groundwater and has not analyzed groundwater samples from wells located in the LNAPL plume area. The final remedy for the Bulk Fuels Facility Spill cannot be determined until this characterization work has been completed. Additionally, the Permittee has not installed any groundwater monitoring wells to investigate the vertical extent of the dissolved-phase groundwater contamination, the effects of vertical gradients, and the geology of the aquifer at any appreciable depth below the water table. The dissolved-phase plume is approaching one or more

Water Utility Authority well fields. Given that the pumping of water supply wells is known to induce vertical gradients in groundwater and can cause significant components of vertical flow in the vicinity of such wells, vertical characterization of groundwater quality and geology is required.

The leading edge and the eastern and western margins of the plume are undefined, and the nature and concentrations of contaminants in the core of the plume are poorly characterized because existing wells are located too far apart (generally at distances greater than 500 feet). Additionally, only one upgradient well has been installed that may yield groundwater samples that are free from contamination. Given the magnitude of this spill, several upgradient wells should be installed that are screened at different depths at and below the water table to ensure that all areas of contaminated groundwater have been located, and that the background wells are truly monitoring background water quality.

Therefore, on or before **July 7, 2010**, the Permittee must submit to the Department for its review and approval a Groundwater Investigation Plan that describes the additional actions the Permittee will take to characterize the nature, horizontal and vertical extent, and the fate and rate of migration of the groundwater contamination. The Groundwater Investigation Plan shall include construction details and the locations and depths of the groundwater monitoring wells to be installed, actions to characterize the geology and hydrogeology at and below the water table, and the groundwater flow direction and velocity. The plan shall also present details on field procedures, and the sampling and analysis of groundwater and related quality control. The Groundwater Investigation Plan shall describe the results, the means (*e.g.*, cross-sections, plan views) by which these results will be reported after the investigation is completed, and a schedule for implementation of the work that complies with the compliance schedule in Table 4 of this letter.

Table 4. Compliance Schedule for Groundwater Investigation

Task	**Date Due**
Submit Groundwater Investigation Plan to the Department	July 7, 2010
Complete installation of all wells	Within 12 months after Department approval of Groundwater Investigation Plan
Submit well installation report to the Department	Within 15 months after Department approval of Groundwater Investigation Plan
Complete first eight quarters of groundwater sampling and analysis	Within 36 months after Department approval of Groundwater Investigation Plan

Groundwater Sampling	Quarterly after well installations completed
Submit quarterly groundwater monitoring reports to the Department	60 days after the quarter during which sampling occurred

In addition to any locations the Permittee identifies, the Groundwater Investigation Plan shall also include a description of the installation of groundwater monitoring wells at the locations listed in Table 5 of this letter (all coordinates in this table are State Plane Coordinates in feet, NAD83). Three groundwater monitoring wells shall be installed at each of the cluster well locations listed in Table 5. The screen depths shown in Table 5 are distances (in feet) that the top of the screens shall be set below the water table. Screen lengths for wells shall not exceed 15 feet, with the exception that wells screened across the water table (those with screen depths of zero in Table 5) shall have screens 20 feet long, with no more than 15 feet of said screen length situated below the water table.

In addition to any other tools the Permittee identifies, the Groundwater Investigation Plan shall also include details describing the geophysical logging of all existing and new wells using induction (deep), neutron, and gamma (large crystal) tools. Geophysical logging at the cluster well locations listed in Table 5 is required in only the well at each location having the deepest screened interval.

Table 5. Cluster well locations and screen depths relative to the water table.

Location #	Easting	Northing	Screen Depths	Characterization Purpose
1	1542189	1476725	0, 15, 40	Plume margin
2	1541984	1476042	0, 15, 40	Plume margin
3	1543703	1476600	0, 15, 40	Plume margin
4	1543372	1475065	0, 15, 40	Plume margin
5	1543643	1477939	0, 15, 85	Leading edge and deep characterization
6	1541430	1472370	0, 15, 40	Background water quality
7	1542812	1473601	0, 15, 40	Plume margin
8	1542722	1477726	0, 15, 40	Leading edge
9	1543054	1477788	0, 15, 40	Leading edge
10	1543774	1477304	0, 15, 40	Leading edge
11	1541774	1473718	0, 15, 85	Plume core, deep delineation
12	1542362	1473801	0, 15, 85	Plume core, deep characterization
13	1542305	1474340	0, 15, 85	Plume core, deep characterization
14	1542736	1474715	0, 15, 85	Plume core, deep characterization
15	1542860	1475860	0, 15, 85	Plume core, deep characterization
16	1542189	1475207	0, 15, 85	Plume core, deep characterization
17	1541891	1473151	0, 15, 85	Plume core, deep characterization
18	1542203	1474071	0, 15, 85	Plume core, deep

				characterization
19	1542653	1475338	0, 15, 85	Plume core, deep characterization
20	1542535	1475975	0, 15, 85	Plume core, deep characterization
21	1543199	1475767	0, 15, 85	Plume core, deep characterization
22	1543068	1476494	0, 15, 85	Plume core, deep characterization

C. REQUIREMENT FOR INTERIM MEASURES

In its October 28, 2009 letter, the GWQB wrote:

> The New Mexico Environment Department (NMED) has determined, based on information generated by Kirtland Air Force Base (KAFB) during its investigations, that the scale and observed impact of the Light Non-Aqueous Phase Liquid (LNLAP) hydrocarbon contamination of groundwater associated with the SS-111 Bulk Fuels Facility constituting the majority of the KAFB ST-106 LNAPL plume has been largely defined. This plume of LNAPL hydrocarbons has been found to have contaminated groundwater over a substantial area that is the source of drinking water supplies for the City of Albuquerque and is also located in the vicinity of several public water supply wells. The volume of LNAPL hydrocarbons on groundwater, which has been estimated by KAFB to be in the millions of gallons, will take a substantial period of time to remediate. Currently, the majority of the LNAPL hydrocarbon plume is located off of KAFB property and is not being actively remediated.

The Permittee's records indicate that the LNAPL and dissolved-phase plumes have migrated horizontally a distance of about 0.5 mile and 0.9 miles, respectively, from the area of the Former Fuel Offloading Rack.

Interim measures are required to reduce or prevent the migration of contaminants, or to reduce or prevent human or environmental exposure to contaminants while long-term corrective action remedies are evaluated and implemented. Section K.1 of the HSWA Module IV of the Permit states:

> If during the course of any activity initiated under this module, the Administrative Authority determines that a release or potential release of hazardous constituents from a SWMU poses a threat to human health and the environment, the Administrative Authority may specify interim measures. The Administrative Authority will determine the specific measure, including potential permit modifications, and the schedule for implementing the required measures.

Additionally, Section K.2 of Module IV of the Permit states:

The following factors may be considered by the Administrative Authority in determining the need for interim measures.

1. Time required to develop and implement a final remedy;
2. Actual and potential exposure to human and environmental receptors; and
3. The potential for the further degradation of the medium absent interim measures.

The Department has determined that the Bulk Fuel Facility Spill poses a threat to human health and the environment, and furthermore, endangers the groundwater resource – including water supply wells – relied upon by the Albuquerque Bernalillo County Water Utility Authority for delivery of safe drinking water to its customers. The contamination also threatens KAFB water supply wells, and those that supply the Veterans Administration ("VA") Hospital. The large size of the LNAPL plume and its proximity to these water supply wells requires that urgent action be taken to prevent the LNAPL plume from contaminating more of Albuquerque's drinking-water supply.

The Permittee has estimated the volume of fuel released from the Bulk Fuels Facility to range from about 1-2 million gallons, but the actual volume could be considerably larger because characterization of the vadose zone is inadequate. For example, the Department has estimated the volume of sorbed fuel at or greater than 100 ppm in soil to be about 4.8 million gallons; this does not include fuel in soil gas, fuel dissolved in groundwater, and floating fuel forming the LNAPL plume. The Department has estimated the fuel included in the LNAPL plume to be approximately 3 million gallons, giving a total volume of fuel sorbed to soil and that contained within the LNAPL plume at nearly 8 million gallons. The Permittee's records indicate that it has installed and is operating "interim ICE SVE" units on the Permittee's property; however, these four soil-vapor extraction (SVE) units are not an adequate interim measure to address the existing ground water contamination, including the LNAPL plume that has migrated beyond the facility boundary. From April 2003 to September 2009, these SVE units have extracted an estimated 286,600 gallons of fuel. From April through September 2009, the average extraction rate has declined by 25 per cent. The average extraction rate for each SVE unit is about 2,975 gallons per month.

At the rate of extraction achieved so far by the existing SVE units, the operation of these units would take over 14 years to remove 2 million gallons of fuel. This length of time is unacceptable because additional groundwater within the capture zone of Water Utility Authority water supply wells could become contaminated before the remediation could be completed. Furthermore, should the Department's calculations prove to be more accurate than the Permittee's estimated volume of fuel, it would take over 56 years for the remediation of the fuel to be completed.

Additionally, although the Permittee knows that considerable volumes of fuel have leaked from the Former Fuel Offloading Rack, the Permittee has not removed all of the structures associated with the Former Fuel Offloading Rack (mostly the underground portions of the original structures), and has not excavated and removed contaminated soil around the Former Fuel Offloading Rack. The Permittee has instead abandoned the structures and contaminated soil in place. Soil containing considerable amounts of sorbed fuel, thus containing high concentrations of hazardous constituents, must exist at the Former Fuel Offloading Rack at shallow depths, posing a continuing source of contamination and threat to the groundwater resource.

Therefore, on or before **June 7, 2010,** the Permittee must submit to the Department for its review and approval an Interim Measures ("IM") Plan that describes what immediate actions it will take to remediate and stop the migration of the LNAPL plume. The IM Plan must also describe excavation and removal of all structures of the Former Fuel Offloading Rack, including the underground components, and the excavation and removal of contaminated soil at and in the vicinity of the Former Fuel Offloading Rack to a depth of at least 20 feet. The IM Plan must also include an implementation schedule showing that remediation of the LNAPL plume will be completed within five years of the Department's approval of the IM Plan, and that excavation and removal of structures and contaminated soil at and in the vicinity of the Former Fuel Offloading Rack will be completed within one year of the Department's approval.

Furthermore, on March 16, 2010, the Permittee sent a *Stage 2 Abatement Plan Modification Addendum* (dated March 16, 2010) concerning the proposed installation of three additional offsite groundwater monitoring wells. The March 16 submittal does not address the deficiencies identified by the GWQB in its letters of June 23 and October 28, 2009. This plan would not adequately characterize the LNAPL plume, the dissolved-phase groundwater contamination, or contaminated soil and soil gas at the Bulk Fuels Facility. However, given the urgency to complete characterization and implement an effective remedy, the NMED nevertheless approves the March 16, 2010, submittal as a second and separate interim measure, subject to the modifications described herein:

1. The March 16 plan proposes that well screens are to be constructed with lengths of 25 feet or more. Screen lengths for the wells shall not exceed 20 feet, with 15 feet of screen situated below the water table, and 5 feet of screen constructed above the water table.
2. The March 16 plan proposes that wells completed in the area of the LNAPL plume will not be developed after installation, and proposes that groundwater samples will not be acquired for laboratory analysis from wells located within the area of the LNAPL plume. Although existing wells within the area of LNAPL plume have in the past served only as sampling points to measure LNAPL thickness and as soil-vapor extraction points, these wells must now also be available to sample groundwater below the floating LNAPL so that concentrations of dissolved-phase contaminants can be assessed in this area. This same requirement will also apply to all future wells installed to address the Bulk Fuels Facility Spill, including the wells required under this letter. Thus, all wells that address the Bulk Fuels Facility Spill, including those located within the LNAPL

plume area, shall be properly developed to reduce turbidity and to remove residual drilling fluids (if any).

3. Groundwater at all wells within the LNAPL plume shall be sampled for laboratory analysis of hazardous constituents (volatile and semi-volatile organic compounds) and TPH after the wells are developed.
4. Proposed wells KAFB-10626 and KAFB-10628 shall be installed across the water table at the locations proposed in the March 16 plan. These two wells correspond to locations #5 and 13, respectively, in Table 5 above.
5. Proposed well KAFB-10627 shall be installed at location #6 listed in Table 5 above, which is a different location than that proposed by the Permittee in the March 16 submittal.
6. A tremie pipe shall be used to install the filter pack and seal for each well, and to place grout.
7. Grout shall be placed in lifts, with the first lift no greater than 100 feet in length and subsequent lifts no greater than approximately 200 feet. All lifts shall be allowed to dry until stable before the next lift is placed.
8. The March 16 plan does not contain a schedule for implementation. The March 16, 2010, plan shall be implemented **within two weeks** of approval from the City of Albuquerque to access the City property (e.g., Bullhead Park), to the extent access from the City is required for well installation. The Permittee shall otherwise implement the submittal **immediately**. All work shall be completed no later than **July 6, 2010**, or **90 days** after required access from the City is granted, whichever is later. Completion includes development of all new and existing wells that have not been previously developed, and the sampling of all wells within the LNAPL plume.
9. Sampling results (from item #3) above shall be reported to the NMED in writing on October 5, 2010, or 120 days after required access from the City is granted, whichever is later.

Table 6. Compliance Schedule for Interim Measures

Task	Date Due
Submit Interim Measures Plan to the Department	June 7, 2010
Complete excavation and removal of structures and soil at Former Fuel Offloading Rack	Within one year of approval of Interim Measures Plan
Complete remediation of LNAPL plume	Within five years of approval of Interim Measures Plan

Implement March 16, 2010 Stage 2 Abatement Plan Modification Addendum with required modifications	Immediately, except within two weeks of gaining permission for that portion of the March 16 Plan that requires access to City property.
Submit report to the Department on well installations conducted under March 16 Plan	July 6, 2010, or 90 days after required access from the City is granted, whichever is later
Submit report to the Department on groundwater sampling results conducted under March 16 Plan	October 5, 2010, or 120 days after required access from the City is granted, whichever is later

Until such time that the IM Plan is approved by the NMED, the Permittee shall continue to operate the four SVE units already in service 24 hours per day, 7 days a week, except when necessary to perform maintenance or repairs. If maintenance or repairs are necessary, the maintenance or repairs shall be completed as quickly as practicable, and the unit returned to service immediately after maintenance or repairs are completed. Any maintenance or repairs that will take more than 3 calendar days shall be reported in writing to the Department within 24 hours of discovery that the maintenance or repairs will take more than 3 days. The Permittee shall explain in the report why the maintenance or repairs will take more than 3 calendar days and why the delay is beyond the control of the Permittee.

D. REQUIREMENT TO CONDUCT A CORRECTIVE MEASURES EVALUATION

In accordance with Section M.1 of HSWA Module IV of the Permit, if the Administrative Authority has reason to believe that a SWMU has released concentrations of hazardous constituents, or if the Administrative Authority determines that contaminants present a threat to human health and the environment given site-specific exposure conditions, the Administrative Authority may require a Corrective Measures Study (herein referred to a Corrective Measures Evaluation, or "CME"). With this letter, the Department hereby notifies the Permittee that it is required to conduct a CME for the Bulk Fuels Facility Spill. The CME shall be conducted to develop remedial alternatives that, if implemented, would be appropriate to effectively arrest and remediate contamination in the vadose zone, the LNAPL plume, and the dissolved-phase groundwater contamination in a reasonable period of time. A CME Report shall be prepared that describes in detail the results of the CME. The CME Report shall be submitted to the Department within 180 days after the Department notifies the Permittee that characterization of the Bulk Fuels Facility Spill has been completed and approved by the Department. The CME and CME Report shall also be completed in accordance with Sections O and S of HSWA Module IV of the Permit.

E. REPORTING REQUIREMENTS

The investigation plans required under this letter shall include relevant maps and cross-sections that show concentration data for contaminants and other relevant information with supporting data posted on the maps and cross-sections in a legible manner, and clearly showing which borings/wells contributed data towards construction of the maps and cross-sections and which did not. Tables including all existing soil borings, soil-gas monitoring wells, and groundwater monitoring wells, listing their surveyed location, sampling points and maximum depth of exploration shall also be included in the reports and plans. For soil-gas monitoring wells, tables and graphs shall also be included providing trends of TPH concentrations versus time for the depths below ground surface of 25, 50, 150, 250, 350, and 450 feet.

F. CONCLUSIONS

The requirements in this letter to conduct corrective action at the Bulk Fuel Facility Spill are mandatory. If the Permittee fails to comply with the directives of this letter, the Department may take the following actions, or some combination of the following actions, to enforce these requirements: 1) issue a compliance order under section 74-4-10 of the HWA seeking injunctive relief or civil penalties for noncompliance; 2) file a civil action under sections 74-4-10 and 74-4-10.1(E) of the HWA or section 7002(a) of RCRA, 42 U.S.C. § 6972(a), seeking injunctive relief or civil penalties; or 3) file an action seeking criminal penalties under section 74-4-11 of the HWA. This list of authorities is not exhaustive and NMED reserves its rights to take any action authorized by law to enforce the requirements of the HWA and the HWMR.

The Permittee shall respond directly to my attention, with copy to Mr. Bill Olson of the GWQB, and Mr. William Moats (NMED HWB, 5500 San Antonio NE, Albuquerque, NM 87109), on all correspondence and required plans and reports related to the Bulk Fuels Facility Spill upon receipt of this letter, unless otherwise directed by HWB. All submittals and correspondence must be submitted in hardcopy and electronic format. Assessment of fees for the submittal of corrective action documents pursuant to 20.4.2. NMAC shall be made under separate cover.

If you have any questions or comments concerning the technical matters in this letter, you may contact William McDonald or Sid Brandwein of my staff at (505) 222-9582 and (505) 222-9504, respectively. If you have other questions or comments, I may be contacted directly at 505-476-6000.

Sincerely,

James P. Bearzi
Chief
Hazardous Waste Bureau

cc: M. Leavitt, Director, NMED WWMD
J. Kieling, NMED HWB
W. Moats, NMED HWB
B. McDonald, NMED HWB
S. Brandwein, NMED HWB
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A. Puglisi, NMED GWQB
B. Swanson, NMED GWQB
L. Barnhart, NMED OGC
B. Gallegos, AEHD
B. Gastian, ABCWUA
L. King, EPA-Region 6

File: Reading and KAFB 2010

ATTACHMENT 2

August 6, 2010 Correspondence from NMED HWB to Colonel Robert L. Maness, Base Commander, 377 ABW/CC Re: SWMUs ST-106 and SS-111, BFF Spill, Kirtland, AFB

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CERTIFIED MAIL - RETURN RECEIPT REQUESTED

August 6, 2010

Colonel Robert L. Maness
Base Commander
377 ABW/CC
2000 Wyoming Blvd. SE
Kirtland AFB, NM 87117-5606

Mr. John Pike
Director, Environmental Management Section
377 MSG/CEANR
2050 Wyoming Blvd., Suite 116
Kirtland AFB, NM 87117-5270

**RE: BULK FUELS FACILITY SPILL, SWMUS ST-106 AND SS-111
DIRECTIVE FOR CONDUCTING INTERIM MEASURES AND NOTICE OF DISAPPROVAL
INTERIM MEASURES WORK PLAN, JUNE 2010;
VADOSE ZONE WORK PLAN, JUNE 2010;
GROUNDWATER INVESTIGATION WORK PLAN, JUNE 2010
KIRTLAND AIR FORCE BASE, EPA ID# NM9570024423
HWB-KAFB-10-015, HWB-KAFB-10-016, HWB-KAFB-10-019**

Dear Col. Maness and Mr. Pike:

The contamination caused by the Bulk Fuels Facility Spill at Kirtland Air Force Base (KAFB) represents a significant threat to human health and the environment, particularly to well water that supplies drinking water to portions of Albuquerque, KAFB, and the Veterans' Administration Hospital. Even though this release was first discovered 10 years ago, the U. S. Air Force (Permittee) has not characterized the nature and extent of Bulk Fuels Facility Spill, nor conducted adequate remediation. The threat posed by this release demands immediate and aggressive action as called for in the New Mexico Environment Department's (NMED's) April 2, 2010 letter.

The NMED has reviewed the Interim Measures Work Plan (June 2010), Vadose Zone Work Plan (June 2010), and Groundwater Investigation Work Plan (June 2010) regarding the KAFB Bulk Fuels Facility Spill, Solid Waste Management Units (SWMUs) ST-106 and SS-111. The plans were submitted in response to the NMED's letter of April 2, 2010, which concerned the need for additional site characterization and interim measures to remediate contamination in groundwater, source areas, and fuel floating on the water table.

NMED finds that all three plans are deficient. This Notice of Disapproval (NOD) is issued to the Permittee with the intent that the Permittee correct the deficiencies identified herein. This NOD includes general comments that apply to all three documents, and general and specific comments concerning deficiencies found in each of the individual plans. These comments comprise Part 1 of this letter.

Due to the urgent need to accelerate certain aspects of remediation and characterization, the Permittee is also directed herein to implement interim measures in the form of additional soil vapor extraction and to take various other actions including establishing sentry groundwater monitoring wells and providing NMED certain critical information. This direction comprises Part 2 of this letter, and also sets forth requirements related to well construction, sampling of environmental media, field and laboratory quality assurance, and reporting.

PART 1

A. Deficiencies Common to All Three Plans

1. Appendix A of the Vadose Zone and Interim Measures Work Plans and Appendix D of the Groundwater Investigation Work Plan – Appendix A and Appendix D are exactly the same plan (about 500 pages, dated April 2004), appended to and occupying 80% or more (by number of pages) of the Vadose Zone, Interim Measures, and Groundwater Investigation Work Plans. Although the plan presented in Appendices A and D is voluminous, it is only a general plan that lays out the Permittee's internal requirements for conducting corrective action for the entire base. Furthermore, the copies of this plan provided to the NMED are missing figures (Figure 3-4), have their own appendices that are noted as "to be provided at a later date", and, in places, have outdated information (Table B7.2-1, page B-177 of Appendix B of Appendix A).

Because Appendices A and D are not specific to the Bulk Fuels Facility Spill, they do not describe in sufficient detail how, for example, project organization, data management, and quality assurance will be implemented under the Vadose Zone, Groundwater Investigation, and Interim Measures Work Plans. For example, under the project management plan, the organizational chart only shows KAFB management. The field sampling plan discusses the various types of field quality control (QC) samples that could be utilized during an investigation, but does not set forth the specific types of QC samples that should be prepared or collected for the Bulk Fuels Facility Project. Furthermore, because it is only a general plan for the entire base, the plan does not commit to the collection of QC samples for any project.

Appendices A and D must be deleted from the Vadose Zone, Groundwater Investigation, and Interim Measures Work Plans. They have little value because they do not contain the appropriate level of detail for characterization and clean up of the Bulk Fuels Facility Spill and do not commit the Permittee to do anything. The Permittee shall revise the Vadose Zone, Groundwater Investigation, and Interim Measures Work Plans to include the appropriate level of detail and commitment on project organization, data management, and field and laboratory quality assurance.

2. Appendix B of the Vadose Zone and Interim Measures Work Plans and Appendix A of the Groundwater Investigation Work Plan – These appendices include only a 2006 NMED guidance document. The guidance is outdated and adds little, if any, value to the Vadose Zone, Interim Measures, and Groundwater Investigation Work Plans, and thus, must be deleted from all three plans. NMED guidance documents may be cited, if necessary, in future submittals.

3. Community Relations - The community relations plan is not included in Appendix A of the Vadose Zone and Interim Measures Work Plans and Appendix D of the Groundwater Investigation Work Plan. Instead, the appendices state "*Appendix I, Community Relations Plan, (to be provided at a later date)*". The Permittee shall revise the Vadose Zone, Interim Measures, and Groundwater Investigation Work Plans to include a community relations plan specific to the Bulk Fuels Facility spill. The plan must specify how the Permittee will inform the public, including the Albuquerque Bernalillo County Water Utility Authority (WUA), the City of Albuquerque, and the Veterans Administration of progress made on characterization and clean up of the Bulk Fuels Facility spill.

4. Schedules – Characterization and clean up of the Bulk Fuels Facility Spill is expected to be a large, complex, and interactive project with many deadlines that will have to be met by the Permittee. The Gantt charts provided in the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans do not contain sufficient detail and are unacceptable because they over simplify field work on the schedules as only a few tasks. A Gantt chart showing all major tasks, their dependency if any on other tasks, and their early/late starts, early/late completions and critical paths must be provided in each of the plans. NMED expects that charts of sufficient detail would likely require presentation on sheets larger than 11" x 17".

The Permittee must also submit to the NMED a Gantt chart that integrates all of the work to be done under the three plans. This Gantt chart must be submitted with the Vadose Zone Work Plan.

5. Organization - The organization plans in the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans only include mention of a project manager and a field team manager, and again reference the general site plan under Appendix A of the Vadose Zone and Interim Measures Work Plans and Appendix D of the Groundwater Investigation Work Plan. NMED notes that there are personnel mentioned by name under the Project Management Plan of Appendix A and Appendix D that have not worked for the Permittee at KAFB for the last several years.

It is likely that more than a project manager and a field team manager will be required to manage and execute a project of this size and complexity. Furthermore, it is unclear if there will be a separate field team manager for different tasks, such as conducting geophysical logging, drilling and installation of wells, operating and maintaining soil vapor extraction (SVE) units, and sampling of environmental media. Also, the plans do not include details on the responsibilities and the qualifications of the personnel (by position) that will be involved.

Simply stating that a kick off meeting " ...will outline roles and responsibilities of all participants..." is not acceptable. It must be clearly understood in writing prior to project start who (by position) will be responsible for overseeing and conducting the myriad of events that need to happen such as field work, interpretation and management of various data, data validation, updating of the conceptual site model, communicating and reporting, and so forth. The Permittee must revise the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans to correct these deficiencies.

6. Data Management - The Data Management Plan provided in Appendix D of Appendix A of the Vadose Zone and Interim Measures Work Plans and Appendix D of Appendix D in the Groundwater Investigation Work Plan is a general plan for entire base (see Comment #1 of Section A, Part 1) and, thus, is not specific to the Bulk Fuels Facility Spill. The plan specifically fails to provide detail concerning the types of data that are to be managed, schedules for data submittals and entries into the database, how accuracy and completeness of the data will be ensured, and data availability to the NMED. The Permittee must revise the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans to correct these deficiencies.

7. Identification of and Approach to Addressing Data Gaps - Section 1.2 of each of the plans states "following previous investigations at the BFF, data gaps were identified...". Because these work plans are meant at a minimum to address data gaps identified in NMED's letter of April 2, 1010, the Permittee must list the data gaps that apply to each of the three plans, as appropriate for the topic of the plan, and indicate where in each of the plans the data gaps are addressed. The Permittee must revise the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans to include a description of the data gaps identified by the NMED and point specifically to where in each the document these data gaps are addressed.

8. Extent of Contamination and Clean Up Criteria – The extent of contamination in the various media (soil, soil vapor, groundwater) shall be based upon determining at what locations hazardous constituents occur at levels that exceed approved background concentrations. This was stated in the NMED's letter of April 2, 2010, and applies to all RCRA facilities in New Mexico that must conduct correction action.

Regarding clean up criteria, any soil contamination left in place within 20 feet of the surface must meet NMED's risk requirements for an acceptable level of risk for all hazardous constituents (10^{-5} for carcinogens and Hazards Index < 1 for noncarcinogens under a residential land-use scenario). Any soil contamination left in place at any depth must also have sufficiently low concentrations of hazardous constituents to be protective of groundwater. The Permittee may use the NMED's Soil Screening Levels in lieu of conducting a baseline risk assessment to determine the risk of contaminants.

While the use of total petroleum hydrocarbons (TPH) as an indicator of contamination is convenient for field screening, the risk to human health and the environment must be assessed through the use of laboratory analysis of hazardous constituents (e.g., benzene, toluene, ethylene dibromide (EDB), naphthalene, xylenes). The Permittee must revise the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans accordingly.

9. Site Specific Conceptual Model **-** The plans continue to provide what appears to be an outdated conceptual model of geologic, hydrologic, and contaminant conditions. However, regardless of the use of current data or the lack thereof, graphical representations of the conceptual model are of poor quality because the graphics are not always legible, are often too small to convey details, don't present sufficient numbers of cross-sections, and rely too much on the presentation of cartoons in lieu of detailed and accurate drawings (for example, Figures 2-8 and 2-9 in the Groundwater Investigation Work Plan).

NMED expected more in the discussion of site specific geology, as what was provided is similar to that presented in reports for the last 8 years or so. A site conceptual model encompassing the source area(s), the fuel percolation area, the light non-aqueous phased liquid (LNAPL) plume floating on groundwater, and the dissolved-phase contaminant plume in groundwater must be included in each of the plans. The model should be illustrated through the liberal use of detailed, accurate, and scaled geologic cross-sections, maps in plan view, and any other necessary graphical representations to clearly and accurately show geologic and hydrologic features, and contaminant levels.

NMED suggests that the geophysical logs, especially the electric logs, for KAFB-0115, KAFB-10624, KAFB-16 and Ridgecrest-3 wells would be useful for assisting in the interpretation of the stratigraphy of the area of interest, as these logs clearly show certain stratigraphic horizons in the vadose zone that are distinctive and widespread units ("marker beds"). The site-specific conceptual model in the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans must be revised to correct the above noted deficiencies.

10. Failure to Provide Graphics and Data Submittals **–** Section E of NMED's April 2, 2010 letter states "The investigation plans required under this letter shall include relevant maps and cross-sections that show concentration data for contaminants and other relevant information with supporting data posted on the maps and cross-sections in a ***legible*** (emphasis added) manner, and clearly showing which borings/wells contributed data towards construction of the maps and cross-sections and which did not. Tables including all existing soil borings, soil-gas monitoring wells, and groundwater monitoring wells, listing their surveyed location, sampling points and maximum depth of exploration shall also be included in the reports and plans. For soil-gas monitoring wells, tables and graphs shall also be included providing trends of TPH concentration versus time for the depths below ground surface of 25, 50, 150, 250, 350, and 450 feet."

Many of the figures in the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans are illegible and the required tables and graphs were not included, or were not provided in the format required. These tables and graphs are necessary to assess the adequacy of proposed locations of borings/wells/SVE units. These tables and graphs of the required types, formats, and in legible form must be included in the revised Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans.

11. Quality Assurance (QA)/Quality Control (QC) plan - The Quality Assurance Plan provided in Appendix D of Appendix A (or Appendix D of Appendix D in the GW Plan) is a general plan for the entire base (see Comment #1, Section A, Part 1 of this letter) and is not specific to the Bulk Fuels Spill Project. The Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans must specify exactly what field and laboratory quality control samples are to be prepared or collected, as appropriate, and other aspects about quality control that are important to the Bulk Fuels Facility project, including the quality control targets that will be considered acceptable for each of the analytes of concern for each given media. The Permittee must revise the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans to correct these deficiencies.

12. Certification Statements - The Vadose Zone, Interim Measures, and Groundwater Investigation Work Plans and associated transmittal letters do not contain the required signed certification statement under RCRA and the New Mexico Hazardous Waste Act. Pursuant to 20.4.1.900 NMAC, incorporating 40 C.F.R. § 270.1 1 (d)(1), all plans and reports shall include a certification, signed by a chief or senior executive officer of the Facility stating:

> 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 fine and imprisonment for knowing violations.

The revised Vadose Zone, Interim Measures, and Groundwater Investigation Work Plans or associated transmittal letters must include this signed certification.

13. Waste Management - The Waste Management Plan provided in Appendix E of Appendix A of the Vadose Zone and Interim Measures Work Plan, and Appendix E of Appendix D in the Groundwater Investigation Work Plan) is a general plan for entire base (see Comment #1, Section A, Part 1 of this letter) and is not specific to the Bulk Fuels Facility Spill project.

Investigation Derived Waste (IDW) includes, but is not limited to, general refuse, drill cuttings, excess sample material, water (e.g., decontamination, development, purge), spent materials, and used disposable equipment generated during the course of investigation, corrective action, or monitoring activities. All IDW shall be properly characterized and disposed of, and otherwise managed in accordance with all federal, state, and local laws and regulations. The Permittee shall include a description of the anticipated IDW management process as a revision to the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans.

B. Interim Measures Work Plan

1. General Comments on Interim Measures Work Plan

The Interim Measures Work Plan was to address two major requirements of NMED's letter of April 2, 2010: 1) remove the Fuel Offloading Rack and excavate to a depth of 20 feet contaminated soil surrounding the Fuel Offloading Rack; and 2) conduct interim measures to remediate the LNAPL plume within five years. This Part (Part 1) of this letter addresses the deficiencies on addressing the first requirement; Part 2 addresses the second requirement to immediately take action to remediate the LNAPL plume floating on the groundwater. Rather than complying with NMED's April 2, 2010 direction to take immediate action vis à vis LNAPL remediation, the Permittee proposes characterization of the vadose zone for some unspecified time period, followed later by SVE. More specifically, the Interim Measures Work Plan includes: testing six wells to determine LNAPL transmissivity (Tn); conducting air sparging and multi-phase extraction pilot tests, and conducting characterization studies using PneuLog tests.

NMED emphasizes that interim measures are actions quickly taken to reduce or prevent the migration of contaminants, or reduce or prevent exposure to contaminants while long-term remedies are evaluated. While characterization studies may be useful for improving remediation efforts, or for proposing and designing a final remedy, interim measures for remediating LNAPL floating on groundwater need to be implemented immediately. Any effort to successfully remove LNAPL floating on groundwater must also involve the removal of LNAPL from the source(s) and fuel percolation areas within the vadose zone.

2. Specific Comments on Interim Measures Work Plan

1. *Page 2-10, Section 2.4* – This section of the plan indicates that the Permittee is preparing a report on indoor air quality, and that the report is currently in draft. A copy of the final indoor air quality report must be provided to the NMED by **October 6, 2010**, and as indicated in the Compliance Schedule of Table 5 of this letter.
2. *Page 3-1, Section 3* - Throughout Section 3 (for example, Sections 3.2, 3.2.2, 3.4.1, 3.4.2, 3.5) the Permittee states its intent to characterize and excavate only soils with "mobile LNAPL", and to leave any other contaminated soil for later remediation under the Corrective Measures Implementation Plan (CMI), which the Permittee referred to as a Corrective Measures Evaluation (CME). The term "mobile LNAPL" was coined by the Permittee and apparently means soil containing such a high concentration of fuel contamination that the soil is dripping wet with fuel.

The reasons given by the Permittee not to excavate other contaminated soils (soil without mobile LNAPL) is that a risk assessment would have to be developed separately for such soils, and the Permittee expresses its desire to delay excavation of such soils until long-term corrective actions are initiated for the site. Due to the urgent need for action at this site, such an approach is not acceptable. The Permittee can rapidly develop target clean up goals based on NMED's risk requirements noted above, or simply use NMED's soil screening levels for hazardous constituents. Soils do not need to be dripping wet with fuel to pose a risk to human health or the environment. NMED estimates that a Corrective Measures Implementation Plan will not be approved for at least several years because of the inadequate state of site characterization today. Leaving contaminated soil in the ground that poses a significant risk to human health or the environment for what will likely be a fairly long time period before long-term corrective actions are initiated is unacceptable. As indicated in Comment #8 in Section A of Part 1 of this letter, all contaminated soil to a depth of 20 feet that represents an unacceptable risk to human health or the environment shall be excavated and removed from the Fuel Offloading Rack area.

As mentioned above, due to the urgent need to accelerate remediation, the Permittee is directed in Part 2 of this letter to implement interim measures, which includes removal of the remaining components of the Fuel Offloading Rack and excavation of contaminated soil. This work shall be completed in accordance with the Interim Measures Work Plan as modified by the requirements of this letter and in accordance with the Compliance Schedule in Table 5 of this letter.

3. Page 3-2, Section 3.2.2 – This section indicates that soil samples will be analyzed in the laboratory only if samples do not respond to a field test kit. This is an unacceptable approach. The Permittee shall use laboratory analysis all soil samples in shallow borings for TPH, VOCs, SVOCs, and lead.

4. Page 3-4, Section 3.4.2 – This section indicates that a detailed excavation plan for the Fuel Offloading Rack will be submitted to the NMED at a later date. NMED's April 2, 2010 letter intended for the Interim Measure Work Plan to be the detailed plan.

The excavation of contaminated soil and removal of structures at the Fuel Offloading Rack is a relatively simple "dig and haul" operation, and represents by far the easiest of the two major interim measures that the Permittee was directed to accomplish in NMED's letter of April 2, 2010. NMED requires the Permittee to begin excavation and removal of structures at the Fuel Offloading Rack immediately (see Section A of Part 2 of this letter).

5. Page 4-1, Section 4.2 – In part, this section states "Kirtland AFB proposes to install an IRM to remove, to the extent practicable within five years of work plan approval, mobile LNAPL present at the water table that has the potential to migrate along the water table and potentially further endanger the regional aquifer that provides drinking water for ABCWUA. Immobile LANPL and sorbed and dissolved fuel contamination in groundwater will be addressed by the future CME."

The NMED finds several unacceptable concepts related to these statements. First, as previously mentioned, NMED does not agree with the Permittee-coined terms "mobile LNAPL" and "immobile LNAPL." The point of the interim measure is to clean up contamination (LNAPL) that poses a threat to groundwater, regardless of contaminant concentrations. Even LNAPL that is not migrating along the water table has the potential to contaminate groundwater with concentrations of hazardous constituents that are at unsafe levels for human consumption. Second, the phrase "to the extent practicable" suggests that the Permittee has already admitted defeat without even attempting to clean up the groundwater and the floating LNAPL. Third, the LNAPL floating on the water table endangers water supply wells in addition to those operated by the WUA. Lastly, like the cleaning up of contaminated soil around the Fuel Offloading Rack, the Permittee is stating its desire to delay clean up for at least several years while a final remedy through an approved CMI Plan is implemented, which is unacceptable. The Permittee must revise the Interim Measures Work Plan to remove the above-noted deficiencies.

6. *Page 4-4, Section 4.6* - In the last paragraph the Permittee states that "Routine system optimization will be performed ... to maintain the highest mass extraction rate..."

The Permittee shall revise this section to explain in detail how the system will be optimized.

7. *Page 5-1, Section 5* - The Permittee states: "Vadose zone interim remedial measures will be implemented if data collected during the PneuLog profiling, supplemented by results of the concurrent vadose zone investigation, identify the presence of potentially mobile LNAPL within the vadose zone."

As mentioned above, the NMED does not agree with the Permittee-coined terms "mobile LNAPL" and "immobile LNAPL." It should be inarguable that fuel infiltrated from near or at the ground surface and has percolated through the vadose zone to groundwater. Some fuel is likely still draining to groundwater. However, hazardous constituents can still migrate to groundwater as vapor even in areas where the draining of liquid fuel to groundwater has stopped or never took place. The Permittee must revise the Interim Measures Work Plan to indicate that remediation of the vadose zone will be conducted to accomplish clean up of LNAPL floating on the groundwater, regardless of whether fuel-saturated conditions exist in the vadose zone in a given area.

8. *Page 5-2, Section 5.2* - The fourth paragraph states: "PneuLog will be performed at three locations...starting from the point(s) of release to the water table."

Figure 5-1 shows the proposed locations for PneuLog testing about 750 feet northeast of the Fuel Offloading Rack and approximately 750 feet north of the southern extent of the LNAPL plume that is floating on groundwater. According to the conceptual model provided in the Interim Measures Work Plan, the proposed locations for PneuLog testing could lead to missing the path of percolation that the fuel took to groundwater.

The Permittee must revise the Interim Measures Work Plan to include some PneuLog testing in the fuel percolation area. See Comment #4 in Section C of Part 1 of this letter for information on the area NMED has identified as the fuel percolation area. Indicate also in the Interim Measures Work Plan the significance of using three locations for PneuLog testing and explain in more detail how the air flow potential of the geologic units will be assessed and used in the design to optimize SVE.

The Interim Measures Work Plan shall also be revised to indicate that geologic and geophysical (induction, gamma, and neutron) logs will be made for the boreholes used for PneuLog testing.

9. *Figures.* Figures 2-2 through 2-5 are very difficult, and in some cases impossible to read. Cross-section A-A' is not the view seen in Figure 2-8.

The Permittee shall revise the Interim Measures Work Plan to include corrected and legible figures.

C. Vadose Zone Work Plan

1. General Comments on Vadose Zone Work Plan

In NMED's letter of April 2, 2010, the Permittee was directed to submit a Vadose Zone Investigation Plan that describes the additional actions the Permittee will take to investigate vadose zone hydrology and geology, to identify and characterize the source of the releases at the Bulk Fuel Facility, and to identify the extent of soil and soil-gas contamination in the vadose zone from the surface to groundwater. The Vadose Zone Plan was to describe in detail all research, locations, depths and methods of exploration, field procedures, sampling and analysis of soil and soil gas and related quality control procedures, the results and the means by which the results are to be reported, and a schedule of the work.

The Vadose Zone Work Plan that has been submitted is inadequate to accomplish the objectives established in NMED's letter of April 2, 2010. A major reason is that the proposed borings and soil-vapor wells are located too far apart to characterize in adequate detail the contaminant and geologic conditions in the vadose zone. NMED therefore directs herein a general increase in the number of sampling points. The Permittee shall revise the Vadose Zone Work Plan to include all of the soil borings and soil-vapor well installations required by this letter.

For the convenience of providing further discussion in this letter, NMED has divided the vadose zone into five principal areas: the tank farm, pipeline, Fuel Offloading Rack, fuel percolation area, and the far field area of the soil-vapor plume. Each of these areas is discussed below.

1. Tank Farm – Contamination is known to occur from the surface to deep levels at the Tank Farm. In its letter of April 2, 2010, NMED directed that nine deep soil borings/soil-vapor wells be completed in the tank farm area; the Permittee proposed only three. Through its direction in it April 2, 2010 letter, NMED was hoping to avoid the time-consuming process of "dickering" with the Permittee on numbers of borings (and wells, to be discussed later). Nevertheless, in the interest of comity and upon further consideration, NMED agrees that by adjusting locations and completing some shallow borings, the tank farm area could be covered at least initially by five deep soil borings/soil-vapor wells and five shallow soil borings. Depending on what is found, additional soil borings/soil-vapor wells may be needed, and NMED reserves its rights to require such additional borings, wells, or both in the future.

The Permittee shall complete the soil borings/soil-vapor wells at locations #16, 17, 19 and 20; and the soil vapor well at location #6 that are listed in Tables 1 and 2 of this letter, respectively, and shown on Figure 1 enclosed with this letter. The Permittee shall also complete shallow soil borings to a depth of at least 20 feet at locations #1 through 5, which are listed in Table 3 of this letter and shown also on Figure 1. Soil samples from the shallow borings shall be collected at depths of 0, 5, 10, 15, and 20 feet and shall be analyzed for TPH, VOCs, SVOCs, and lead.

2. Pipeline – The Permittee has not investigated the pipeline that runs between the tank farm, the pump house, and the Fuel Offloading Rack. In NMED's letter of April 2, 2010, the Permittee was directed to complete four deep soil borings/soil-vapor wells along the buried and exposed portions of the pipeline. The Permittee proposed none.

In lieu of completing deep soil borings/soil-vapor wells, the Permittee proposed to complete shallow borings along the buried portion of the pipeline extending south of the pump house. However, the Vadose Zone Work Plan is unclear as to the number of shallow boreholes that would be completed. Additionally, the proposed plan is inadequate because the entire length of pipeline between the tank farm and the Fuel Offloading Rack is not included in the investigation.

The Permittee shall complete the deep soil borings/soil-vapor wells at locations #4, 6, 7, 8, and 24 that are listed in Table 1 of this letter and shown on Figure 1. The Permittee shall also complete shallow borings along the entire length of the pipeline between the tank farm and the Fuel Offloading Rack, regardless of whether the pipeline runs underground or on the surface. The borings shall be spaced at intervals not to exceed 25 feet and are to be located on both sides of the pipeline. Soil samples from the shallow borings shall be collected at depths of 0, 5, 10, 15, and 20 feet. The soil samples from deep and shallow borings shall be analyzed for TPH, VOCs, SVOCs, and lead. Depending on the results, NMED may require further investigation of this area, including more and deeper borings.

3. Fuel Offloading Rack – The Fuel Offloading Rack is supposedly the main source of the fuel spill, but it has not been adequately characterized since discovery of the fuel leak 10 years ago. Previous investigative efforts appear to have been arbitrarily terminated once TPH concentrations were found to be less than 100 mg/kg in soil and below 100 ppmv in soil vapor. In NMED's letter of April 2, 2010, the Permittee was directed to complete a ***minimum*** of six deep soil sampling/vapor wells at the Fuel Offloading Rack to determine the full extent of contamination; the Permittee proposed four. NMED reaffirms its previous direction. The Permittee shall complete the soil borings/soil-vapor wells at locations #1, 2, 3, 4, 11, and 12 that are listed in Table 1 of this letter and shown in Figure 1.

4. Fuel percolation area – This area, east of the Fuel Offloading Rack, is currently believed to constitute the core of the contamination in the vadose zone, and represents the place where fuel presumably migrated to groundwater. In NMED's letter of April 2, 2010, the Permittee was directed to complete a ***minimum*** of six deep soil sampling/vapor wells in order to significantly improve characterization of this area. This is critical to understanding the amount of fuel contamination in the vadose zone that must be remediated. The Permittee proposed to complete only two of the deep soil sampling/vapor wells that the NMED specified.

The Permittee did, however, propose an additional 3 deep soil sampling/vapor wells at locations further to the east. NMED agrees that these latter locations are necessary to properly characterize this area. Thus, to improve the understanding of the amount of fuel contamination in the vadose zone that must be remediated, the Permittee shall complete the soil borings/soil-vapor wells at locations #5, 9, 10, 21, 22, 23, 25, 26, and 27 listed in Table 1 and shown on Figure 1.

5. Far field area of Soil-Vapor plume – In its letter of April 2, 2010, NMED directed the Permittee to install six soil-vapor wells at locations north of the Fuel Offloading Rack and fuel percolation area to investigate the concentrations of hazardous constituents in soil gas that overlies groundwater in these areas. The Permittee shall complete the soil-vapor wells at locations #1, 2, 4, 3, 5, 6, 8, and 9; and the soil boring/soil-vapor well at location #24, that are listed in Tables 2 and 1, respectively, and shown on Figure 1.

6. Sampling Requirements Applicable to all Five Vadose Zone Areas - Soil samples from the deep borings shall be collected at a frequency of at least one sample every 10 feet for the first 50 feet, and at least one sample thereafter every 50 feet to total depth, and at least one sample at total depth in each boring. Each deep boring at each location shall be drilled from the surface to the water table, and each deep boring shall be completed as a permanent soil-gas monitoring well. The soil-gas monitoring wells shall be capable of yielding discrete samples of soil gas recovered from depths of 25, 50, 150, 250, 350, and 450 feet below the ground surface.

All boreholes that will have soil-vapor monitoring wells constructed in them shall be logged using induction (medium and deep), neutron, and gamma tools. Geologic logs shall also be prepared for these boreholes showing the geologic conditions from the surface to the total depth of each borehole.

The coordinates in Tables 1-3 are State Plane Coordinates in feet, NAD83. All boring/soil vapor well locations are also shown on Figure 1 enclosed with this letter.

Table 1. Borehole Locations for Soil Sampling and for Conversion to Soil-Vapor Monitoring Wells.

Location #	Easting	Northing	Characterization Purpose
1	1541119	1473793	Step out from Fuel Offloading Rack
2	1540808	1473503	Step out from Fuel Offloading Rack
3	1541123	1473310	Step out from Fuel Offloading Rack
4	1541425	1473313	Step out from Fuel Offloading Rack and piping

5	1541961	1473492	Fuel percolation area
6	1542002	1473057	Piping
7	1541794	1473061	Piping
8	1542370	1473058	Piping
9	1541898	1473276	Fuel percolation area
10	1541720	1473369	Fuel percolation area
11	1541776	1473740	Step out from Fuel Offloading Rack
12	1541658	1473505	Fuel percolation area and Fuel Offloading Rack
16	1541992	1472768	Fuel tanks
17	1542229	1472916	Fuel tanks
19	1542485	1472911	Fuel tanks
20	1542428	1472716	Fuel tanks
21	1541611	1473238	Fuel percolation area
22	1542137	1473266	Fuel percolation area
23	1542131	1473571	Fuel percolation area
24	1541620	1472955	Far Field and piping
25	1542807	1473592	Fuel percolation area
26	1542422	1473506	Fuel percolation area
27	1542360	1473808	Fuel percolation area

Table 2. Locations for Soil-Gas Monitoring Wells.

Location #	Easting	Northing	Characterization Purpose
1	1542900	1474092	Far Field
2	1543194	1474680	Far Field
3	1542306	1474093	Far Field
4	1541555	1475049	Far Field
5	1541248	1474141	Far Field
6	1542259	1472591	Far Field and fuel tanks
8	1542504	1475414	Far Field
9	1542436	1474878	Far Field

Table 3. Locations for Shallow Soil Borings in Tank Farm Area.

Location #	Easting	Northing
1	1542544	1472810
2	1542282	1472806
3	1542125	1472784
4	1542081	1472959
5	1541941	1472867

The Permittee shall revise the Vadose Zone Work Plan to incorporate the general comments and correct the deficiencies noted above.

2. Specific Comments on Vadose Zone Work Plan

1. Downhole Geophysical Logging - Section 3.2.1.1, Table 3-1, Topic 3, states "If proposed vapor monitoring points are screened in zones determined to be fine grained lithologic units adjust the screen location vapor monitoring points up or down to the nearest coarser grained unit."

Because individual fine grained or coarse grained beds do not necessarily extend laterally for any significant distances, any geophysical logs used to adjust screen locations must be generated for that particular borehole.

The Permittee must revise the Vadose Zone Work Plan to indicate the maximum distance that screened zones are to be adjusted from the required screen depths should adjustment be necessary. For screens that are to be set 100 feet apart as directed under this letter, the Permittee may adjust screens by no more than 25 feet. For screens that are to be set 25 feet apart, the Permittee may adjust screens by no more than 5 feet.

2. Seismic Refraction, Section 3.2.1.2 - NMED encourages the use of geophysical techniques; however, NMED is doubtful that seismic refraction will prove useful in this case. NMED is concerned that refraction will only detect shallow loose material near the surface, somewhat more dense subsurface material, and saturated material beginning at the water table. Although KAFB is free to conduct the refraction survey, the NMED will not allow such survey to delay completion of other work required for characterizing and cleaning up the Bulk Fuels Facility Spill.

If the Permittee proceeds with conducting the refraction survey, the following issues must be addressed in the revised work plan.

A. Explain why seismic refraction was chosen and not shallow reflection.

B. Explain how seismic refraction is expected to identify the difference between a fine-grained unit and a coarse-grained unit above the saturated zone at depths of 450-500 feet (see DQO step 5 for topic 1 on Table 3-1). Table 3-1, DQO step 6, topic 1 implies that refraction will be able to define a unit within 1-foot depth at a depth of 500 feet. These Data Quality Objectives cannot likely be achieved.

C. If the 1-foot depth is actually referring to the location of geophones, specify what the QC targets are for the seismic survey (for example, how close should the interpreted seismic interface be to the actual depth to water). Specify the site-specific conceptual model of the seismic layering. Indicate the expected thicknesses versus depth of units to be detected.

D. Explain what seismic source is planned to be used in this "noisy" environment that can carry an off-the-end shot for the 1500 foot line. Conceptually, specify how many shot points and what locations are planned per line.

E. Figure 3-1 shows 13 seismic lines that are all oriented in an east-west direction. Section 3.2.1.2 discusses orthogonal lines. Clarify how many lines are planned. Specify how the orthogonal lines will be placed, and show them on a corrected Figure 3-1. Explain why the proposed seismic lines are shown crossing buildings.

3. Resistivity, Section 3.2.1.3 – Like the refraction survey discussed in the proceeding comment, the NMED is doubtful that the IP/RES techniques will prove useful in this case. Although KAFB is free to conduct the resistivity survey, the NMED will not allow such a survey to delay completion of other work required for characterizing and cleaning up the Bulk Fuels Facility Spill.

If the Permittee proceeds with conducting the survey, the following issues must be addressed in the revised work plan.

A. As described in Section 3.2.1.3 of the plan, 56 stakes are proposed to be situated along 1,850 feet transects. This amounts to an electrode separation of about 30 feet, which would yield a shallowest apparent resistivity of the upper nominal 30 feet, with a value every 30 feet horizontally. Explain how the resistivity survey is expected to provide good results with all the surface interferences, cultural conditions, pipelines, surface topography changes, utilities, and other conditions known to be present at the site. Explain how close, for example, does the interpreted depth to groundwater need to be to meet the "Specify Limits on Decision Errors" concept on Table 3-1. Specify the QC procedures to be performed, such as calibrating to a known resistance and reciprocity tests.

B. Explain why the proposed resistivity lines are shown crossing buildings.

C. Indicate whether the geophysical parameters measured in the Sunbelt Geophysics report were taken into account in planning the resistivity investigation.

D. Specify what size transmitter is to be used to be able to measure the appropriate parameters with appropriate detail at large depths, and what electrode arrays are to be used.

E. Indicate if an analysis has been conducted modeling what MN, AB, and AB-MN spacings seem plausible based upon site-specific resistivities (estimated from resistivity or induction logs) and equipment specifications.

F. F. Indicate and explain the computer model by which the data are to be interpreted.

4. Page 3-5, Section 3.2.3 – Substitute semi-volatile organic compounds (SVOCs) for polycyclic aromatic hydrocarbons (PAHs) and add lead to the parameters to be analyzed for in soil. The Permittee must revise the Vadose Zone Work Plan accordingly.

5. Page 3-6, Section 3.2.3 – The first paragraph on this page says that soil samples containing LNAPL will not be sent to the laboratory for chemical analysis. All soil samples, including those containing LNAPL, must be sent to a laboratory and analyzed for TPH, VOCs, SVOCs, and lead. The Permittee must revise the Vadose Zone Work Plan accordingly.

6. Page 3-6, Section 3.2.4 – This section states that screens on soil-vapor monitoring wells will be set to "anticipated depths" of 25, 50, 150, 250, 350, and 450 feet. The Permittee must revise the Vadose Zone Work Plan to indicate the maximum distance that screened zones are to be adjusted from the required screen depths, should adjustment be necessary. For screens that are to be set 100 feet apart as directed under this letter, the Permittee may adjust screens by no more than 25 feet. For screens that are to be set 25 feet apart, the Permittee may adjust screens by no more than 5 feet. The Permittee must revise the Vadose Zone Work Plan accordingly.

7. Cross-section "A-A" - Cross-section A-A' location shown on Figures 2-2 through 2-5 does not correspond to Cross-Section A-A' shown in Figure 2-8. Supply the intended cross-section A-A' with data shown clearly and legibly, and with appropriate data.

D. Groundwater Investigation Work Plan

General Comments on Groundwater Investigation Work Plan

In NMED's letter of April 2, 2010, the Permittee was directed to submit a Groundwater Investigation Work Plan that describes the additional actions the Permittee will take to characterize the nature, horizontal and vertical extent, and the fate and rate of migration of the groundwater contamination. The Groundwater Investigation Work Plan was also to include construction details and the locations and depths of the groundwater monitoring wells to be installed, actions to characterize the geology and hydrogeology at and below the water table, groundwater flow direction and velocity, field procedures, and the sampling and analysis of groundwater and related quality control. The Groundwater Investigation Work Plan was also to describe the means *(e.g.,* cross-sections, plan views) by which results would be reported after the investigation and include a schedule to complete the work.

The leading (northern) edge and the eastern and western margins of the dissolved-phase and LNAPL plumes are as yet undefined, and the nature and concentrations of contaminants in the core of each of the plumes are poorly characterized because existing wells are located too far apart (generally at distances greater than 500 feet), vertical characterization information is nonexistent, and water quality beneath the LNAPL plume has not been assessed. Additionally, the vertical extent of contaminated groundwater, key aspects of the hydrology of the groundwater (hydraulic conductivity, velocity), and the geology (horizontal and vertical characteristics) of the saturated zone are poorly defined or are unknown.

In general, the Groundwater Investigation Work Plan proposes too few wells, both in a vertical and horizontal sense, than is needed to adequately characterize the geology, hydrology, and the nature and extent of contamination over such a large area of groundwater contamination. As mentioned earlier, NMED was hoping to avoid the time-consuming process of "dickering" with the Permittee on numbers of borings and wells by providing clear and specific direction in its April 2, 2010 letter. Nevertheless, in the interest of comity and upon further consideration, NMED agrees that by adjusting locations some well locations directed in NMED's April 2, 2010 letter can be replaced with some proposed by the Permittee in the Groundwater Investigation Work Plan. NMED nonetheless directs an increase in the number of sampling points over that proposed by the Permittee, with the goal of achieving adequate site characterization more quickly to address the urgent matter of cleaning up the Bulk Fuels Facility Spill. Depending on what is found, additional wells may be needed, and NMED reserves its rights to require such additional borings, wells, or both in the future. The Permittee shall revise the Groundwater Investigation Work Plan to include all of the well installations required by this letter.

NMED has identified several other general deficiencies with the Groundwater Investigation Work Plan, which includes issues related to background water quality, vertical characterization, water quality beneath the LNPAL plume, rate of contaminant migration, cluster/nested wells, and characterization of plume cores and margins. These general deficiencies are discussed below.

1. Background Water Quality - Only two upgradient wells have been installed that potentially may yield groundwater samples that are free from contamination. Both of these wells were only recently completed; none is screened appreciably below the water table to provide vertical characterization of water quality, geology, and hydrologic conditions. The Permittee must complete the background cluster/nested wells at location #6 listed in Table 4 of this letter and shown on Figure 2 (enclosed).

2. Vertical Characterization – The plan identifies proposed wells that are to be screened at various depths below the water table as "B" and "C" wells, with the "C" wells the deepest screened well at a given cluster/nested well location. Due to urgency of this matter, the NMED does not approve of "C" well installation being contingent on "B" well results. Given that the pumping of water supply wells is known to induce vertical gradients in groundwater, can cause significant components of vertical flow in the vicinity of such wells, and draws water preferentially from productive zones that may be deeper than the water table, vertical characterization of groundwater quality, hydrology, and geology is required for all well installations specified by this letter.

3. Water Quality Beneath the LNAPL Plume - Although the lack of water quality information was identified specifically by the NMED as a data gap, the Groundwater Investigation Work Plan states that groundwater at well locations within the boundaries of the LNAPL plume will not be sampled and analyzed. This is an unacceptable approach. Knowledge of water quality beneath the LNAPL plume is crucial to understand the full extent and magnitude of the groundwater contamination.

4. Rate of Contaminant Migration - Although a critical question to be answered, it was not clear in the Groundwater Investigation Work Plan if the Permittee has a plan to address the rate of migration of either the dissolved-phase or LNAPL contaminant plumes, and in particular, the time it would take for the dissolved-phase plume to reach surrounding well fields. The Permittee must clarify this point.

5. Cluster versus Nested Wells – The NMED has no objections to the use of nested wells instead of cluster wells, provided the nested wells are properly constructed. However, in this case the NMED will not accept wells that are constructed with 3-inch diameter casing and screens. Three-inch diameter casing and screens are inappropriate for constructing groundwater monitoring wells that will be installed to depths of 500 feet or more. The Permittee shall design wells to be constructed in cluster or nested configurations using casing and screen that are no smaller than 5 inches in diameter. The borehole surrounding the well casing for a nested or cluster well must be of sufficient diameter to allow for an adequate annular space between the borehole and well casing and screen. The annular space must be of sufficient size to allow for proper construction of filter packs and seals, and for the installation of grouting (see the groundwater monitoring well construction requirements set forth in Part 2 of this letter).

6. Characterization of Plume Cores – The dissolved-phase and LNAPL plumes extend off base to nearly 0.9 to 0.5 miles, respectively from the presumed source, yet a total of only eight wells currently exist off-base to characterize the cores of both plumes. Of these eight wells, this includes two wells where groundwater has not been sampled for water quality in the past and one well that was only very recently installed at Bullhead Park for which no water quality data has been submitted to the NMED.

In NMED's letter of April 2, 2010, the Permittee was directed to install groundwater monitoring wells at a ***minimum*** of eight additional locations to characterize the concentrations of contaminants, and the geologic and hydrologic conditions that exist off-base in the plume cores; instead, the Permittee proposed only four.

To achieve the objective of providing initial plume-core characterization, the Permittee shall install the groundwater monitoring wells at locations #11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, and 23 listed in Table 4 and shown on Figure 2.

7. *Characterization of Plume Margins* – Only five existing wells define the edge of the plume off-base (including one well recently installed). In NMED's letter of April 2, 2010, the Permittee was directed to install groundwater monitoring wells at a ***minimum*** of eight additional locations to characterize the concentrations of contaminants, and the geologic and hydrologic conditions that exist off base along the plume margins; instead, the Permittee proposed five.

To adequately provide initial plume-edge characterization, the Permittee shall install the groundwater monitoring wells at locations #1, 2, 3, 4, 5, 7, 8, 9, 10, 24, 25, 26, 27, and 28 that are listed in Table 4 and shown on Figure 2.

Three groundwater monitoring wells shall be installed at different depths at each of the well locations listed in Table 4. The screen depths shown in Table 4 are distances (in feet) that the top of the screens shall be set below the water table, except wells screened across the water table (those with screen depths of zero in Table 4) may have screens that extend above the water table. Screen lengths for wells shall not exceed 15 feet, with the exception that wells screened across the water table shall have screens 20 feet long, with no more than 15 feet of screen length situated below the water table.

The geologic conditions encountered from the surface to the total depth of the borings at each well location shall be logged. Boreholes completed for well installations at all locations shall also be logged using induction (medium and deep), neutron, and gamma (large crystal) tools. Geophysical and geologic logging at a given cluster well location is required only in the well at the location having the deepest screened interval.

Coordinates in Table 4 are State Plane Coordinates in feet, NAD83. All of the locations listed in Table 4 are also shown on Figure 2 enclosed with this letter.

Table 4. Well locations and screen depths relative to the water table.

Location #	Easting	Northing	Screen Depths	Characterization Purpose
1	1542189	1476725	0, 15, 40	Plume margin, deep characterization
2	1541984	1476042	0, 15, 40	Plume margin, deep characterization
3	1543703	1476600	0, 15, 40	Plume margin, deep characterization
4	1543372	1475065	0, 15, 40	Plume margin, deep characterization
5	1543643	1477939	0, 15, 85	Plume margin, deep characterization
6	1541430	1472370	15, 40*	Background water quality, deep characterization

7	1542812	1473601	0, 15, 40	Plume margin, deep characterization
8	1542722	1477726	0, 15, 40	Plume margin, deep characterization
9	1543054	1477788	0, 15, 40	Plume margin, deep characterization
10	1543774	1477304	0, 15, 40	Plume margin, deep characterization
11	1541774	1473718	0, 15, 85	Plume core, deep characterization
12	1542362	1473801	0, 15, 85	Plume core, deep characterization
13	1542305	1474340	15, 85*	Plume core, deep characterization
14	1542736	1474715	0, 15, 85	Plume core, deep characterization
15	1542860	1475860	0, 15, 85	Plume core, deep characterization
16	1542189	1475207	0, 15, 85	Plume core, deep characterization
17	1541731	1473291	0, 15, 85	Plume core, deep characterization
18	1542203	1474071	0, 15, 85	Plume core, deep characterization
19	1542565	1475360	0, 15, 85	Plume core, deep characterization
20	1542535	1475975	0, 15, 85	Plume core, deep characterization
21	1543199	1475767	0, 15, 85	Plume core, deep characterization
22	1543068	1476494	0, 15, 85	Plume core, deep characterization
23	1541968	1474648	0, 15, 85	Plume core, deep characterization
24	1541682	1474703	15, 40*	Plume margin, deep characterization
25	1541025	1474360	15, 40*	Plume margin, deep characterization
26	1540407	1474016	15, 40*	Plume margin, deep characterization
27	1543712	1475683	15, 40*	Plume margin, deep characterization
28	1543364	1477684	0, 15, 40	Plume margin, deep characterization

* - water table well already exists

The Permittee shall revise the Groundwater Investigation Work Plan to incorporate the general comments and correct the deficiencies noted above.

Specific Comments on Groundwater Investigation Work Plan

1. Page 3-6, Section 3.3.4 and Figure 3-3 – Well construction details are missing, as the wrong figure was submitted for a well construction diagram in the Work Plan. The Permittee shall revise the Groundwater Investigation Work Plan to correct the deficiency noted above.

2. *Page 3-4, Section 3.3.2* – This section states that "NMED will be notified regarding any deviations in well constructions per Section 4.0." Aside from the fact that there is no Section 4.0, well construction and any changes thereto must be approved in advance by the NMED. E-mail or telephone approval may suffice to facilitate in-field decision-making. The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

3. *Page 3-5, Section 3.3.3* – Soil samples shall be collected at well locations #11, 12, 17, and 18 listed in Table 4 from the deepest borehole at each location. The samples shall be collected at a frequency of at least one sample every 10 feet for the first 50 feet of the borehole, then at least one sample every 50 feet to the bottom of the borehole, and at total depth of the borehole. The soil samples must be analyzed in the laboratory for TPH, VOCs, SVOCs, and lead. The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

4. *Page 3-7, Section 3.3.5* – This section indicates that wells screened below the water table will be considered by the Permittee to be "piezometers" (normally for measuring only hydraulic head). Groundwater samples must be collected from all wells, regardless if the wells are screened at the water table or deeper, and all samples must be analyzed for TPH and hazardous constituents. The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

5. *Page 3-7, Section 3.3.5* – This section states that wells located within the area of the floating LNAPL will not be developed. All wells, including those within the LNAPL plume, shall be properly developed to provide representative water samples. The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

6. *Page 3-7, Section 3.3.6* – This section states that groundwater at wells located within the area of the floating LNAPL will not be sampled. Groundwater in all wells will be sampled, including those within the LNAPL plume. The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

7. *Page 3-7, Section 3.3.6* – For analysis of groundwater samples, add lead and substitute SVOCs for PAHs, and dissolved iron and dissolved manganese for iron and manganese, respectively. Samples must not be filtered, except for sample fractions for dissolved iron and dissolved manganese.

Add alkalinity and pH to the list of field parameters.

The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

8. *Page 3-6, Section 3.3.4* - It is not clear how many wells are actually proposed because wells KAFB-10629, KAFB-10630, and KAFB-10638 are not listed on Table 3-2 of the Groundwater Investigation Work Plan. The Permittee must clarify or resolve this discrepancy in a revision to the Groundwater Investigation Work Plan.

9. *Page 3-1, Section 3.1.1* - Indicate what geophysical logs will be run and at what stage of the borehole/well installation process. The discussion should be included in Section 3.3 instead of Section 3.1.1. The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

10. *Page 3-2, Section 3.3.1* - See specific Comments #2 and 3 for the Vadose Zone Work Plan regarding surface geophysical surveys.

PART 2

A. Direction to Conduct Interim Measures and Other Actions

In NMED's letter of April 2, 2010, the Permittee was informed that the NMED has determined that the Bulk Fuel Facility Spill poses a threat to human health and the environment, and furthermore, endangers the groundwater resource – including water supply wells – relied upon by the WUA for delivery of safe drinking water to its customers. The contamination also threatens KAFB and the Veterans Administration ("VA") Hospital water-supply wells. The large extent of this contamination and its proximity to water supply wells requires that urgent action be taken.

The NMED has estimated that nearly 8 million gallons of fuel have been released at the Bulk Fuels Facility. The Permittee is operating four SVE units on the Permittee's property; however, these soil-vapor extraction units will not clean up the contamination thus far known to occur from the Bulk Fuels Facility Spill in a reasonable time frame. Because the Permittee's Interim Measures Work Plan does not contain any interim measures that could be implemented immediately, the NMED herein is directing the Permittee to:

1. conduct additional soil vapor extraction,
2. improve the Operation and Maintenance Plan for the SVE units,
3. begin immediate excavation of contaminated soil at the Fuel Offloading Rack,
4. provide an estimate of the contaminant migration rate,
5. install sentry wells,
6. log existing wells, including using geophysical methods,
7. submit critical data to the NMED, and
8. provide adequate funding to the WUA for sampling and analysis of well water.

SVE and these other actions must be initiated or completed, as appropriate, by the deadlines indicated in this letter and in the Compliance Schedule in Table 5. Additionally, this letter specifies minimum requirements that the Permittee must meet regarding well installations, well development, sampling, geophysical logging, preparing geologic logs, notification of activities, field and laboratory quality control, and reporting.

1. Soil Vapor Extraction

a. The Permittee has demonstrated that SVE has worked to remove contaminate vapors from the vadose zone. The Permittee shall install and operate additional SVE units at the following locations:

i. No later than **October 6, 2010** (Table 5) at existing groundwater monitoring wells KAFB-3411, KAFB-10614, and KAFB-10624, which are located in the core of the vadose zone contamination.

ii. No later than **November 8, 2010** (Table 5) at soil boring/soil-vapor monitoring well locations #4, 5, 9, 10, 11, 12, and 21 that are listed in Table 1 of this letter. These wells, to be located in the core of contamination, should be designed to serve both as vapor extraction wells and as soil-vapor monitoring wells. The Permittee must also conduct geologic logging and borehole geophysical logging at each location. The Permittee shall comply with the collection and analysis of soil samples as specified in Part 1 of this letter for well installations.

iii. No later than **October 6, 2010** (Table 5) or 60 days after required access is granted, which ever is later, at existing groundwater monitoring wells KAFB-10617 and 10618 which are located at the northern extent of the LNAPL plume.

iv. No later than **November 8, 2010** (Table 5) or 60 days after required access is granted, which ever is later, at existing groundwater monitoring wells KAFB-10610 which is located at the northern extent of the 1-foot thick layer of LNAPL plume.

v. No later than **November 8, 2010** (Table 5) or 60 days after required access is granted, which ever is later, locations #3, 8 and 9 on Table 2 of this letter shall be made ready for conducting future soil vapor extraction by completing soil-vapor monitoring/extraction wells at this location. The Permittee must conduct geologic logging and borehole geophysical logging at this location and shall comply with the collection and analysis of soil samples as specified in Part 1 of this letter for well installations.

b. The Permittee shall continue to operate SVE units at the locations of the four existing SVE units (located at the Fuel Offloading Rack, KAFB-1065, KAFB-1066, and KAFB-1068).

Until such time that the interim measures plan is approved by the NMED, the Permittee shall continue to operate all SVE units 24 hours per day, 7 days a week, except when necessary to perform maintenance or repairs. If maintenance or repairs are necessary, the maintenance or repairs shall be completed as quickly as practicable, and the unit returned to service immediately after maintenance or repairs are completed. Any maintenance or repairs that will take more than 3 calendar days shall be reported in writing to the NMED within 24 hours of discovery that the maintenance or repairs will take more than 3 days. The Permittee shall explain in the report why the maintenance or repairs will take more than 3 calendar days and why the delay is beyond the control of the Permittee.

The SVE units shall be similar to those currently in use for the Bulk Fuels Facility Spill and shall be capable of extracting soil vapor at a minimum flow rate of 27 SCFM. The SVE units shall also average over a period of 12 months an operating efficiency (operating time relative to down time) of no less than 85%. The SVE units shall meet the regulatory requirements for air emissions enforced by the City of Albuquerque Environmental Health Department. The Permittee is responsible for obtaining all necessary permissions and permits to construct and operate the SVE units.

If the City of Albuquerque Environmental Health Department will not issue an air permit to operate the SVE units specified by this letter, the Permittee shall immediately notify the NMED in writing and shall substitute a different technology for conducting SVE and treating emissions that will meet the regulatory requirements enforced by the City of Albuquerque Environmental Health Department and the deadlines set forth in this letter in the Compliance Schedule shown in Table 5.

2. Operation and Maintenance (O&M) Plan

The Permittee shall modify its O&M Plan to reduce down time of SVE units by maintaining in inventory commonly-needed spare parts for maintenance and repairs, and keeping a spare engine available for SVE units that suffer catastrophic engine failures. The spare parts and engine shall be maintained by the Permittee in inventory by **September 7, 2010**. The Permittee shall provide NMED with a written list of the spare parts and spare engine kept in inventory by **October 6, 2010** (Table 5).

3. Excavation of Soil and Removal of Fuel Offloading Rack

The Permittee shall by **October 6, 2010** (Table 5) begin removal of the remaining components of the Fuel Offloading Rack and excavation of contaminated soil to 20 feet. The excavation of soil and removal of the Fuel Offloading Rack shall be completed by **October 6, 2011** (Table 5), and a report on completion of the work submitted to the NMED by **January 15, 2012** (Table 5). Any soil contamination left in place must meet NMED's requirements for clean up (see Comment # 8 of Section A of Part 1 of this letter). The Permittee may use direct push sampling and field analysis to help determine which soils require excavation. However, laboratory analysis shall be conducted to determine the concentrations of hazardous constituents in soil for the purpose of defining the final extent of excavation, for risk assessment, and for waste determinations.

Soil shall be sampled to determine whether all contaminated soil that poses an unacceptable risk to human health or the environment has been removed to a depth of at least 20 feet. Soil samples shall be analyzed in the laboratory for TPH, VOCs, SVOCs, and lead, and collected on all sides and the bottom of the excavation at a spacing not to exceed 25 feet.

4. Estimates of Contaminant Migration Rate

The Permittee must provide NMED by **September 7, 2010** (Table 5) with calculations showing the estimated velocity of and the travel time for the dissolved-phase contaminant plume to first reach the closest well in the Ridgecrest well field, the Veteran Administration (VA) Hospital Well, and KAFB production wells KAFB-3, KAFB-15, and KAFB-16. The calculations shall consider the direction and gradient of groundwater flow, and the geologic and hydrologic properties of the aquifer under a worse-case scenario. The Permittee shall provide the source of all information used to support the required calculations.

5. Installation of Sentry Wells

a. The Permittee must install groundwater monitoring wells (water table, intermediate, and deep wells referred to as A, B, and C wells) at location #28 of Table 4 of this letter, north of the leading edge of the dissolved-phase contaminant plume, by no later than **November 8, 2010** (Table 5) or 90 days after required access is granted, which ever is later. These wells will serve as sentry wells for the northern extent of the dissolved-phase plume.
b. The Permittee must install B and C groundwater monitoring wells at existing well locations KAFB-10613 and KAFB-1064, near the V.A. Hospital, by no later than **November 8, 2010** (Table 5) or 90 days after required access is granted, which ever is later. These wells will serve as sentry wells for the V.A. Hospital.
c. The Permittee must install A, B, and C groundwater monitoring wells at location #3 listed in Table 4 of this letter, on the east edge of the dissolved-phase contaminant plume, by no later than **November 8, 2010** (Table 5) or 90 days after required access is granted, which ever is later. These wells will serve as sentry wells for the northeastern extent of the dissolved-phase plume.
d. The Permittee must install A, B, and C groundwater monitoring wells at location #1 listed in Table 4 of this letter, on the west edge of the dissolved-phase contaminant plume no later than **November 8, 2010** (Table 5) or 90 days after required access is granted, which ever is later. These wells will serve as sentry wells for the northwestern extent of the dissolved-phase plume.
e. The Permittee must also conduct geologic and borehole geophysical logging of each well discussed in paragraphs a-d of this section. Geologic logging must be completed during the drilling of the boreholes; geophysical logging must be completed within 30 days of well completion (Table 5). Copies of the geologic and geophysical logs must be provided to the NMED by the submittal dates for quarterly reports specified in NMED's letter of June 4, 2010.

Wells constructed in cluster or nested configuration must meet the requirements set forth in Comment # 5 of Section D of Part 1 of this letter. Groundwater samples shall be collected and analyzed in a laboratory at a quarterly frequency from each sentry well in accordance with the direction in NMED's letter of June 4, 2010, and directions under this letter.

6. Geophysical logging of Existing Wells

The Permittee must conduct borehole geophysical logging (medium and deep induction, gamma, and neutron) at all existing groundwater monitoring wells. Copies of the geophysical logs must be provided to the NMED by **October 6, 2010** (Table 5).

7. Submitting Critical Data to NMED

The Permittee failed to provide certain critical information required in NMED's April 2, 2010 letter. The Permittee must provide the following information to the NMED by **September 7, 2010** (Table 5):

i. tables in electronic format (Excel™) showing the locations (x, y, z), sampling points, and maximum depths of all soil borings and vapor and groundwater monitoring wells;
ii. Survey plats for all wells.
iii. tabulated data in electronic format (Excel™) and graphs showing hydrocarbons (HC) and trends of major hazardous constituent (such as benzene, toluene, ethylene dibromide, xylenes, naphthalene, ethylbenzene, and lead) concentrations versus time for soil vapor for each extraction and each soil-vapor and groundwater monitoring well, as applicable.
iv. tabulated data in electronic format (Excel™) and graphs showing trends of TPH and major hazardous constituent (such as benzene, toluene, ethylene dibromide, xylenes, naphthalene, ethylbenzene, and lead) concentrations versus time for groundwater for each groundwater monitoring well.
v. Cross-sections showing the geology of the site drawn to a horizontal scale of 1 inch equals 50 feet, a vertical scale of 1 inch = 50 feet, and along the orientations A-A', B-B', C-C', and D-D' as shown on Figure 3 enclosed with this letter.
vi. Cross-sections showing the geology of the site drawn to a horizontal scale of 1 inch equals 300 feet, a vertical scale of 1 inch = 50 feet, and along the orientations A-A', B-B', C-C', and D-D' as shown on Figure 4 enclosed with this letter.
vii. Cross-sections showing concentrations of major hazardous constituents in soil, drawn to a horizontal scale of 1 inch equals 50 feet, a vertical scale of 1 inch = 50 feet, and along the orientations A-A', B-B', C-C', and D-D' as shown on Figure 3 enclosed with this letter.
viii. Cross-sections showing concentrations of major hazardous constituents in soil vapor, drawn to a horizontal scale of 1 inch equals 50 feet, a vertical scale of 1 inch = 50 feet, and along the orientations A-A', B-B', C-C', and D-D' as shown on Figure 3 enclosed with this letter.
ix. Cross-sections showing concentrations of major hazardous constituents in groundwater, drawn to a horizontal scale of 1 inch equals 300 feet, a vertical scale of 1 inch = 50 feet, and along the orientations A-A', B-B', C-C', and D-D' as shown on Figure 4 enclosed with this letter.

8. Sampling and Analysis of Water Production Wells

NMED understands that the Permittee is providing funding to the WUA to analyze groundwater samples from WUA water-supply wells threatened by contamination originating from the Bulk Fuels Facility Spill. NMED has also become aware that the analytical method used by the WUA to test for ethylene dibromide (EDB) is 524.2 rather than Method 504.1, the latter which is normally used for purposes of determining compliance with Safe Drinking Water Act.

NMED does not consider analysis by Method 524.2 to be sufficiently sensitive to provide adequate early-warning protection for the WUA wells. The Permittee shall continue to collaborate with the WUA to ensure that water quality is safe for human consumption, but will also ensure the samples are analyzed by Method 504.1. The Permittee shall provide copies of the laboratory results to the NMED in quarterly reports in accordance with the reporting requirements of NMED's letter of June 4, 2010.

B. Technical Requirements for Conducting Interim Measures

1. Notification of Sampling and other Field Activities

The Permittee shall notify the NMED in writing of field sampling or other field activities undertaken in accordance with the requirements of this letter, and shall provide the NMED the opportunity to collect split samples upon request by the NMED. For such sampling or other field activities, the Permittee shall provide the NMED with as much advance notice as is practicable, but no less than 15 days prior to the conduct of such sampling. The Permittee shall notify the NMED in writing a minimum of 15 days prior to the implementation of the Interim Measures, Groundwater Investigation and Vadose Zone Work Plans. Notification of sampling or other field activities may be made by email, fax, or letter.

2. Soil-Vapor Well Construction

Soil-vapor monitoring wells shall be designed and constructed in a manner that will yield high-quality samples. Soil vapor wells shall not be installed with the use of any fluids. Soil vapor wells may be completed by backfilling with native materials. The Permittee shall not sample the well before the expiration of the 24-hour equilibration period following completion of installation. Information on the design and construction of soil-vapor monitoring wells shall be recorded as for groundwater monitoring wells.

3. Groundwater Monitoring Well Construction

Groundwater monitoring wells shall be designed and constructed in a manner that will yield high quality samples, ensure that the well will last the duration of the project, and ensure that the well will not serve as a conduit for hazardous constituents to migrate between different stratigraphic units or aquifers. The design and construction of groundwater monitoring wells shall comply with the guidelines established in various RCRA guidance, including, but not limited to:

EPA, *RCRA Groundwater Monitoring Technical Enforcement Guidance Document*, OSWER-9950.1, September, 1986; and

Aller, L., Bennett, T.W., Hackett, G., Petty, R.J., Lehr, J.H., Sedoris, H., Nielsen, D.M., and Denne, J.E., *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*, EPA 600/4-89/034, 1989.

1. Drilling Methods

The Permittee shall abide by the following conditions:

1. Drilling shall be performed in a manner that minimizes impacts to the natural properties of the subsurface materials;
2. Drilling shall be performed in a manner that contamination and cross-contamination of groundwater and aquifer materials is avoided;

1. The drilling method shall allow for the collection of representative samples of rock, unconsolidated sediment, and soil;
2. The drilling method shall allow the Permittee to determine when the appropriate location for the screened interval(s) has been encountered;
3. The drilling method shall allow for the proper placement of a filter pack and annular sealant for each monitored zone, and the borehole diameter shall be at least four inches larger in diameter than the nominal diameter of the well casing and screen to allow adequate space for emplacement of the filter pack and annular sealants;
4. The drilling method shall also allow for the collection of representative groundwater samples; and
5. Drilling fluids, including air, shall be used only when minimal impact to the surrounding formation and groundwater can be ensured.

All drilling equipment shall be in good working condition and capable of performing the planned tasks. Drilling rigs and equipment shall be operated by properly trained crews. Drilling equipment shall be properly decontaminated before initiation of drilling for each boring. Precautions shall be taken to prevent the migration of contaminants between geologic, hydrologic, or other identifiable zones during drilling and well installation activities.
The drilling and sampling shall be conducted under the direction of a qualified engineer or geologist. Known site features and/or site survey grid markers shall be used as references to locate each boring prior to surveying the location.

2. Well Construction Materials

When selecting construction materials, the primary concern shall be selecting well construction materials that will not contribute to or remove hazardous waste or constituents from groundwater samples. Other factors to be considered include the tensile strength, compressive strength, and collapse strength of the materials; the length of time the monitoring well will be in service; and the material's resistance to chemical and microbiological corrosion.

3. Design and Construction of Screens and Filter Packs

Screens and filter packs shall be designed to allow accurate sampling of the saturated zone that the well is intended to sample, minimize the passage of formation materials (turbidity) into the well, and ensure sufficient structural integrity to prevent the collapse of the intake structure. The filter pack shall be installed in a manner that prevents bridging and particle-size segregation. Filter packs shall be installed by the tremie pipe method. At least two inches of filter pack material shall be installed between the screen and the borehole wall, and two feet of filter pack material shall extend above the top of the screen. A minimum of six inches and a maximum of two feet of filter pack material shall also be placed under the bottom of the screen. The precise volume of filter pack material required shall be calculated and recorded before placement, and the actual volume used shall be determined and recorded during construction. Any significant discrepancy between the calculated and actual volume shall be explained. Prior to installing the filter pack annular seal, a one to two-foot layer of chemically inert fine sand shall be placed over the filter pack to prevent the intrusion of annular sealants into the filter pack.

4. Design and Construction of Annular Seals

The annular space between the casing and the borehole wall shall be properly sealed to prevent cross-contamination. The materials used for annular sealants shall be chemically inert with respect to the highest anticipated concentration of chemical constituents expected in the groundwater. The precise volume of annular sealant required shall be calculated and recorded before placement, and the actual volume shall be determined and recorded during construction. Any significant discrepancy between the calculated volume and the actual volume shall be explained.

During construction, an annular seal shall be placed on top of the filter pack. This seal shall normally consist of a high solids (10 to 30 percent) bentonite material in the form of bentonite pellets, granular bentonite, or bentonite chips. The seal shall be placed in the annulus through a tremie pipe. A tamping device shall be used to ensure that the seal is emplaced at the proper depth. The bentonite seal shall be placed above the filter pack with a minimum of two-foot vertical thickness. The bentonite seal shall be allowed to completely hydrate in conformance with the manufacturer's specifications prior to installing the overlying annular grout seal.
A grout seal shall be installed on top of the filter pack seal. The grout shall be placed into the annular space by the tremie pipe method, from the top of the filter pack annular seal to within a few feet of the ground surface; however, the grout shall be installed at intervals necessary to allow it time to cure and not damage the filter pack or filter pack annular seal during installation of the grout. The grout seal shall be allowed to cure for a minimum of 24 hours before the concrete surface pad is installed. All grouts shall be prepared in accordance with the manufacturer's specifications.

5. Surface Completion Methods

Monitoring wells may be completed either as flush-mounted wells, or as above-ground completions. A surface seal shall be installed over the grout seal and extended vertically up the well annulus to the land surface. The lower end of the surface seal shall extend a minimum of one foot below the frost line to prevent damage from frost heaving. The composition of the surface seal shall be neat cement or concrete. In above-ground completions wherein the well casing rises or sticks up above ground level, a three-foot square by four-inch thick concrete surface pad shall be installed around the well immediately after the protective casing is installed. The surface pad shall be sloped so that drainage will be off the pad and away from the protective casing. In addition, a minimum of one inch of the finished pad shall be below grade or ground elevation to prevent washing and undermining by soil erosion.

Protective casing with a locking cover shall be installed around the well casing (stickup or riser) to prevent damage or unauthorized entry. The protective casing shall be anchored in the concrete surface pad below the frost line and extend at least several inches above the casing stickup. A weep hole shall be drilled into the protective casing just above the top of the concrete surface pad to prevent water from accumulating and freezing inside the protective casing. A cap shall be placed on the well riser to prevent the entry of foreign materials into the well, and a lock shall be installed on the cover of the protective casing to provide security against tampering. If a well is located in an area that receives vehicular traffic, a minimum of three bumper guards consisting of steel pipes three to four inches in diameter and a minimum of five-feet in length shall be installed next to the concrete surface pad. The bumper guards shall be installed to a minimum depth of two feet below the ground surface in a concrete footing and extend a minimum of three feet above ground surface. The pipes that form the bumper guards shall be filled with concrete to provide additional strength, and shall be painted a bright color to make them readily visible.
If flush-mounted completions are required (e.g., in active roadway areas), a protective structure such as a traffic-rated utility vault or meter box shall be installed around the casing. In addition, measures should be taken to prevent the accumulation of surface water in the protective structure and around the well intake. These measures shall include outfitting the protective structure with a steel lid or manhole cover that has a rubber seal or gasket, and ensuring that the bond between the cement surface seal and the protective structure is watertight. A lock shall be installed on the lid or cover of the protective structure to prevent unauthorized access to the well.

6. Well Development Methods

All monitoring wells shall be developed to create an effective filter pack around the screen, correct damage to the formation caused by drilling, remove residual drilling mud or other drilling additives, if present, and fine particles from the formation near the borehole, and assist in restoring the original water quality of the aquifer in the vicinity of the well. Monitoring wells shall be developed until the column of water in each well is free of visible sediment, and the pH, temperature, turbidity, and specific conductance have stabilized to within 10%. If a well is pumped dry, the water level shall be allowed to sufficiently recover before the next development period is initiated.

If water is introduced to a borehole during drilling and completion, then at minimum the same volume of water shall be removed from the well during development. In addition, the volume of water withdrawn from or introduced into a well during development shall be recorded. Well development must be completed within 30 days of installation.

4. Surveying Requirements for Groundwater Monitoring and Soil-Vapor Wells

The horizontal and vertical coordinates of the measuring point at the top of each monitoring well casing and the ground surface elevation at each monitoring well location shall be determined by a registered New Mexico professional land surveyor or licensed Professional Engineer. Horizontal coordinates shall be measured in accordance with the State Plane Coordinate System. Horizontal positions shall be measured to the nearest 0.1 foot, and vertical elevations shall be measured to the nearest 0.01 foot.

5. Well Completion Reports

For each monitoring well, the Permittee shall submit to the NMED a completion summary report which shall include a well construction log and diagram, a geologic log, and a well development log. The report for each well shall be submitted in accordance with the quarterly schedule set forth in NMED's letter of June 4, 2010.

6. Well Construction Diagrams and Logs

Information on the design, construction, and development of each monitoring well shall be recorded. Construction diagrams and logs shall include the following information:

1. Well, boring name/number;
2. Date/time of construction;
3. Borehole diameter and casing diameter;
4. Surveyed location coordinates;
5. Total depth, expressed both as depth below ground surface and elevation above sea level;
6. Name of drilling contractor;
7. Casing length;
8. Casing materials;
9. Casing and screen joint type;
10. Screened intervals, expressed both as depth(s) below ground surface and elevation(s) above sea level;
11. Screen materials;
12. Screen slot size and design;
13. Filter-pack material and size;
14. Filter-pack volume (calculated and actual);
15. Filter-pack placement method;

16. Filter-pack interval(s), expressed both as depth(s) below ground surface and elevation(s) above sea level;
17. Annular sealant composition;
18. Annular sealant placement method;
19. Annular sealant volume (calculated and actual);
20. Annular sealant interval, expressed both as depth below ground surface and elevation above sea level;
21. Surface sealant composition;
22. Surface seal placement method;
23. Surface sealant volume (calculated and actual);
24. Surface sealant interval, expressed both as depth below ground surface and elevation above sea level;
25. Surface seal and well apron design and construction;
26. Development procedure and turbidity measurements;
27. Well development purge volume(s) and stabilization parameter measurements;
28. Type, design, and construction of protective casing;
29. Type of cap and lock;
30. Ground surface elevation above sea level;
31. Survey reference point elevation above sea level on well casing;
32. Top of casing elevation above sea level;
33. Top of protective steel casing elevation above sea level;
34. Drilling method(s); and
35. Types, quantities, and dates/times that additives were introduced, if any.

7. Measurement of Groundwater Levels

Groundwater levels shall be measured in all monitoring wells associated with the Bulk Fuels Facility Spill within 72 hours from the start of monitoring the water level in the first well. Groundwater levels shall be obtained prior to purging for any sampling event. Measurement data and the date and time of each measurement shall be recorded on a field log. The depth to groundwater shall be measured to the nearest 0.01 foot. The depth to groundwater shall be recorded relative to the surveyed well casing rim.

8. Sampling of Environmental Media

Sampling of environmental media (groundwater, soil, and soil vapor) shall comply with the requirements set forth in NMED's letter of June 4, 2010, and in accordance with the additional requirements provided herein.

1. Soil Sampling Requirements

Relatively undisturbed discrete soil and rock samples shall be obtained during the advancement of each boring for the purpose of logging and analytical testing. A split-barrel sampler lined with brass sleeves, a coring device, or other method approved in advance by the NMED shall be used to obtain samples during the drilling of each boring.

Soil samples are subject to the same field quality assurance, laboratory quality assurance, data validation, and reporting requirements as for groundwater and soil-vapor samples; including requirements to collect or prepare, as appropriate, and analyze field quality control samples. Soil samples collected for the purpose of analyzing for VOCs and SVOCs shall not be mixed to homogenize samples for any reason.

2. Groundwater Sample Collection

Groundwater samples shall be obtained within eight hours of the completion of well purging. Groundwater in monitoring wells with low recharge rates and that purge dry shall be sampled when the water level in the well has recovered sufficiently to collect the required samples. Sample collection methods shall be documented in field monitoring logs. Samples shall be placed into appropriate clean containers. Decontamination procedures shall be established and, implemented, for nondedicated water sampling equipment.

The Permittee shall obtain groundwater samples for dissolved metals analysis using disposable in-line filters with a 0.45 micron mesh size.

9. Field Quality Control

Field duplicates shall consist of two samples collected sequentially. Field duplicate samples shall be collected and analyzed at a frequency of at least 10 percent of the total number of environmental samples submitted for analysis. At a minimum, one duplicate sample per sampling event shall always be collected and analyzed.

Field blanks shall be prepared and analyzed at a frequency of no less than one per day. Field blanks shall be generated by filling sample containers in the field with deionized water and submitting the field blank, along with the groundwater samples, to an analytical laboratory.

Equipment blanks shall be prepared and analyzed at a rate of at least five percent of the total number of environmental samples submitted for analysis, but no less than one equipment blank per sampling day. Equipment blanks shall be generated by rinsing decontaminated sampling equipment with deionized water, and capturing the rinsate water in an appropriate clean container. The equipment blank then shall be submitted with the groundwater samples to the analytical laboratory for the same analyses as the environmental samples.

Trip blanks shall be prepared using deionized water. Trip blanks shall be managed exactly the same as environmental samples. Trip blanks shall accompany sampling personnel into the field throughout sampling activities, and then shall be placed into a shipping container with environmental samples for shipment to the analytical laboratory. Trip blanks shall be analyzed at a frequency of one for each shipping container holding samples for VOC analysis.

10. Laboratory Quality Assurance

The Permittee shall ensure that contract analytical laboratories maintain internal quality assurance programs in accordance with EPA and industry-accepted practices and procedures. At a minimum, the laboratories shall use a combination of standards, blanks, surrogates, duplicates, matrix spike/matrix spike duplicates (MS/MSD), and other laboratory control samples to assess data quality. The laboratories shall establish control limits for individual chemicals or groups of chemicals based on the long-term performance of the test methods. In addition, the laboratories shall establish internal QA/QC procedures that meet EPA's laboratory certification requirements. Specific procedures to be completed are identified in the following sections. If a laboratory is unable or unwilling to meet the requirements of this Permit, the Permittee shall select a different laboratory that can and will meet the requirements.

1. Laboratory Equipment Calibration Procedures

The laboratories' equipment calibration procedures, calibration frequency, and calibration standards shall be in accordance with the EPA test method requirements and documented in quality assurance and standard operating procedures manuals. All instruments and equipment used by laboratories shall be operated, calibrated, and maintained according to manufacturers' guidelines and recommendations. Operation, calibration, and maintenance shall be performed by personnel who have been properly trained in these procedures. A routine schedule and record of instrument calibration and maintenance shall be kept on file at the laboratories.

2. Laboratory QC Samples

Analytical procedures shall be evaluated for quality by analyzing reagent blanks or method blanks, surrogates, MS/MSDs, and laboratory duplicates, as appropriate for each method. At a minimum, laboratories shall analyze laboratory blanks, MS/MSDs, and laboratory duplicates at a frequency of at least one in 20 for all batch runs requiring EPA test methods and at a frequency of at least one in 10 for non-EPA test methods. All laboratory quality control data reported with the Facility's sample analysis results must be related to the analysis of the Facility's samples.

11. Data Validation

The Permittee shall evaluate all sample data, and all field and laboratory QC results for acceptability. Each group of samples shall be evaluated using data validation guidelines contained in EPA guidance documents, the latest version of SW-846, and industry-accepted methods and procedures. Additionally, the Permittee shall evaluate all data for compliance with the following parameters:

1. Representativeness -- The Permittee shall implement procedures to assure representative samples are collected and analyzed, such as repeated measurements of the same parameter at the same location over several distinct sampling events. The Permittee shall note any procedures or variations that may affect the collection or analysis of representative samples and shall qualify the data accordingly;

2. Comparability -- To assure comparability of data, the Permittee shall implement standard collection and analytical procedures, and shall report analytical results in appropriate units for comparison with other data (e.g., past studies, comparable sites, screening levels, and cleanup standards). Any procedure or variation that may affect comparability shall be noted, and the data shall be qualified appropriately;

3. Completeness -- The Permittee shall evaluate all laboratory data for completeness with respect to data quality objectives. The degree of completeness shall be reported with the data in any reports in which the data are referenced;

4. Accuracy -- The Permittee shall evaluate all data for accuracy with respect to percent recovered of spiked samples. Results shall be reported for each analyte in any report in which the data are cited; and

5. Precision -- The Permittee shall evaluate all data for precision with respect to RPDs of duplicate samples. Results shall be reported for each analyte in any report in which the data are cited.

12. Waste Management

Waste management of investigation derived waste shall be in accordance with that set forth in Part 1 of this letter.

13. Geophysical Logs

Geophysical logging shall be conducted using induction (deep, medium), neutron, and gamma (large crystal) tools. Geophysical logging at cluster/nested well locations is required in only the well at each location that has the deepest screened interval.

Geophysical logs submitted to the NMED must show results of the induction logging (medium and deep) in millimhos per meter, neutron logging in American Petroleum Institute (API) neutron units, and gamma logging in API calibrated counts per second, the results of each method plotted versus depth from the surface to total depth of the borehole for which the log represents. The name of the borehole, location of the borehole, the date(s) that the borehole was completed, the drilling method, and the elevation of the top of the borehole shall also be noted on the boring log. The data must be provided to the NMED in hard copy and in digital format.

14. Field and Geologic Logs

The physical characteristics of soil and rock samples, such as mineralogy and lithic content, ASTM soil classification, moisture content, texture, color, presence of stains or odors, field screening results, depth, location, method of sample collection, the presence of any water-bearing zones and any unusual or notable conditions encountered during drilling shall be recorded in a field log. Field logs shall be completed by a qualified geologist.

The Permittee shall prepare geologic logs for each borehole showing relative to borehole depth the rock types, thickness of rock units, and water bearing zones (including that at and below the water table). The name of the borehole, location of the borehole, the date(s) that the borehole was completed, the drilling method, and the elevation of the top of the borehole shall also be noted on the boring log. The data must be provided to the NMED in hard copy and in digital format.

15. Reporting

Unless specified otherwise in this letter, the Permittee shall report to the NMED the information that is required by NMED's letter of June 4, 2010, and by the indicated schedules in that letter. Reporting for the additional SVE units required to be installed under Part 2 of this letter shall also be in accordance with NMED's letter of June 4, 2010.

Final Direction

The Permittee shall meet the deadlines specified in the Compliance Schedule of Table 5 of this letter. The Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans must be completely revised and resubmitted. The Permittee shall submit to NMED by **September 7, 2010** (Table 5) revisions of the Vadose Zone, Interim Measures, and Groundwater Investigation Work Plans that correct the deficiencies noted herein and incorporate the requirements set forth in this letter. The Permittee shall also implement the interim measures and other actions as directed under Part 2 of this letter by the dates indicated and in accordance with the schedule in Table 5.

The investigation plans required under this letter shall include relevant maps and cross-sections that show concentration data for contaminants and other relevant information with supporting data posted on the maps and cross-sections in a legible manner, and clearly showing which borings/wells contributed data towards construction of the maps and cross-sections and which did not. Tables including all existing soil borings, soil-gas monitoring wells, and groundwater monitoring wells, listing their surveyed location, sampling points and maximum depth of exploration shall also be included in the reports and plans. For soil-gas monitoring wells, tables and graphs shall also be included providing trends of TPH concentrations versus time for the depths below ground surface of 25, 50, 150, 250, 350, and 450 feet.

To the extent any requirement of this letter requires access to property not owned or controlled by the Permittee, the Permittee shall use its best efforts to obtain access from the present owners of such property to conduct the required activities. In the event that access is not obtained when necessary, the Permittee shall immediately notify the NMED in writing regarding its best efforts and its failure to obtain such access.

Table 5. Compliance Schedule.

Revisions to Work Plans	
Submittal	Due Date
Interim Measures Work Plan	September 7, 2010
Vadose Zone Work Plan	September 7, 2010
Groundwater Investigation Work Plan	September 7, 2010
Other Document Submittals	
Indoor Air Quality Report	October 6, 2010
Interim Measures and other Actions	
Install and operate SVE units at KAFB-3411, KAFB-10614, and KAFB-10624	October 6, 2010
Install and operate SVE units at soil boring/monitoring well locations #4, 5, 9, 10, 11, and 12 (see Table 1)	November 8, 2010 or 60 days after required access is granted, which ever is later
Install and operate SVE units at KAFB-10617 and KAFB-10618	October 6, 2010
Install and operate SVE units at soil boring/monitoring well location KAFB-10610	November 8, 2010 or 60 days after required access is granted, which ever is later
Prepare for SVE operation at soil boring/monitoring well locations #3, 8, and 9 (see Table 2)	November 8, 2010 or 60 days after required access is granted, which ever is later
Operate SVE units at Fuel Offloading Rack and KAFB-1065, KAFB-1066, and KAFB-1068	Immediately, except operation of SVE Unit at Fuel Offloading Rack may be temporarily suspended while excavating soil and removing remaining components of the Fuel Offloading Rack.
Maintain spare parts and spare engine for SVE units in inventory	September 7, 2010
Report that spare parts and spare engine for SVE units is in inventory	October 6, 2010
Begin excavation of contaminated soil and removing remaining components of the Fuel Offloading Rack.	October 6, 2010
Complete excavation of contaminated soil and	October 6, 2011

removing remaining components of the Fuel Offloading Rack.	
Report on completion of excavation of contaminated soil and removing remaining components of the Fuel Offloading Rack.	January 15, 2012
Submit estimate of contaminant migration rate to NMED	September 7, 2010
Complete A, B, and C sentry wells at location #28 (see Table 4)	November 8, 2010 or 90 days after required access is granted, which ever is later
Complete B and C sentry wells at KAFB-10613 and KAFB-1064	November 8, 2010 or 90 days after required access is granted, which ever is later
Complete A, B, and C sentry wells at location #3 (see Table 4)	November 8, 2010 or 90 days after required access is granted, which ever is later
Complete A, B, and C sentry wells at location #1 (see Table 4)	November 8, 2010 or 90 days after required access is granted, which ever is later
Complete geologic logs of new wells at locations #1, 3, 28, KAFB-10613 and KAFB-1064	During drilling of each well
Complete geophysical logs of new wells at locations #1, 3, 28, KAFB-10613 and KAFB-1064	Within 30 days of well completion
Submit copies of geologic and geophysical logs for locations #1, 3, 28, KAFB-10613 and KAFB-1064	In accordance with NMED letter of June 4, 2010
Submit copies of geophysical logs of existing wells	October 6, 2010
Submit critical data to NMED (Section A.7 of Part 2).	September 7, 2010
Notification of sampling and other field activities (Section B.1 of Part 2)	No less than 15 days prior to implementation
Submit geologic and geophysical logs for sentry wells	In accordance with NMED letter of June 4, 2010
Submit water quality data for WUA wells	In accordance with NMED letter of June 4, 2010
Submit well completion reports	In accordance with NMED letter of June 4, 2010
Submit report on all SVE units	In accordance with NMED letter of June 4, 2010
Report to NMED if any SVE units will not receive an air emissions permit to operate	Immediately
Report to NMED down time of SVE units that will exceed a duration of 72 hours	Within 24 hours of discovery that repairs or maintenance will take more than 72 hours to complete

The Permittee shall respond directly to my attention, with copy to Mr. Bill Olson of the NMED's Ground Water Quality Bureau, and Mr. William Moats (NMED HWB, 5500 San Antonio NE, Albuquerque, NM 87109), on all correspondence and required plans and reports related to the Bulk Fuels Facility Spill, unless otherwise directed by NMED. All submittals and correspondence must be submitted in hardcopy and electronic format.

If you have any questions regarding the technical aspects of this letter, please contact Mr. William Moats of my staff at (505) 222-9551. Any other questions should be directed to me at 505-476-6016.

Sincerely,

James P. Bearzi
Chief
Hazardous Waste Bureau

Enclosures: Figures 1-4

cc: J. Kieling, NMED HWB
W. Moats, NMED HWB
W. McDonald, NMED HWB
S. Brandwein, NMED HWB
B. Olsen, HWB GWQB
A. Puglisi, HWB GWQB
B. Swanson, HWB GWQB
L. Barnhart, NMED OGC
B. Gallegos, AEHD
B. Gastian, ABCWUA
L. King, EPA-Region 6 (6PD-N)
File: Reading and KAFB 2010

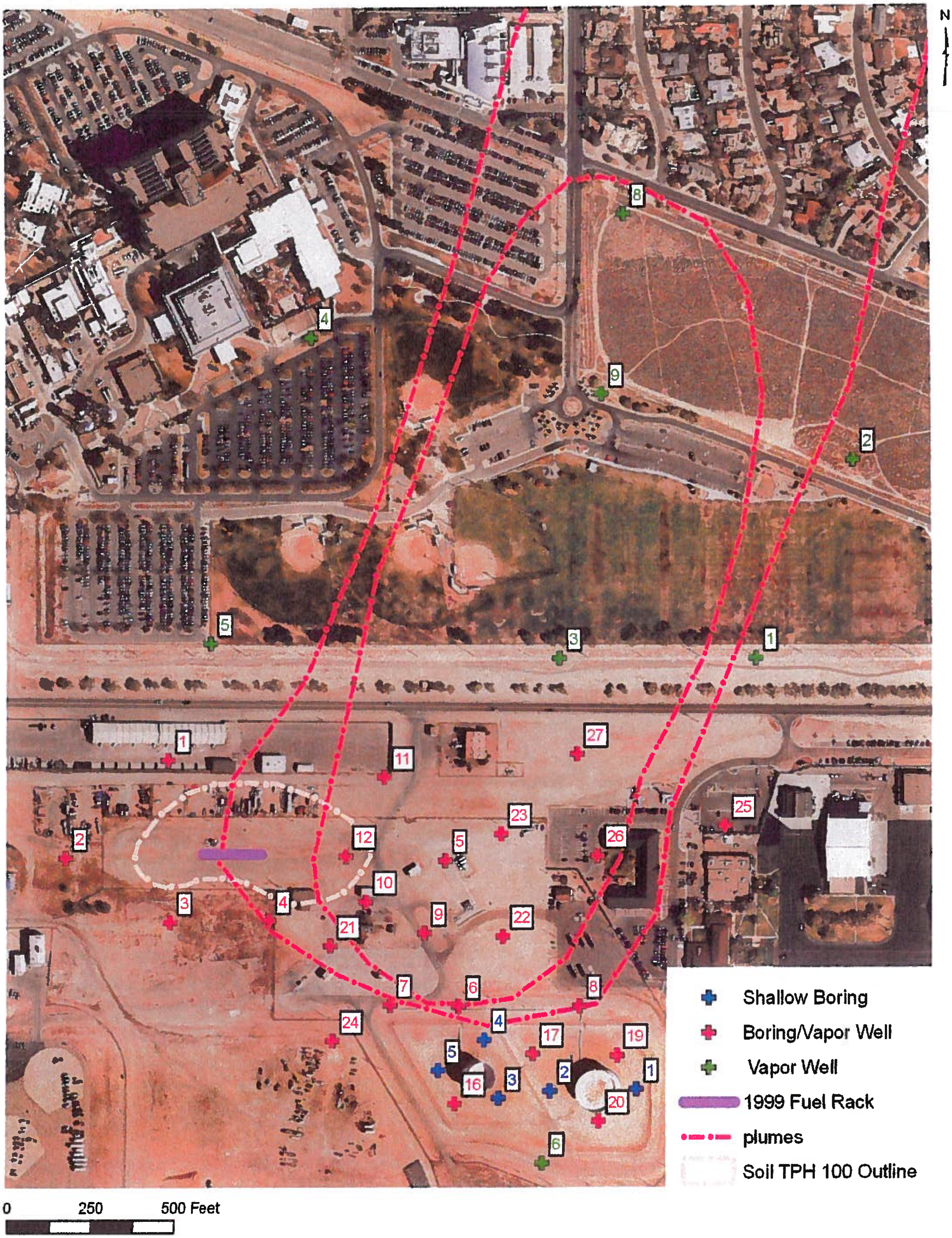

Figure 1. Soil Boring and
Soil-Vapor Monitoring Well Locations

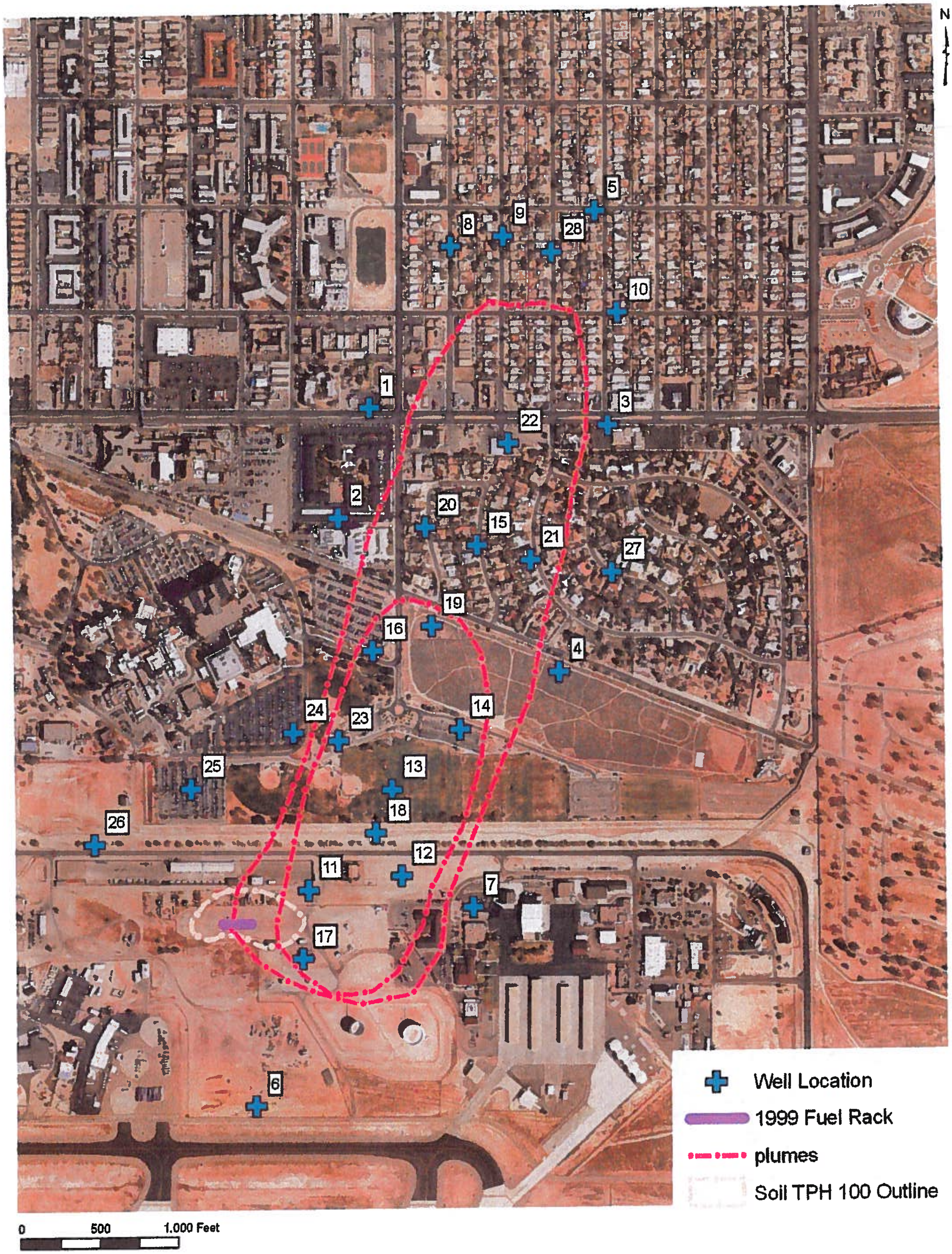

Figure 2. Groundwater Monitoring Well Locations

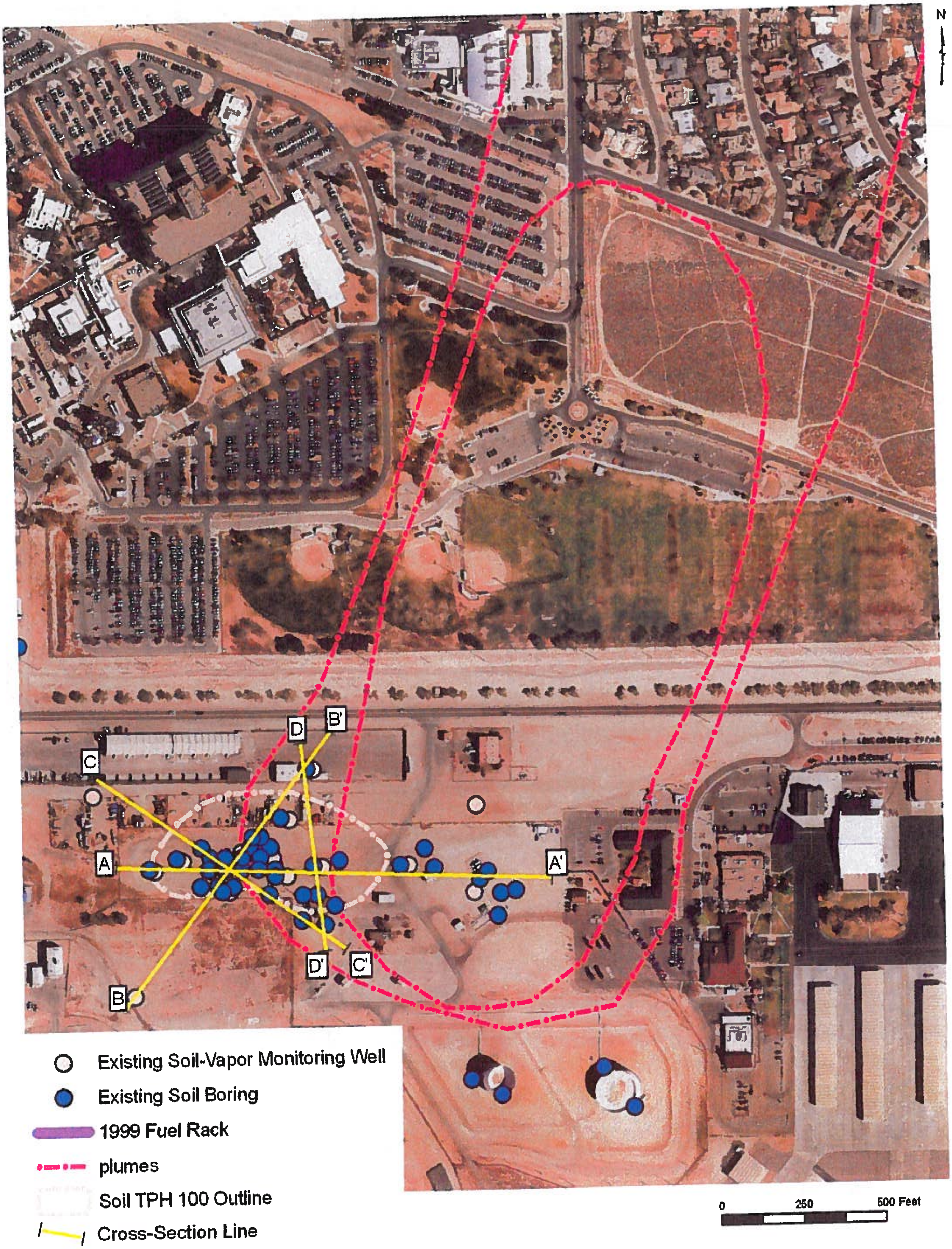

Figure 3 Existing Soil Boring, Soil-Vapor Monitoring Well and Cross-Section Locations

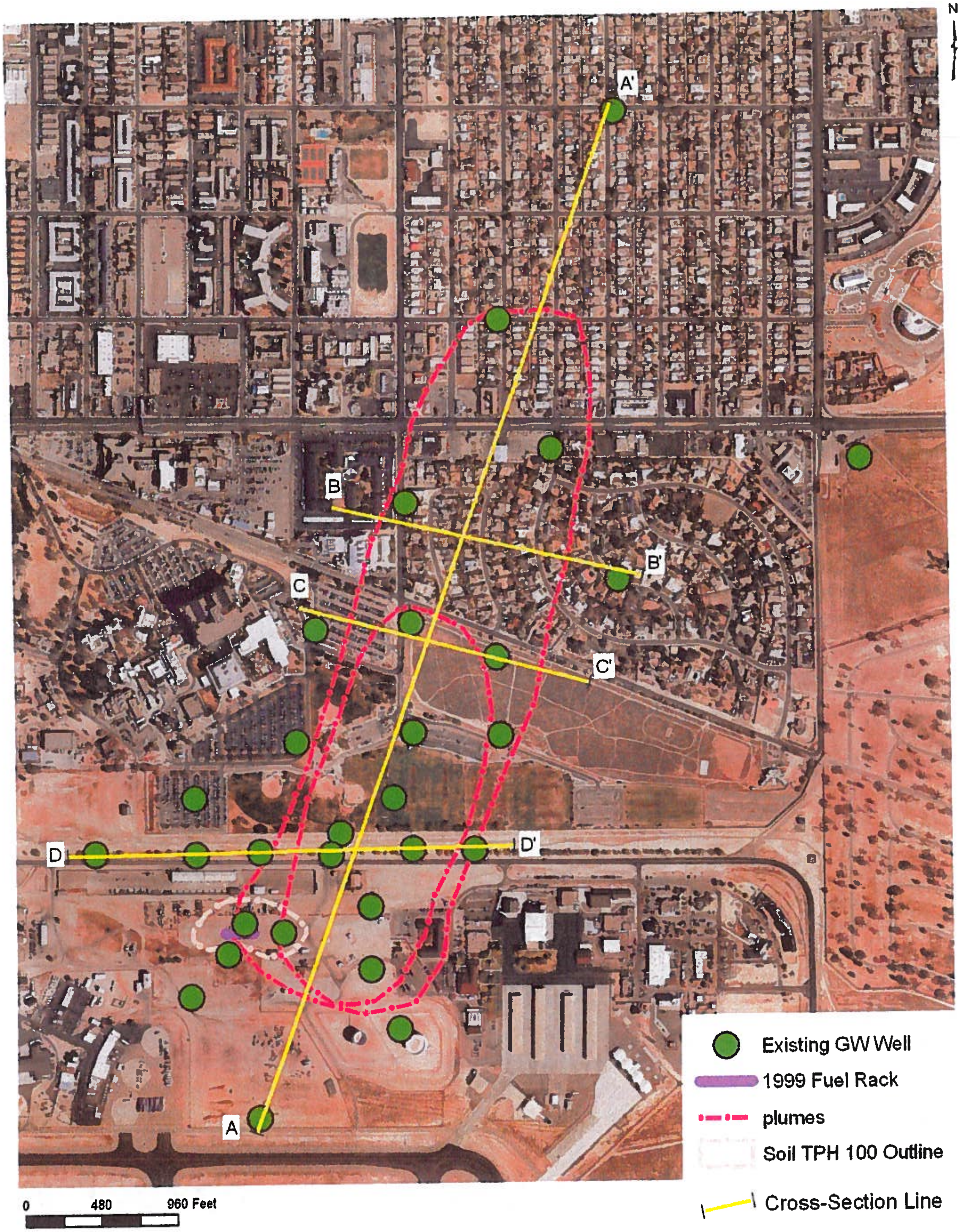

Figure 4. Existing Well and Cross-Section Locations

APPENDIX B

Project Schedule

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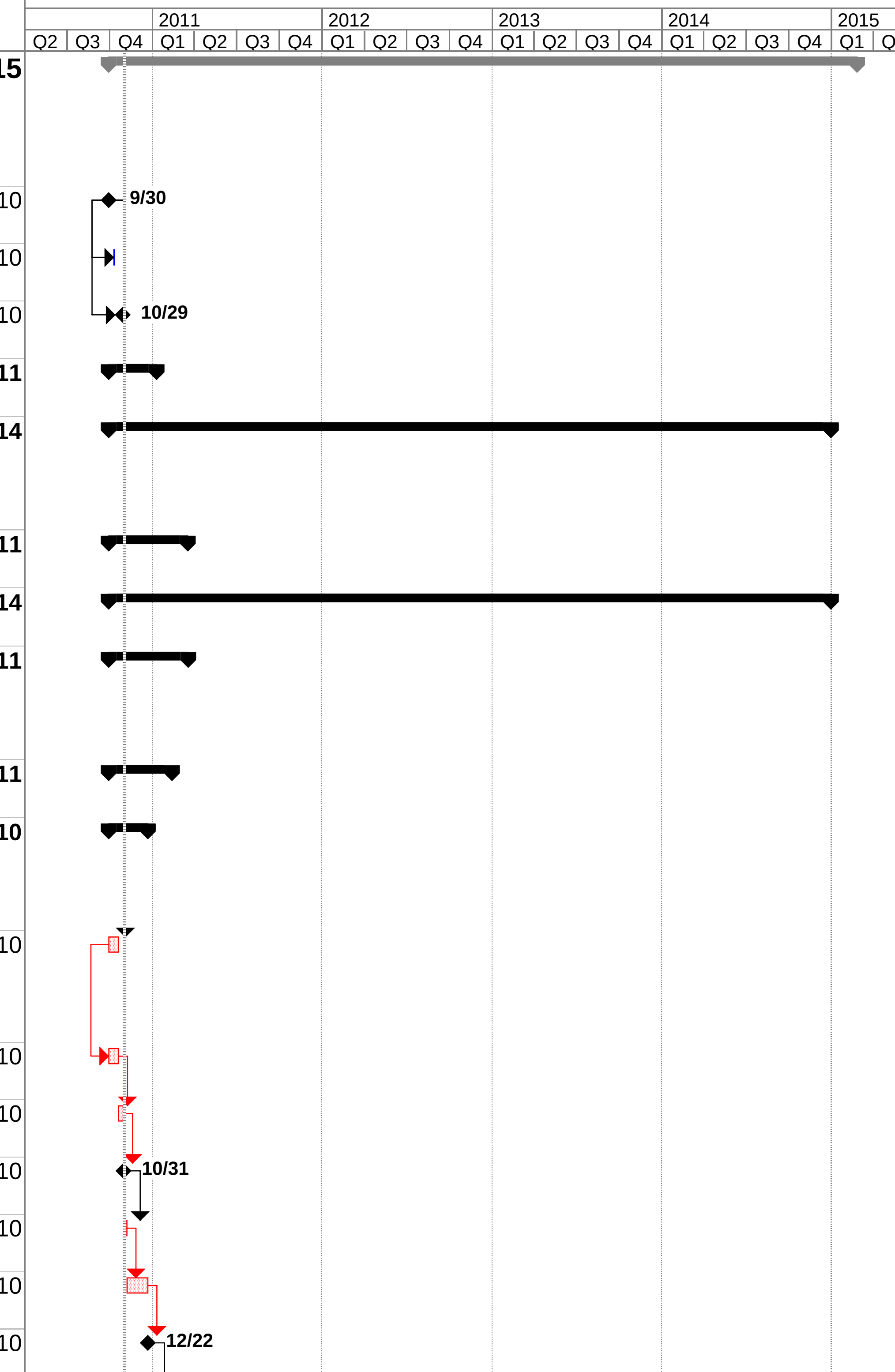
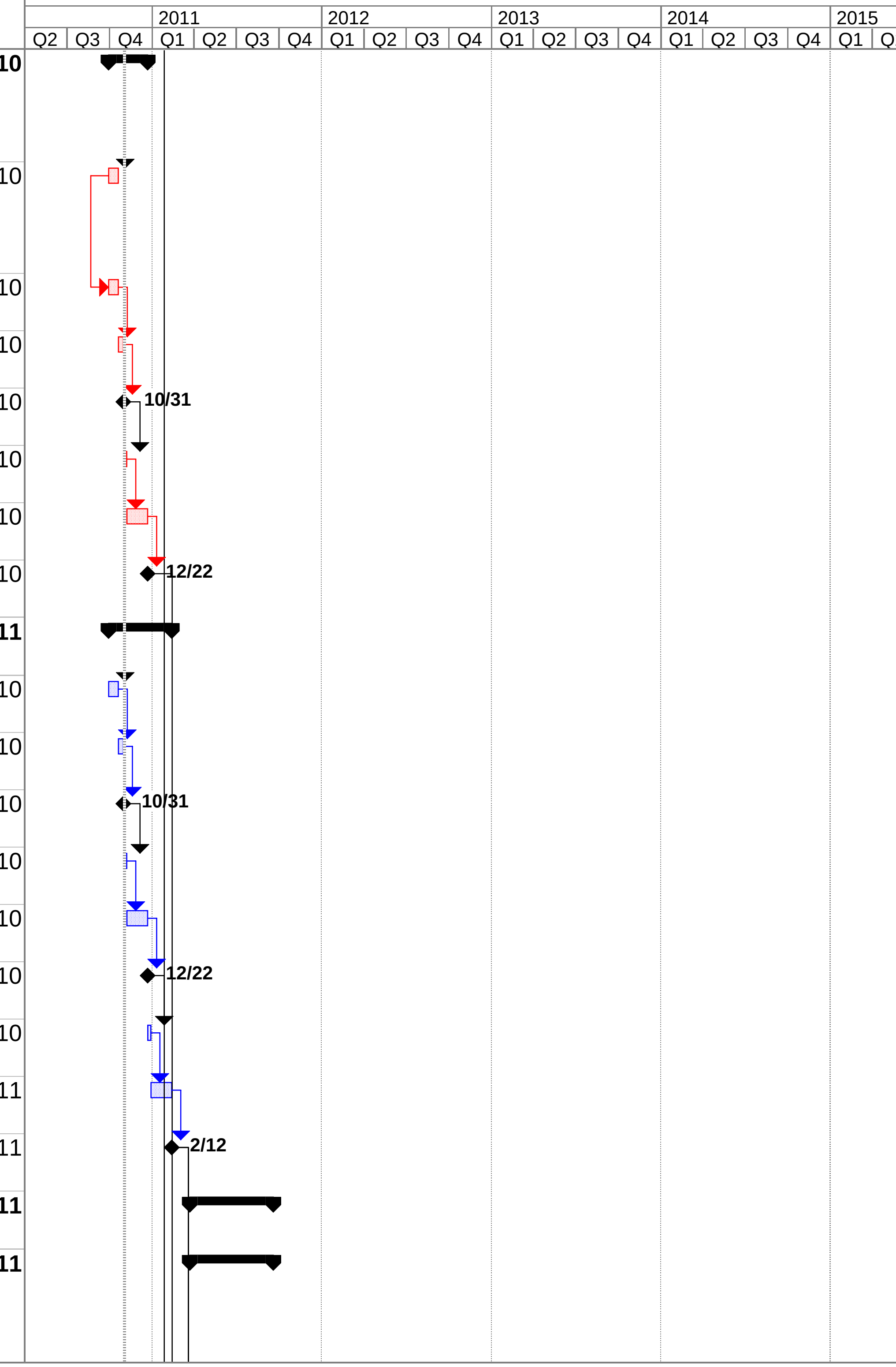
Activity ID	QA PM	CLIN Sub-CLIN	Task Name	Duration	Start	Finish
0		2001	**Kirtland Air Force Base Environmental Remediation Services at Bulk Fuels Facility (BFF)**	**1610 days**	**Thu 9/30/10**	**Wed 2/25/15**
1			Task Order Award/Notice to Proceed	0 days	Thu 9/30/10	Thu 9/30/10
2			Project Kick-Off Meeting	1 day	Mon 10/11/10	Mon 10/11/10
3			Submit Well Permit Application	0 days	Fri 10/29/10	Fri 10/29/10
4		2001AA	**Project Management Plan (PMP) and Quality Assurance Surveillance Plan (QASP)**	**103 days**	**Thu 9/30/10**	**Mon 1/10/11**
12		2001AB	**Site Plans in Accordance w / Performance Work Statement (PWS) and Community Relations**	**1554 days**	**Thu 9/30/10**	**Wed 12/31/14**
13			**Community Relations Plan**	**170 days**	**Thu 9/30/10**	**Fri 3/18/11**
23			**Community Relations**	**1554 days**	**Thu 9/30/10**	**Wed 12/31/14**
99			**Pre-Remedy Monitoring Work Plan, Health and Safety Plan (HASP), Quality Assurance Project Plan (QAPP)**	**171 days**	**Thu 9/30/10**	**Sat 3/19/11**
109			**Vadose Zone, Groundwater and Interim Measures Work Plans - Part I**	**136 days**	**Thu 9/30/10**	**Sat 2/12/11**
110			**Resource Conservation and Recovery Act Facility Investigation (RFI) Work Plan for the Vadose Zone at the BFF**	**84 days**	**Thu 9/30/10**	**Wed 12/22/10**
111			Prepare Draft Final (RFI) Work Plan for the Vadose Zone (Revise Existing Plan/Incorporate Regulator Comments)	21 days	Thu 9/30/10	Wed 10/20/10
112			Prepare Draft ROE	21 days	Thu 9/30/10	Wed 10/20/10
113	QA		Army/Air Force Review	11 days	Thu 10/21/10	Sun 10/31/10
114	PM		Army/Air Force Approval	0 days	Sun 10/31/10	Sun 10/31/10
115			Prepare Final Vadose Zone RFI Work Plan	7 days	Mon 11/1/10	Sun 11/7/10
116	QA		Regulator/Stakeholder Review	45 days	Mon 11/8/10	Wed 12/22/10
117	PM		Regulator/Stakeholder Approval	0 days	Wed 12/22/10	Wed 12/22/10



Project: Kirtland Air Force Base Envir
Date: Mon 11/1/10

Task		Milestone	◆	Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone	◇	External Tasks		Deadline	⇩
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

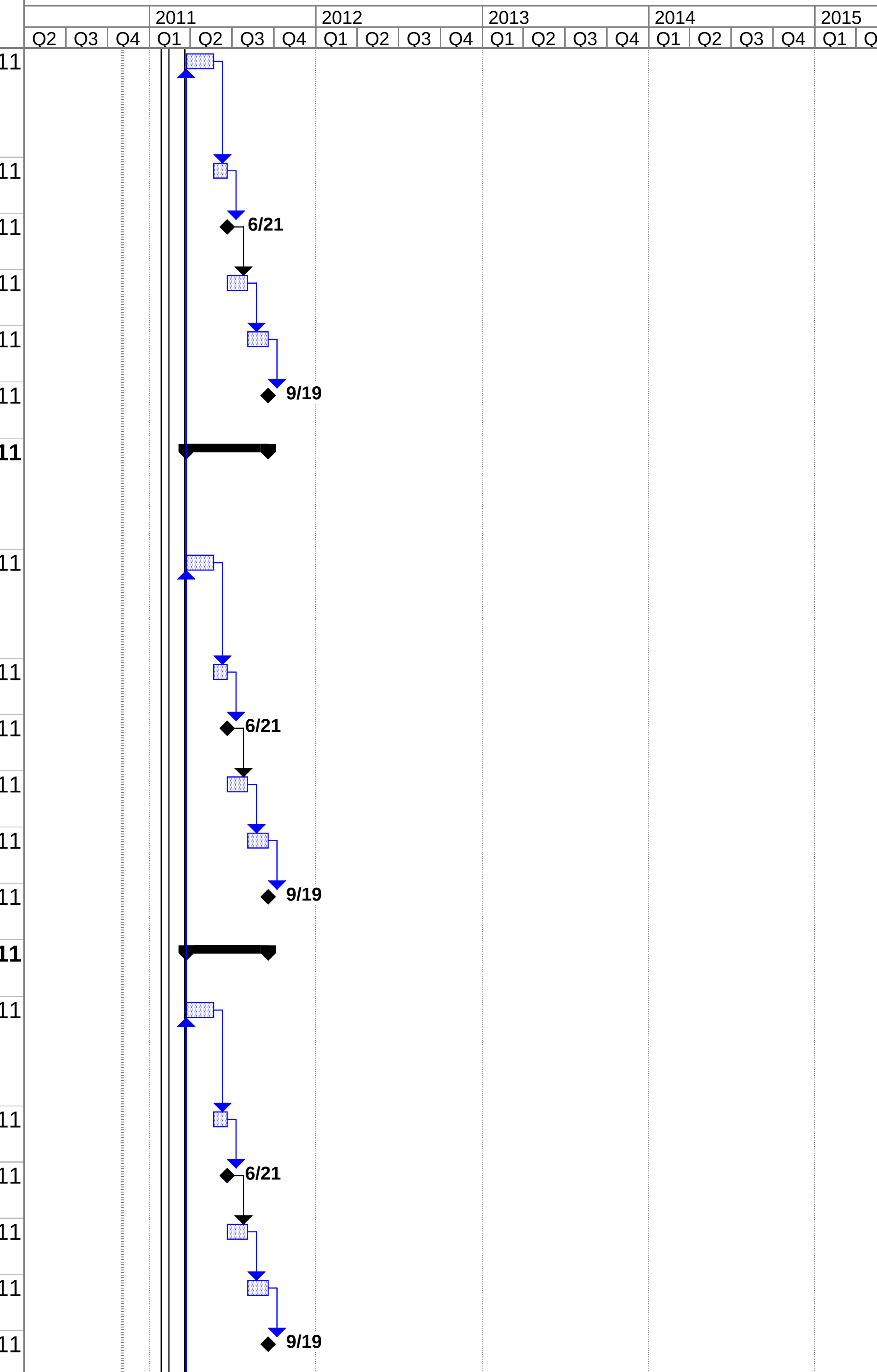
Activity ID	QA PM	CLIN Sub-CLIN	Task Name	Duration	Start	Finish
118			**Resource Conservation and Recovery Act Facility Investigation (RFI) Work Plan for Groundwater at the BFF**	**84 days**	**Thu 9/30/10**	**Wed 12/22/10**
119			Prepare Draft Final (RFI) Work Plan for Groundwater (Revise Existing Plan/Incorporate Regulator Comments)	21 days	Thu 9/30/10	Wed 10/20/10
120			Prepare Draft ROE	21 days	Thu 9/30/10	Wed 10/20/10
121	QA		Army/Air Force Review	11 days	Thu 10/21/10	Sun 10/31/10
122	PM		Army/Air Force Approval	0 days	Sun 10/31/10	Sun 10/31/10
123			Prepare Final Groundwater RFI Work Plan	7 days	Mon 11/1/10	Sun 11/7/10
124	QA		Regulator/Stakeholder Review	45 days	Mon 11/8/10	Wed 12/22/10
125	PM		Regulator/Stakeholder Approval	0 days	Wed 12/22/10	Wed 12/22/10
126			**Interim Measures Work Plan**	**136 days**	**Thu 9/30/10**	**Sat 2/12/11**
127			Revise Existing Interim Measures Work Plan	21 days	Thu 9/30/10	Wed 10/20/10
128	QA		Army/Air Force Review	11 days	Thu 10/21/10	Sun 10/31/10
129	PM		Army/Air Force Approval	0 days	Sun 10/31/10	Sun 10/31/10
130			Prepare Draft Final Interim Measures Work Plan	7 days	Mon 11/1/10	Sun 11/7/10
131	QA		Regulator/Stakeholder Review	45 days	Mon 11/8/10	Wed 12/22/10
132	PM		Regulator/Stakeholder Approval	0 days	Wed 12/22/10	Wed 12/22/10
133			Prepare Final Interim Measures Work Plan	7 days	Thu 12/23/10	Wed 12/29/10
134	QA		Regulator/Stakeholder Review	45 days	Thu 12/30/10	Sat 2/12/11
135	PM		Regulator/Stakeholder Approval	0 days	Sat 2/12/11	Sat 2/12/11
136			**Vadose Zone, Groundwater and Interim Measures Work Plans - Part II**	**180 days**	**Thu 3/24/11**	**Mon 9/19/11**
137			**Resource Conservation and Recovery Act Facility Investigation (RFI) Work Plan for the Vadose Zone at the BFF**	**180 days**	**Thu 3/24/11**	**Mon 9/19/11**



Project: Kirtland Air Force Base Envir
Date: Mon 11/1/10

Task		Milestone		Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone		External Tasks		Deadline	
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

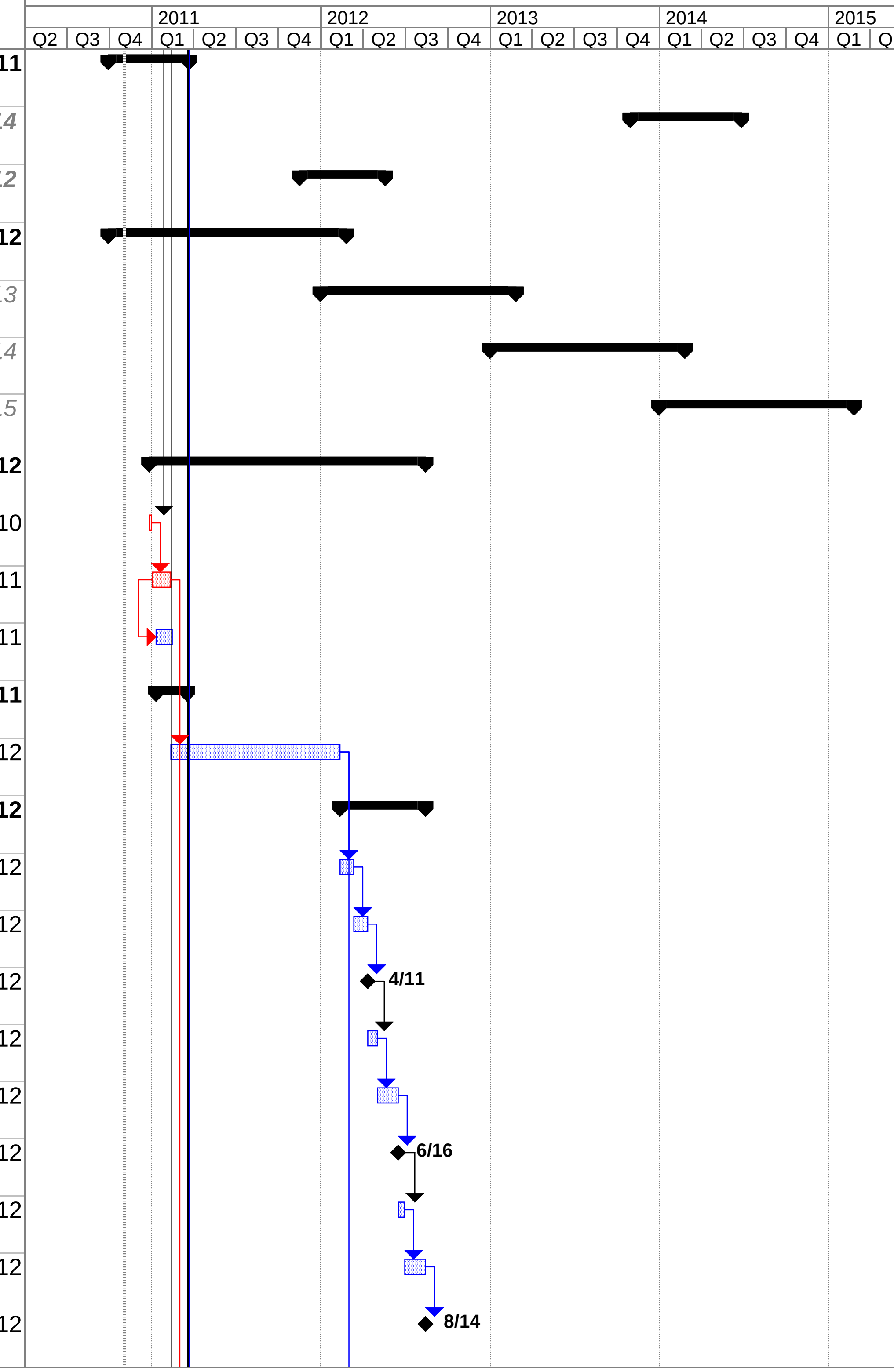
Activity ID	QA PM	CLIN Sub-CLIN	Task Name	Duration	Start	Finish
138			Prepare Draft Final (RFI) Work Plan for the Vadose Zone (Revise Part I Plan/Incorporate Regulator Comments)	60 days	Thu 3/24/11	Sun 5/22/11
139	QA		Army/Air Force Review	30 days	Mon 5/23/11	Tue 6/21/11
140	PM		Army/Air Force Approval	0 days	Tue 6/21/11	Tue 6/21/11
141			Prepare Final Vadose Zone RFI Work Plan	45 days	Wed 6/22/11	Fri 8/5/11
142	QA		Regulator/Stakeholder Review	45 days	Sat 8/6/11	Mon 9/19/11
143	PM		Regulator/Stakeholder Approval	0 days	Mon 9/19/11	Mon 9/19/11
144			**Resource Conservation and Recovery Act Facility Investigation (RFI) Work Plan for Groundwater at the BFF**	**180 days**	**Thu 3/24/11**	**Mon 9/19/11**
145			Prepare Draft Final (RFI) Work Plan for Groundwater (Revise Part I Plan/Incorporate Regulator Comments)	60 days	Thu 3/24/11	Sun 5/22/11
146	QA		Army/Air Force Review	30 days	Mon 5/23/11	Tue 6/21/11
147	PM		Army/Air Force Approval	0 days	Tue 6/21/11	Tue 6/21/11
148			Prepare Final Groundwater RFI Work Plan	45 days	Wed 6/22/11	Fri 8/5/11
149	QA		Regulator/Stakeholder Review	45 days	Sat 8/6/11	Mon 9/19/11
150	PM		Regulator/Stakeholder Approval	0 days	Mon 9/19/11	Mon 9/19/11
151			**Interim Measures Work Plan**	**180 days**	**Thu 3/24/11**	**Mon 9/19/11**
152			Prepare Draft Final Interim Measures Work Plan (Revise Part I Plan/Incorporate Regulator Comments)	60 days	Thu 3/24/11	Sun 5/22/11
153	QA		Army/Air Force Review	30 days	Mon 5/23/11	Tue 6/21/11
154	PM		Army/Air Force Approval	0 days	Tue 6/21/11	Tue 6/21/11
155			Prepare Final Interim Measures Work Plan	45 days	Wed 6/22/11	Fri 8/5/11
156	QA		Regulator/Stakeholder Review	45 days	Sat 8/6/11	Mon 9/19/11
157	PM		Regulator/Stakeholder Approval	0 days	Mon 9/19/11	Mon 9/19/11



Project: Kirtland Air Force Base Envir
Date: Mon 11/1/10

Task		Milestone		Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone		External Tasks		Deadline	
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

Activity ID	QA PM	CLIN Sub-CLIN	Task Name	Duration	Start	Finish
158			**Light Non-Aqueous Phase Liquid (LNAPL) Containment Work Plan**	**174 days**	**Thu 9/30/10**	**Tue 3/22/11**
170		*2001AJ*	*Shaw - Option Site Plans*	*240 days*	*Thu 10/31/13*	*Fri 6/27/14*
180		*2001AK*	*Shaw - Option Site Plans*	*185 days*	*Thu 11/17/11*	*Sat 5/19/12*
191		**2001BA**	**Pre-Remedy Quarterly Monitoring and SVE Operation FY 2011**	**514 days**	**Thu 9/30/10**	**Sat 2/25/12**
281		*2001BB*	*Pre-Remedy Quarterly Monitoring and SVE Operation FY 2012*	*422 days*	*Sun 1/1/12*	*Mon 2/25/13*
384		*2001BC*	*Pre-Remedy Quarterly Monitoring and SVE Operation FY 2013*	*421 days*	*Tue 1/1/13*	*Tue 2/25/14*
487		*2001BD*	*Pre-Remedy Quarterly Monitoring and SVE Operation FY 2014*	*421 days*	*Wed 1/1/14*	*Wed 2/25/15*
590		**2001CA**	**Complete RFI at BFF Vadose Zone**	**597 days**	**Mon 12/27/10**	**Tue 8/14/12**
591			Mobilize Personnel and Equipment	5 days	Mon 12/27/10	Fri 12/31/10
592			Install 35 6-ported Nested Soil Vapor Monitoring Wells	30 days	Mon 1/3/11	Fri 2/11/11
593			Down Hole Geophysical Logging at 35 New Vapor Monitoring Wells	25 days	Tue 1/11/11	Mon 2/14/11
594			**Well Completion Logs**	**67 days**	**Tue 1/11/11**	**Fri 3/18/11**
625			Sampling, Analysis and Validation at BFF Soil Vapor Wells (quarterly - 1 year)	365 days	Sat 2/12/11	Sat 2/11/12
626			**Risk Assessment**	**185 days**	**Sun 2/12/12**	**Tue 8/14/12**
627			Prepare Draft Risk Assessment	30 days	Sun 2/12/12	Mon 3/12/12
628	QA		Army/Air Force Review	30 days	Tue 3/13/12	Wed 4/11/12
629	PM		Army/Air Force Approval	0 days	Wed 4/11/12	Wed 4/11/12
630			Prepare Draft Final Risk Assessment	21 days	Thu 4/12/12	Wed 5/2/12
631	QA		Regulator/Stakeholder Review	45 days	Thu 5/3/12	Sat 6/16/12
632	PM		Regulator/Stakeholder Approval	0 days	Sat 6/16/12	Sat 6/16/12
633			Prepare Final Risk Assessment	14 days	Sun 6/17/12	Sat 6/30/12
634	QA		Regulator/Stakeholder Review	45 days	Sun 7/1/12	Tue 8/14/12
635	PM		Regulator/Stakeholder Approval	0 days	Tue 8/14/12	Tue 8/14/12



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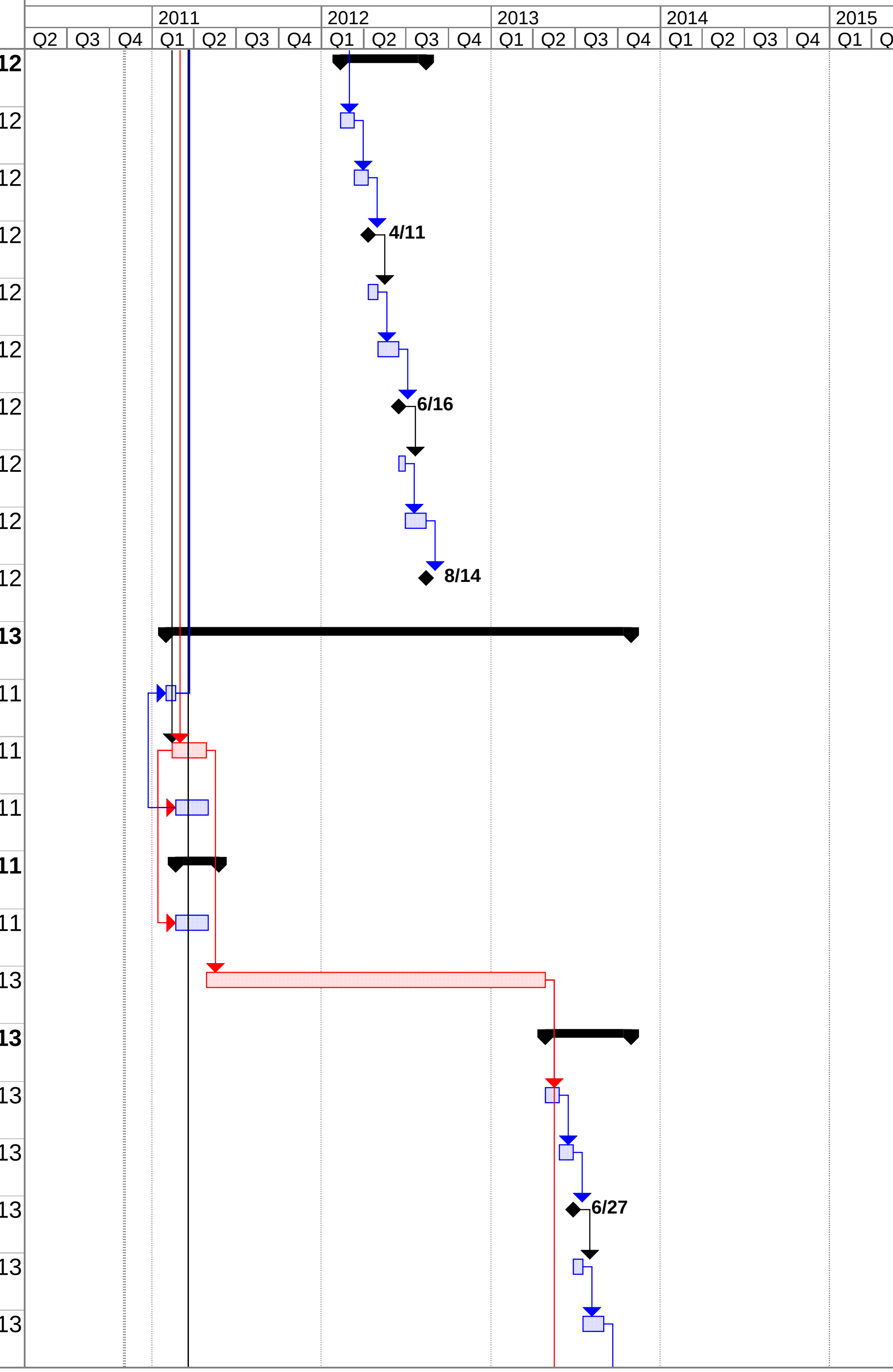
Task		Milestone	◆	Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone	◇	External Tasks		Deadline	⇩
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

Activity ID	QA PM	CLIN Sub-CLIN	Task Name	Duration	Start	Finish
636			**Vadose Zone RCRA Facility Investigation Report**	**185 days**	**Sun 2/12/12**	**Tue 8/14/12**
637			Prepare Draft Vadose Zone RFI Report	30 days	Sun 2/12/12	Mon 3/12/12
638	QA		Army/Air Force Review	30 days	Tue 3/13/12	Wed 4/11/12
639	PM		Army/Air Force Approval	0 days	Wed 4/11/12	Wed 4/11/12
640			Prepare Draft Final Vadose Zone RFI Report	21 days	Thu 4/12/12	Wed 5/2/12
641	QA		Regulator/Stakeholder Review	45 days	Thu 5/3/12	Sat 6/16/12
642	PM		Regulator/Stakeholder Approval	0 days	Sat 6/16/12	Sat 6/16/12
643			Prepare Final Vadose Zone RFI Report	14 days	Sun 6/17/12	Sat 6/30/12
644	QA		Regulator/Stakeholder Review	45 days	Sun 7/1/12	Tue 8/14/12
645	PM		Regulator/Stakeholder Approval	0 days	Tue 8/14/12	Tue 8/14/12
646		**2001CB**	**Complete RFI for BFF Groundwater**	**1003 days**	**Tue 2/1/11**	**Wed 10/30/13**
647			Downhole Geophysical Logging at 29 Existing Groundwater Monitoring Wells	15 days	Tue 2/1/11	Mon 2/21/11
648			Install 78 Single Groundwater Monitoring Wells w/Pumps	54 days	Mon 2/14/11	Thu 4/28/11
649			Downhole Geophysical Logging at 28 New (Deep) Groundwater Monitoring Wells	50 days	Tue 2/22/11	Mon 5/2/11
650			**Well Completion Logs**	**93 days**	**Tue 2/22/11**	**Wed 5/25/11**
699			Sample 78 wells (one time for baseline)	50 days	Tue 2/22/11	Mon 5/2/11
700			Sampling, Analysis and Validation at BFF Groundwater Wells (quarterly - 2 years)	731 days	Fri 4/29/11	Sun 4/28/13
701			**Risk Assessment**	**185 days**	**Mon 4/29/13**	**Wed 10/30/13**
702			Prepare Draft Risk Assessment	30 days	Mon 4/29/13	Tue 5/28/13
703	QA		Army/Air Force Review	30 days	Wed 5/29/13	Thu 6/27/13
704	PM		Army/Air Force Approval	0 days	Thu 6/27/13	Thu 6/27/13
705			Prepare Draft Final Risk Assessment	21 days	Fri 6/28/13	Thu 7/18/13
706	QA		Regulator/Stakeholder Review	45 days	Fri 7/19/13	Sun 9/1/13



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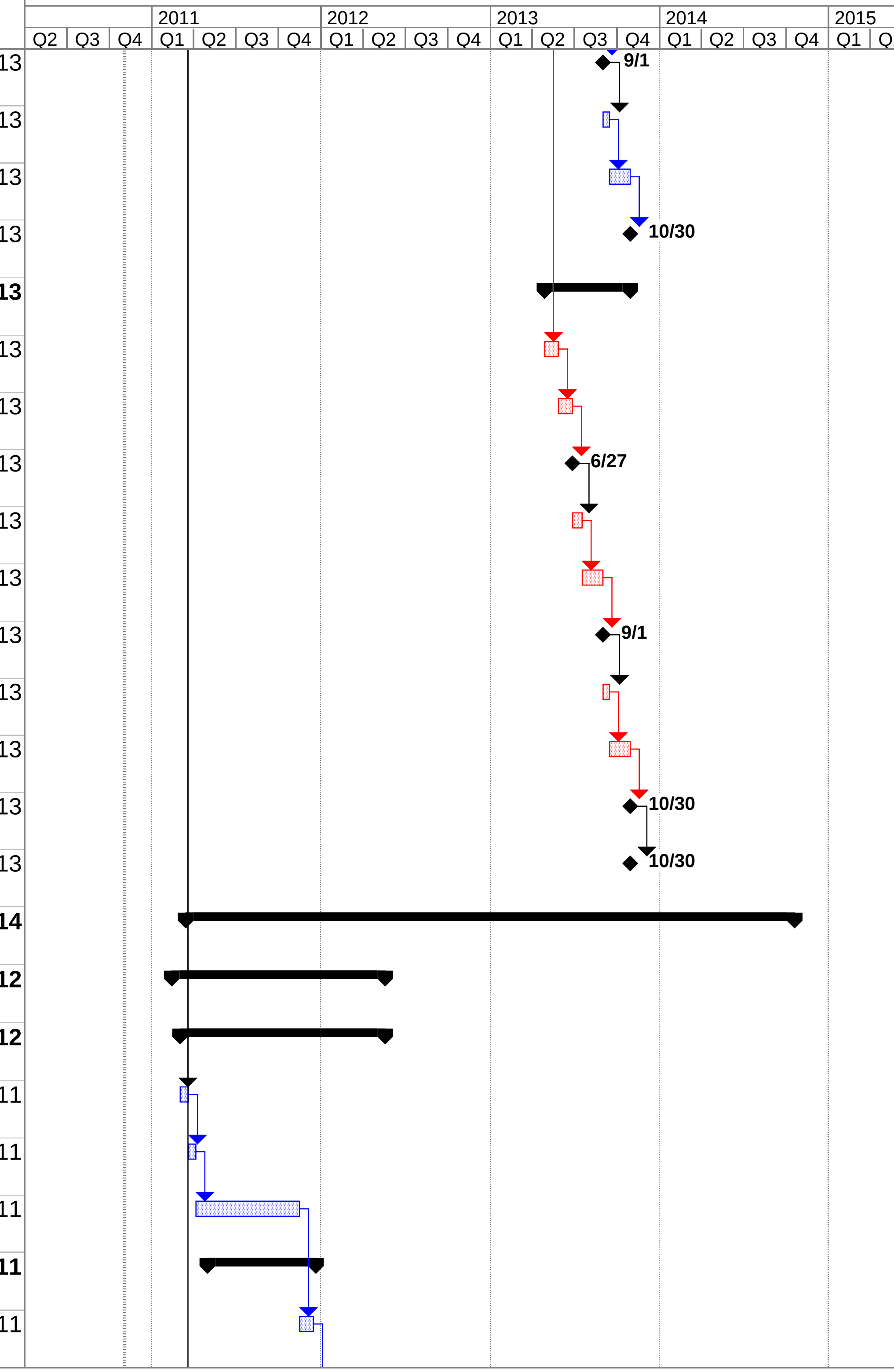
Critical Task	Summary	Rolled Up Milestone	External Tasks	Deadline
Progress	Rolled Up Task	Rolled Up Progress	Project Summary	

Activity ID	QA PM	CLIN Sub-CLIN	Task Name	Duration	Start	Finish
707	PM		Regulator/Stakeholder Approval	0 days	Sun 9/1/13	Sun 9/1/13
708			Prepare Final Risk Assessment	14 days	Mon 9/2/13	Sun 9/15/13
709	QA		Regulator/Stakeholder Review	45 days	Mon 9/16/13	Wed 10/30/13
710	PM		Regulator/Stakeholder Approval	0 days	Wed 10/30/13	Wed 10/30/13
711			**Groundwater RCRA Facility Investigation Report**	**185 days**	**Mon 4/29/13**	**Wed 10/30/13**
712			Prepare Draft Groundwater RFI Report	30 days	Mon 4/29/13	Tue 5/28/13
713	QA		Army/Air Force Review	30 days	Wed 5/29/13	Thu 6/27/13
714	PM		Army/Air Force Approval	0 days	Thu 6/27/13	Thu 6/27/13
715			Prepare Draft Final Groundwater RFI Report	21 days	Fri 6/28/13	Thu 7/18/13
716	QA		Regulator/Stakeholder Review	45 days	Fri 7/19/13	Sun 9/1/13
717	PM		Regulator/Stakeholder Approval	0 days	Sun 9/1/13	Sun 9/1/13
718			Prepare Final Groundwater RFI Report	14 days	Mon 9/2/13	Sun 9/15/13
719	QA		Regulator/Stakeholder Review	45 days	Mon 9/16/13	Wed 10/30/13
720	PM		Regulator/Stakeholder Approval	0 days	Wed 10/30/13	Wed 10/30/13
721			RFI at the BFF Groundwater Complete	0 days	Wed 10/30/13	Wed 10/30/13
722		**2001DA**	**Installation of Interim Measure (IM) for Light Non-Aqueous Phase Liquid (LNAPL)**	**1315 days**	**Tue 3/15/11**	**Mon 10/20/14**
859		**2001EA**	**Interim Measure (IM) for Vadose Deep / Shallow Zone**	**461 days**	**Mon 2/14/11**	**Sat 5/19/12**
860			**IM Vadose Zone Deep**	**443 days**	**Fri 3/4/11**	**Sat 5/19/12**
861			Bail Down Pilot Testing	12 days	Fri 3/4/11	Mon 3/21/11
862			Radius of Influence Testing	12 days	Tue 3/22/11	Wed 4/6/11
863			Well Installation/Pneu Log Testing	160 days	Thu 4/7/11	Wed 11/16/11
864			**Well Completion/Pneu Log Report**	**234 days**	**Mon 5/2/11**	**Wed 12/21/11**
892			Prepare Draft IM SVE Report	30 days	Thu 11/17/11	Fri 12/16/11



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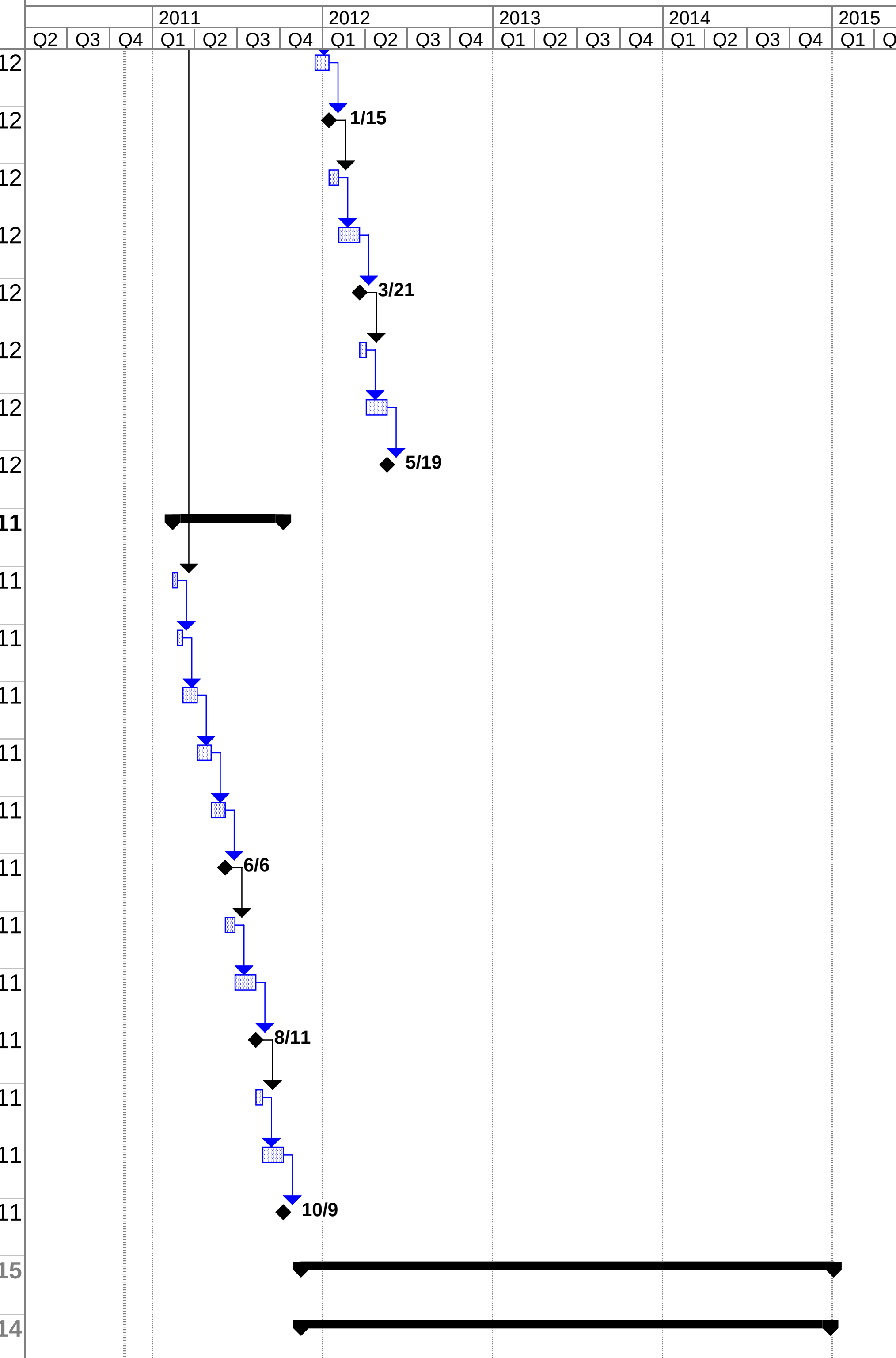
Critical Task		Summary		Rolled Up Milestone	◇	External Tasks		Deadline	⇩
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

Activity ID	QA PM	CLIN Sub-CLIN	Task Name	Duration	Start	Finish
893	QA		Army/Air Force Review	30 days	Sat 12/17/11	Sun 1/15/12
894	PM		Army/Air Force Approval	0 days	Sun 1/15/12	Sun 1/15/12
895			Prepare Draft Final IM SVE Report	21 days	Mon 1/16/12	Sun 2/5/12
896	QA		Regulator/Stakeholder Review	45 days	Mon 2/6/12	Wed 3/21/12
897	PM		Regulator/Stakeholder Approval	0 days	Wed 3/21/12	Wed 3/21/12
898			Prepare Final IM SVE Report	14 days	Thu 3/22/12	Wed 4/4/12
899	QA		Regulator/Stakeholder Review	45 days	Thu 4/5/12	Sat 5/19/12
900	PM		Regulator/Stakeholder Approval	0 days	Sat 5/19/12	Sat 5/19/12
901			**IM Vadose Zone Shallow**	**238 days**	**Mon 2/14/11**	**Sun 10/9/11**
902			Fuel Off Loading Rack Soil Investigation (below ground pipeline - 980ft)	8 days	Mon 2/14/11	Wed 2/23/11
903			Fuel Off Loading Rack Soil Investigation (above ground pipeline - 995ft)	8 days	Thu 2/24/11	Mon 3/7/11
904			Soil Excavation / Disposal / Backfill	23 days	Tue 3/8/11	Thu 4/7/11
905			Prepare Draft Fuel Offloading Soil Investigation Report	30 days	Fri 4/8/11	Sat 5/7/11
906	QA		Army/Air Force Review	30 days	Sun 5/8/11	Mon 6/6/11
907	PM		Army/Air Force Approval	0 days	Mon 6/6/11	Mon 6/6/11
908			Prepare Draft Final Fuel Offloading Soil Investigation Report	21 days	Tue 6/7/11	Mon 6/27/11
909	QA		Regulator/Stakeholder Review	45 days	Tue 6/28/11	Thu 8/11/11
910	PM		Regulator/Stakeholder Approval	0 days	Thu 8/11/11	Thu 8/11/11
911			Prepare Final Fuel Offloading Soil Investigation Report	14 days	Fri 8/12/11	Thu 8/25/11
912	QA		Regulator/Stakeholder Review	45 days	Fri 8/26/11	Sun 10/9/11
913	PM		Regulator/Stakeholder Approval	0 days	Sun 10/9/11	Sun 10/9/11
914		2001FA	Option Vadose Zone Deep Phase II Low Density	1145 days	Thu 11/17/11	Sun 1/4/15
929		2001FB	Option Vadose Zone Deep Phase II Medium Density	1138 days	Thu 11/17/11	Sun 12/28/14



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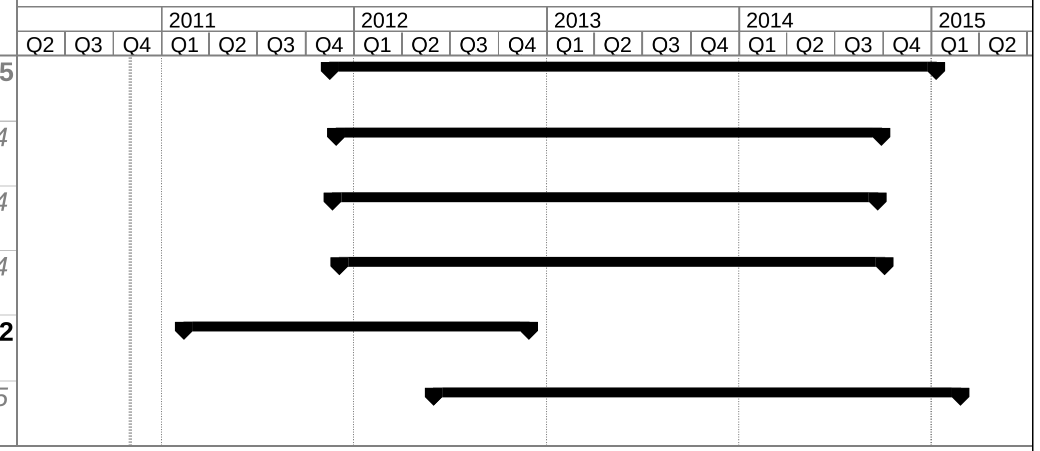
Critical Task		Summary		Rolled Up Milestone		External Tasks		Deadline	
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

Activity ID	QA PM	CLIN Sub-CLIN	Task Name	Duration	Start	Finish
944		**2001FC**	**Option Vadose Zone Deep Phase II High Density**	**1151 days**	**Thu 11/17/11**	**Sat 1/10/15**
959		*2001FD*	***Shaw - Option Vadose Zone Deep Phase II Low Density***	*1035 days*	*Tue 11/29/11*	*Sun 9/28/14*
974		*2001FE*	***Shaw - Option Vadose Zone Deep Phase II Medium Density***	*1035 days*	*Tue 11/22/11*	*Sun 9/21/14*
989		*2001FF*	***Shaw - Option Vadose Zone Deep Phase II High Density***	*1035 days*	*Mon 12/5/11*	*Sat 10/4/14*
1004		**2001GA**	**Groundwater IM**	**655 days**	**Sun 2/13/11**	**Wed 11/28/12**
1052		***2001GB***	***Shaw - Option Installation of Dissolved Phase Plume for LNAPL***	*1000 days*	*Fri 6/1/12*	*Wed 2/25/15*



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Task		Milestone		Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone		External Tasks		Deadline	
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

APPENDIX C

Waste Management Plan

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KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

WASTE MANAGEMENT PLAN
BULK FUELS FACILITY SPILL
SOLID WASTE MANAGEMENT UNITS ST-106 AND SS-111

November 2010

Prepared for
U.S. Army Corps of Engineers
Albuquerque District
Albuquerque, New Mexico 87109

USACE Contract No. W912DY-10-D-0014
Delivery Order 0002

Prepared by
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ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
BTEX	benzene, toluene, ethylbenzene, and xylenes
CFR	Code of Federal Regulations
CHOX	chemical oxidation
CMBST	high-temperature organic destruction
DOT	U.S. Department of Transportation
EPA	U. S. Environmental Protection Agency
IDW	investigation-derived waste
INCIN	incineration
LF	landfill
mg/kg	milligrams per kilogram
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
PCB	polychlorinated biphenyl
PPE	personal protective equipment
RCRA	Resource Conservation and Recovery Act
STABL	stabilization
SVOC	semivolatile compound
TCLP	toxicity characteristic leaching procedure
TPH	total petroleum hydrocarbons
VOC	volatile organic compound
WMP	Waste Management Plan
WWT	wastewater treatment

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1. INTRODUCTION

This document will serve as the Waste Management Plan (WMP) for environmental activities performed at Kirtland Air Force Base (AFB) in support of investigation of the BFF Spill, under U.S. Army Corps of Engineers contract W912DY-10-D-0014, Delivery Order 0002. The WMP governs the minimization, generation, management, storage, and transport and disposal of wastes that are routinely encountered during these environmental activities. The primary focus of this WMP is the management of investigation-derived waste (IDW). Wastes generated during the execution of remedial actions will be governed by this plan to the extent that they can be predicted and easily accommodated with the scope of this WMP.

1.1 Purpose

The purpose of waste management, particularly IDW management, is to leave the site in no worse condition after the implementation of activities than existed before the activities began, and to comply with federal and state waste management regulations and applicable or relevant and appropriate requirements to the extent practicable. These management procedures are directed toward waste minimization to reduce the quantity of waste that will require treatment, storage, or disposal.

1.2 Definitions

Cross-contamination—spread of chemicals from one item to another or from one location to another.

Debris—a solid material exceeding a 60 millimeters particle size that is intended for disposal that can be classified as a manufactured object, plant, or animal matter, or natural geologic material. The following materials are not debris—any material for which a specific treatment standard is provided in Resource Conservation and Recovery Act (RCRA) Subpart D, Part 268; process residuals such as smelter slag and residues from treatment of waste, wastewater sludges, or air emission residues; and intact containers of hazardous waste that are not ruptured and that retain at least 75 percent of their original volume.

Decontamination Fluids—fluids generated after decontamination of equipment. Fluids include soapy water, rinse water, solvents (e.g., isopropanol), and contaminated media removed from equipment during the decontamination process.

Dewatering Fluids—liquid waste generated from dewatering operations in excavations, retention ponds, and drainage channels.

Disposable Equipment—equipment that cannot be decontaminated at the conclusion of an environmental restoration activity and requires disposal. IDW disposable equipment includes bailers, coliwasas (samplers designed to permit representative sampling of multi-phase wastes from drums and other containerized wastes), jars and containers, plastic sheeting, foil, disposable laboratory equipment, etc. Disposable equipment from remedial activities includes small tools, barrier materials, decontamination pad equipment, hoses, chains, timber, survey stakes, etc.

Free Liquids—liquids that readily separate from the solid portion of a waste under ambient temperature and pressure.

Hazardous Waste—a solid waste is a hazardous waste if it is not excluded from regulation as a hazardous waste and exhibits any characteristic of hazardous waste identified in Subpart C and/or D of 40 Code of Federal Regulations (CFR) part 261.

Mixed Waste—radioactive waste that also contains a hazardous waste component regulated under RCRA (see definition of hazardous waste). Although not strictly a mixed waste, radioactive waste containing wastes regulated by the Toxic Substances Control Act (e.g., polychlorinated biphenyls [PCBs], asbestos) or naturally occurring radioactive materials are also considered to be a mixed waste under this plan.

Personal Protective Equipment (PPE)—coveralls, gloves, respirator cartridges, tape, boots, etc.

Purge Water—groundwater pumped from a borehole (monitoring well) prior to sampling.

Radioactive Waste—waste that contains higher than background levels of radioactivity, or is otherwise not releasable for use by the general public. Waste that can be disposed of without regard to its radioactivity is not considered radioactive waste.

Remediation Waste—any media or debris resulting from environmental restoration activities that meet the definition of solid waste in 40 CFR Part 261.

Representative Sample—a sample of a universe or whole (e.g., waste pile, lagoon, groundwater) that can be expected to exhibit the average properties of the universe or whole.

Soil Cuttings—excess soil removed by the direct-push and hollow-stem auger drilling techniques.

Special Waste—New Mexico defines "Special Waste" as the following types of solid wastes that have unique handling, transportation, or disposal requirements to ensure protection of the environment and public health and safety:

- Treated formerly characteristic hazardous wastes
- Packing house and killing plant offal
- Asbestos waste
- Ash
- Infectious waste
- Sludge

- Industrial process waste
- Residue from a spill of a chemical substance or commercial product (including contaminated soils)
- Dry chemicals, which when wetted, become characteristically hazardous

The New Mexico Environment Department (NMED) also defines petroleum-contaminated soil as "Special Waste" if the sum of benzene, toluene, ethylbenzene, and xylene (BTEX) isomer concentrations is greater than 500 milligrams per kilogram (mg/kg), with benzene individually greater than 10 mg/kg, and total petroleum hydrocarbon (TPH) concentration greater than 1,000 mg/kg.

1.3 IDW Minimization

A primary goal of the WMP is to minimize, to a practical extent, the volume of waste that will be generated, stored, and removed from the site for disposal. 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.
  - Avoid a bellows effect when double-bagging contaminated materials.
  - Use containers to minimize the spread of contamination.

- Do not place contaminated materials with clean materials.
- Cover wooden pallets inside the exclusion zone with plastic. 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).
- Use direct-push, hydropunch, or any other waste minimizing sample acquisition techniques whenever possible.

1.4 Regulatory Context

NMED regulates environmental activities in the State of New Mexico. Environmental restoration work at Kirtland AFB is under the jurisdiction of both NMED and the U.S. Environmental Protection Agency (EPA), Region 6. Consequently, the following federal and state regulations form the regulatory context in from which waste management decision making at Kirtland AFB will derive:

- 40 CFR Parts 260 -299, EPA regulations for identification and management of hazardous waste
- 40 CFR Part 761, EPA regulations for management of PCBs
- 49 CFR Parts 100-178, U.S. Department of Transportation (DOT) rules for hazardous materials transport
- 20 New Mexico Administrative Code (NMAC) Chapter 9, New Mexico Solid Waste Management Regulations
- 20 NMAC Chapter 4, New Mexico Hazardous Waste Management Regulations
- 20 NMAC Chapter 5, New Mexico Underground Storage Tanks Regulations
- 20 NMAC Chapter 9, New Mexico Special Waste Requirements Regulations
- 20 NMAC Chapter 6, New Mexico Water Quality Control Commission Regulations

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2. WASTE MANAGEMENT APPROACH

From the time that waste is generated through its ultimate disposal, waste will be managed in compliance with applicable regulatory requirements and in a manner that is protective of human health and the environment. All waste will be managed in compliance with applicable federal, state, local, and Kirtland AFB regulations. A regulatory expert will be actively involved in all planned activities to ensure that the appropriate characterization strategy will be used on a waste-to-waste basis. Furthermore, once characterization data are available, the regulatory expert will interpret the data and in combination with all other associated site history and project circumstance, provide a path forward for managing each waste generated in a timely and compliant manner.

2.1 Project-Specific Wastes

IDW anticipated to be generated during BFF Spill investigation and remediation field activities will consist of contaminated environmental media and associated waste materials from soil (excavation and sampling), drill/soil cuttings (from boreholes and well installation), monitoring well purge and development water, decontamination water, and water generated from pump tests. Waste material associated with these activities includes disposable PPE, disposable sampling equipment (e.g., scoops, bowls), and other inert materials (e.g., plastic, rope, tape, and paper).

2.2 Waste Accumulation and Storage Areas for Containers

Wastes governed by this plan shall be properly managed in an appropriate waste accumulation or storage area from the time it is generated until it is removed from the area (e.g., for disposal or further management). These areas will be, when practical, within the area of contamination at the point of generation. Otherwise waste containers will be staged at strategic and secure areas onsite until waste is properly disposed.

Waste accumulation and storage areas will be kept orderly and clear of non-waste-related items at all times. Minimum standards for the accumulation of waste in containers will be implemented at waste storage areas to ensure that waste is managed in a protective manner. Waste staging areas are not bound by specified time limits as are hazardous waste accumulation/storage areas. Inspections will be required weekly and will included visual confirmation of the following:

- Container is closed securely and/or locked.
- Container is in good condition (i.e., no excessive rust or dents that could compromise container integrity).
- All container labels are legible.
- Pertinent information is marked on drum/label (i.e., site of origin, waste contents, date of generation).
- Waste volume in container has not changed since the last inspection (only for containers where a visual assessment of volume is possible).

2.3 Container Management

IDW may be contained in drums, roll-off boxes, polyethylene tanks, or similar containers. IDW that is placed in a container (i.e., drum, roll-off box) will be managed in accordance with the following practices:

- Containers will be inspected upon receipt and/or before use to ensure the structural integrity of the containers.
- Only DOT-compliant containers will be used to accumulate, store, or transport waste generated at Kirtland AFB.
- Containers used for management of bulk IDW will be secured with a mechanism to prevent tampering. All access points to IDW containers (e.g., drum bungs, roll-off tarps) will be tightened with tools, as necessary, to prevent casual access.
- Once IDW is placed in the container, an appropriate label will be affixed to the container. The label must include the following basic waste identification information:
  - A unique container number
  - Accumulation start date
  - Site identification
  - Contents (e.g., soil, purge water)
  - Emergency contact information

- Drums will be positioned to allow for clear observation of labels and visual inspections for potential leaks. If an aisle is required in the drum storage area in order for a clear visual inspection of the drums, a minimum of three feet aisle space is recommended.
- Containers must always be closed, unless waste is being added to the container.
- Once the waste evaluator has fully characterized a particular waste stream, appropriate label(s) and markings will be placed on the container to reflect the characterization. Any previous labels or markings that were not accurate will be removed.
- Unless special circumstances warrant, IDW from different area of contaminations will not be mixed within a single container.

2.4 Additional Requirements for Hazardous Waste Containers

IDW that has been characterized as hazardous waste will be accumulated or stored in accordance with 40 CFR 262. The following requirements are applicable to only hazardous waste and are in addition to the general container management requirements.

- Containers of fully characterized hazardous waste accumulated in a generator 90-day area will have a hazardous waste label affixed to them and will be marked with the following information:
  - Generator information (name, address)
  - Kirtland EPA identification number
  - Applicable EPA waste number(s) (e.g., D008, F001)
  - Accumulation start date
  - Proper DOT shipping name
  - Appropriate DOT hazard class sticker(s)

In accordance with applicable state and federal hazardous waste and/or DOT regulations additional markings and/or labels may be required in preparation for transport of waste containers off-site.

2.5 Waste Staging Area for Stockpiles

Waste staging areas are defined strictly for the purposes of this plan, as areas within an area of contamination that will be used for the accumulation of stockpiling of soil or water, awaiting further management (e.g., treatment, disposal). Waste staging areas will be established within the boundaries of an area of contamination. Waste staging areas will be established and maintained by the contractor field team manager. For the purpose of the BFF spill remediation activities, centralized waste staging will be located at the BFF spill site location at Kirtland AFB.

2.6 Waste Characterization

IDW will be characterized using data obtained from the analysis of environmental samples collected during the investigation and quarterly monitoring activity that generated the waste, 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. If a particular waste meets the definition of a solid waste and is not excluded from regulation, it will then be determined if the waste meets the criteria of hazardous (characteristic and/or listed) or non-hazardous.

For the purpose of the BFF project, the Kirtland AFB active onsite landfill (LF-268) will be used for disposal of solid non-hazardous wastes. Kirtland AFB currently requires all waste being disposed at LF-268 to be analyzed for the following list of parameters for submittal in order to obtain approval for disposal at the landfill. The requirements include the following:

- Ignitability characteristic as defined in 40 CFR Part 261,
- Corrosivity characteristic as defined in 40 CFR Part 261,
- Reactivity characteristic as defined in 40 CFR Part 261, and
- Toxicity characteristic as defined by EPA Test Method 1311, toxicity characteristic leaching procedure (TCLP) for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), RCRA l metals, herbicides, and pesticides

Analysis for petroleum hydrocarbons is only required for wastes suspected of having petroleum-based contamination. The required petroleum hydrocarbon analyses include:

- TPH by EPA Test Method 8015B
- BTEX by EPA Test Method 8260B or 8021B

The following Table, Landfill-268 Waste Acceptance Criteria, summarizes acceptable levels that are applicable when utilizing the onsite landfill for waste disposal.

Table 1 – Kirtland AFB Landfill-268 Waste Acceptance Criteria

Constituent	Regulatory Level*	Constituent	Regulatory Level*
Arsenic (D004)	5.0 mg/L	Hexachlorobenzene (D032)	0.13 mg/L
Barium (D005)	100.0 mg/L	Hexachlorobutadiene (D033)	0.5 mg/L
Benzene (D018)	5.0 mg/L	Hexachloroethane (D034)	3.0 mg/L
Cadmium (D006)	1.0 mg/L	Lead (D008)	5.0 mg/L
Carbon Tetrachloride (D019)	0.5 mg/L	Lindane (D013)	0.4 mg/L
Chlordane (D020)	0.03 mg/L	Mercury (D009)	0.2 mg/L
Chlorobenzene (D021)	100.0 mg/L	Methoxychlor (D014)	10.0 mg/L
Chloroform (D022)	6.0 mg/L	Methyl ethyl Ketone (D035)	200.0 mg/L
Chromium (D007)	5.0 mg/L	Nitrobenzene (D036)	2.0 mg/L
o-Cresol (D023)	200.0 mg/L	Pentachlorophenol (D037)	100.0 mg/L
m-Cresol (D024)	200.0 mg/L	Pyridine (D038)	5.0 mg/L
p-Cresol (D025)	200.0 mg/L	Selenium (D010)	1.0 mg/L
Cresol (D026)	200.0 mg/L	Silver (D011)	5.0 mg/L
2,4-D (D016)	10.0 mg/L	Tetrachloroethylene (D039)	0.7 mg/L
1,4-Dichlorobenzene (D027)	7.5 mg/L	Toxaphene (D015)	0.5 mg/L
1,2-Dichloroethane (D028)	0.5 mg/L	Trichloroethylene (D040)	0.5 mg/L
1,1-Dichloroethylene (D029)	0.7 mg/L	2,4,5-Trichlorophenol (D041)	400.0 mg/L
2,4-Dinitrotoluene (D030)	0.13 mg/L	2,4,6-Trichlorophenol (D042)	2.0 mg/L
Endrin (D012)	0.02 mg/L	2,4,5-TP (Silvex) (D017)	1.0 mg/L
Heptachlor (D031)	0.008 mg/L	Vinyl Chloride (D043)	0.2 mg/L
BTEX	50 mg/kg	Benzene	10 mg/kg
TPH	100 mg/kg		

* 40 CFR 261.24, Table 1

In addition to the analytical thresholds, listed, the following LF-268 guidance to generators needs to be adhered to in considering the landfill as a disposal option for IDW.

1. The Kirtland AFB civil engineer and Kirtland AFB Landfill require that soil and/or debris from any restoration site or monitoring well installation have analytical documentation characterizing the waste

prior to consideration for disposal. Analytical requirements will be based on the specific site knowledge of the Restoration project manager and/or site engineer.

2. Minimum analytical requirements necessary for soil and debris characterization derived from restoration site or monitoring well activities are defined above (See Table 1, Landfill-268 Waste Acceptance Criteria). For waste and debris that have been characterized during the completion of site activities, analyses previously generated during the characterization process may be used in determination of suitability for disposal.

3. Soil or debris that has been analyzed for hazardous constituents and does not exceed any RCRA regulatory limits (40 CFR 261.24 Table 1) may be disposed of in the Kirtland AFB landfill. Soil and debris containing hazardous constituents exceeding regulatory limits and/or illustrating hazardous waste characteristics will be disposed of at a facility permitted to accept hazardous wastes following appropriate DOT procedures.

4. Petroleum-contaminated soil that has a total BTEX concentration greater than 50 mg/kg, or a benzene concentration greater than 10 mg/kg, or a TPH concentration greater than 100 mg/kg is considered a special waste. Special wastes will not be disposed of in the Kirtland AFB landfill but will be disposed of at a facility permitted to handle special wastes.

5. Kirtland AFB retains the right to reject all material for disposal into the Kirtland AFB Landfill on a case-by-case basis, even if the waste does not exceed regulatory limitations.

6. If a waste is approved for disposal at the Kirtland AFB landfill, a Kirtland AFB Landfill Pass will be issued to the requestor for the waste hauling vehicle. When using a government vehicle to haul waste to the Kirtland AFB landfill, a waste disposal authorization letter is required but a Kirtland AFB landfill pass is not.

The LF-268 specific waste characterization process and analytical requirements will be sufficient to make a general waste determination and allow for appropriate waste management onsite or off site. If the waste exceeds any of the levels listed in the Table 1, with the exception of the TPH and BTEX parameters, the waste will be considered a hazardous waste. That waste will then have to be profiled, treated, and disposed of offsite as a hazardous waste according to the level and type of contamination indicated in the waste characterization results.

In the event there are other reasons why the waste cannot be disposed of at the onsite landfill and all of the waste acceptance criteria are met, that waste will be managed as NMED special waste and shipped offsite accordingly.

The field team manager will stage IDW pending analysis (i.e., waste that is not fully characterized) at the site of origin pending the receipt of analytical data and subsequent characterization, unless otherwise directed by Kirtland AFB personnel. IDW that is generated outside of the Kirtland AFB installation boundary will not be staged at the site of origin. Such wastes will be staged at a waste staging area within the installation boundary at the BFF site.

2.7 Waste Management Implementation

If it is determined that the LF-268 analytical waste acceptance criteria are satisfied, the following information will be presented in a "waste profile" format that will be used consistently to represent each individual waste stream encountered and considered for onsite disposal.

- Submit a memorandum requesting authorization to dispose of investigative-derived debris to the appropriate Solid Waste program manager.
  - Kirtland AFB Activities: Mr. Steven C. Kitt, 377 MSG/CEANC at 846-9014 or Steven.kitt@kirtland.af.mil
- Include in the submittal the name and phone number of the point of contact overseeing the activity, the location from which the waste was generated/site identifier, waste analytical results, hauling companies to be used to transport the waste to the landfill, roll-off identification numbers, and license plate numbers of transport vehicles, if not using roll-offs for waste containment.

As stated, if for any reason waste is not accepted for onsite disposal, arrangements will be made to manage the waste offsite in a compliant manner. Licensed and/or permitted facilities will be used for the purpose of transportation and disposal of waste from Kirtland AFB, as deemed necessary. Waste profile documentation will be prepared for review and signature by Kirtland AFB before shipment offsite. Upon receipt of the signed profile packages waste removal will be coordinated to ensure proper management of all waste being offered for disposal.

Table 2 lists the projected wastes to be generated during activities and the proposed analytical suite, the means of containerizing, probable waste status determinations and the two most likely methods of treatment and disposal.

Table 2 – Management of Projected Waste Streams

Waste Description	Characterization	Containerization	Waste Status	Treatment/Disposal
IDW Soils	LF 268 Suite	-Roll-off -Drum	Non-Hazardous	Direct Land Disposal 1.) LF268 2.) NMED permitted Subtitle D Landfill
IDW Soils	LF268 Suite	-Roll-off -Drum	Hazardous D004-D011 D018-D043	STABL, CHOX, and Land Disposal 1.) WCS Hobbs, NM 2.) Clean Harbors Deer Trail, CO
IDW Water, well purge water, well development water	-LF268 (exclude BTEX, TPH) -WWT specific parameters as needed	-Drum or bulk storage tank	Non-Hazardous	1.) Discharge to ground surface per approval 2.) On-site WWT
Aviation Fuel	-Total Metals -Total VOCs -Flash Point -pH -PCB	-Drum	Hazardous D018	CMBST, INCIN 1.) Off-site Fuel Blending 2.) Off-site Incineration
Spent Carbon	-TCLP Metals -Total VOCs -Flash Point -pH -PCB	-Drum	Hazardous D018	CHOX, INCIN & Land Disposal 1.) Clean harbors 2.) Rhino Environmental
SVE Condensate	-TCLP Metals -TCLP VOC's -Total VOC's -Flash Point -pH	-Drum	Hazardous D018	CHOX, WWT 1.) Clean Harbors 2.) Safety Kleen 3.) Other off-site WWT
Used Oil	Generator Knowledge	-Drum	NA	Recycled

Based on existing information, this table depicts an anticipated approach to waste streams generated in support of the BFF Spill field activities. However, if circumstances and/or analytical results deviate from the expected, necessary adjustments will be made to onsite waste handling and treatment and disposal selection. All procedures for handling and disposal of wastes, including necessary adjustments, will be in accordance with applicable federal and state regulations (see Section 1.4). Any significant adjustments to procedures will be transmitted to stakeholders during monthly status meetings, DQCRs, and other ad hoc meeting/conference calls as discussed in Section 5.1 of the work plan.

All documentation generated in managing each waste stream will be kept on file and provided to the appropriate Kirtland AFB environmental staff.

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APPENDIX D

Field Forms

Form 1: Typical Bore Log Form Used to Describe Split Spoon Samples

Form 2: The Unified Soil Classification System (USCS)

Form 3: Well Abandonment Form

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Form 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.

Form 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				

Form 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.)		
	Clean Gravels (Less than 5% fines)	
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	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
	Clean Sands (Less than 5% fines)	
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	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

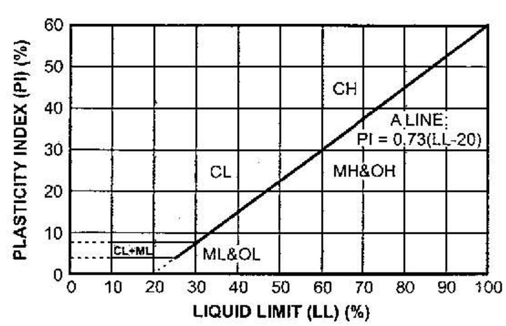
LABORATORY CLASSIFICATION CRITERIA

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

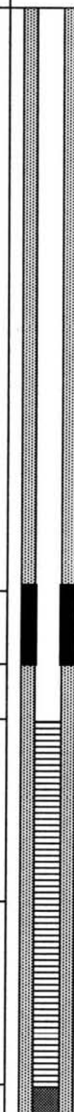


Form 3. Well Abandonment Form

Well Abandonment Form	Project Name	Borehole Number
	Location	Well Number
	Project Number	Page ______ of ______

Logged By	Checked By	Reason For Abandonment	
Driller			
Drilling Method		Measured Depth of Well	Depth to Water
Sampling Method		Was Old Well Removed? Yes No Partial	
Start Date	End Date	Drilled Diameter	Quality of Backfill (Gal)

DEPTH (feet)	SAMPLE NUMBER	MATERIAL DESCRIPTION	BACKFILL DESCRIPTION	WELL CONSTRUCTION DETAILS	WELL SCHEMATIC
				TOP OF SEAL ______	
				TOP OF SAND ______	
				TOP OF SCREEN ______	
				WATER LEVEL ______	
				DEPTH OF WELL ______	
				DEPTH OF HOLE	



Form 3. Well Abandonment Form (Concluded)

Denver Federal Center Boring Log	Project Name Contractor Project Number	Boring Number Page ______ of ______

Depth (ft-bgs)	Blows/6" (recovery)	PID (ppm)	Graphic Log	MATERIAL DESCRIPTION	REMARKS

APPENDIX E

Uniform Federal Policy – Quality Assurance Project Plan (UFP-QAPP) (Pending Review)

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QAPP Worksheet #1 – Title and Approval Page

Quality Assurance Project Plan
Sampling and Analysis Plan
for
Bulk Fuels Facility Spill Solid Waste Management Units ST-106 and SS-111
Kirtland Air Force Base, Albuquerque
New Mexico

USACE CONTRACT NO. W912DY-10-D-0014
Delivery Order No. 0002

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EXECUTIVE SUMMARY

This Quality Assurance Project Plan (QAPP)/Sampling and Analysis Plan (SAP) has been developed by Shaw Environmental & Infrastructure, Inc. (Shaw) under the U.S. Army Corps of Engineers (USACE), Huntsville Center, Contract No. W912DY-10-D-0014, Delivery Order No. 0002. This QAPP/SAP presents pre-remedy quarterly monitoring, groundwater, vadose zone, and interim measure (IM) investigation requirements for the Bulk Fuels Facility (BFF) Spill, Solid Waste Management Units (SWMUs) ST-106 and SS-111, Kirtland Air Force Base (AFB). Albuquerque, New Mexico.

An underground fuel pipeline delivery system failure occurred over several decades at the BFF (SWMUs ST-106 and ST-111). The fuels aviation gasoline (Avgas), Jet Propellant-4 fuel (JP-4), and Jet Propellant-8 fuel (JP-8) have percolated to the groundwater table, resulting in a light dense non-aqueous phase liquid (LNAPL) plume and a dissolved-phase groundwater plume that is migrating off-base toward the City of Albuquerque municipal water supply wells. The leaks have been investigated since the 1990s, but the fuel plume was not discovered until 2007.

In 2005 an inter-governmental task force devised and recommended use of a new QAPP/SAP standard format called the Uniform Federal Policy for QAPPs. Also beginning in 2003 the U.S. Department of Defense (DoD) Environmental Workshop developed the DoD Quality Systems Manual (QSM) which provides baseline requirements for the establishment of quality systems for environmental laboratories. Therefore, this QAPP/SAP has been developed for the Kirtland AFB BFF Spill remediation to meet the 2005 Uniform Federal Policy format requirements and the quality control requirements defined in the DoD QSM for environmental laboratories (version 4.1, April 22, 2009).

This QAPP/SAP covers pre-remedy quarterly groundwater monitoring, quarterly vadose zone monitoring, quarterly vapor monitoring associated with the existing soil vapor extraction (SVE) systems, soil sampling associated with the groundwater and vadose zone investigations and well installation, and the soil sampling activities for the IM investigation at the Former Fuel Offloading Rack (FFOR). The QAPP/SAP describes the sampling field procedures, laboratory analytical methods, quality assurance/quality control protocols, and reporting requirements to address the BFF Spill sampling and analysis results for the period of 2011 through 2014.

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Appendix A Summary of Control Limits for Soil, Soil Gas, and Soil Samples
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Laboratory In-House Control Limits – Soil Gas
Laboratory In-House Control Limits – Soil

Acronyms and Abbreviations

µg/L	microgram(s) per liter
°C	degrees Celsius
ADR	automated data review
APH	air phased petroleum hydrocarbon
AvGas	aviation gasoline
BFF	Bulk Fuels Facility
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAS	chemical abstract service
CCV	continuing calibration verification
COC	chain of custody
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
DQA	data quality assessment
DQO	data quality objective
EDB	ethylene dibromide
EDD	electronic data deliverable
ELAP	environmental laboratory accreditation program
EPA	U.S. Environmental Protection Agency
EPH	extractable petroleum hydrocarbon
FFOR	Former Fuel Offloading Rack
GC/MS	gas chromatography/mass spectrometry
HNO_3	nitric acid
IC	ion chromatography
ICE	internal combustion engine
IDW	investigation-derived waste
IM	interim measure
IIa	compliance with methods, procedures, and contracts
IIb	comparison with measurement performance criteria in the QAPP/SAP
JP-4	Jet Propellant-4 fuel
JP-8	Jet Propellant-8 fuel
KAFB	Kirtland Air Force Base
L	liter(s)
LCS	laboratory control sample
LCSD	laboratory control sample duplicate

Acronyms and Abbreviations (Continued)

LNAPL	light dense non-aqueous phase liquid
LOD	limit of detection
LOQ	limit of quantitation
MA DEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant level
MDL	method detection limit
mg/L	milligram(s) per liter
mL	milliliter(s)
MNA	monitored natural attenuation
MS	matrix spike
MSD	matrix spike duplicate
NA	not applicable
ND	not detected
NE	not established
NELAP	National Environmental Laboratory Accreditation Program
NM	New Mexico
NMED	New Mexico Environmental Department
NMWQCC	New Mexico Water Quality Control Commission standards
NOD	Notice of Deficiency (NOD)
OSHA	Occupational Safety and Health Administration
PDF	portable document format
QA	quality assurance
QAO	quality assurance officer
QAPP	Quality Assurance Project Plan
QC	quality control
QSM	Quality Systems Manual
RCI	reactivity, corrosivity, ignitability
RCRA	Resource Conservation and Recovery Act
RL	reporting limit
RPD	relative percent difference
RSD	relative standard deviation
RSL	regional screening level
RT	retention time
SAP	Sampling and Analysis Plan
SEDD	staged electronic data deliverable
Shaw	Shaw Environmental, Inc.
SOP	standard operating procedure
SSL	soil screening level
SVE	soil vapor extraction
SVM	soil vapor monitoring

Acronyms and Abbreviations (Concluded)

SVOC	semivolatile organic compound
SWMU	solid waste management unit
TBD	to be determined
TCLP	toxicity characteristic leaching procedure
TKN	total kjeldahi nitrogen
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSA	technical systems audit
USACE	U.S. Army Corps of Engineers
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbon
WERS	Worldwide Environmental Remediation Services

QAPP Worksheet #2 – QAPP Identifying Information

Name/Number: Kirtland AFB BFF Spill at SWMUs ST-106 and SS-111
Operable Unit: Not Applicable (NA)
Contractor Name: Shaw
Contract Number: W912DY-10-D-0014, Delivery Order 0002
Contract Title: USACE, Huntsville Center, Worldwide Environmental Remediation Services (WERS)

1. This QAPP/SAP has been prepared in accordance with the requirements of the *Uniform Federal Policy for Quality Assurance Project Plans, Final, Version 1* (U.S. Environmental Protection Agency [EPA], 2005); *Guidance for Quality Assurance Project Plans* (EPA, 2002a); *DoD Quality System Manual for Environmental Laboratories, Version 4.1* (DoD, 2009); and New Mexico Administrative Codes.

2. Identify regulatory program: NMED, Hazardous Waste Bureau Notice of Deficiency (NOD) letter

3. This SAP is a project-specific SAP.

4. List dates of scoping sessions that were held:

Scoping Session was held on July 9, 2010. The provisions for the scope of this work and the level of effort are established based on the scoping section and the following documents:

- Letters from NMED dated April 2, June 4, and August 6, 2010
- Shaw's proposal for Kirtland AFB BFF Spill SWMUs ST-106 and SS-111, Albuquerque, New Mexico, August and September 2010

5. List dates and titles of any SAP documents written for previous site work that are relevant to the current investigation.

- Title: *Base-Wide Plans for Investigations Under the Environmental Restoration Program,* Kirtland AFB, Albuquerque, New Mexico (Tetra Tech, 2004)

QAPP Worksheet #2 – QAPP Identifying Information (Continued)

6. List organizational partners (stakeholders) and connection with lead organization:

   - NMED Hazardous Waste Bureau - Regulatory oversight
   - Air Force/Kirtland AFB - End Customer
   - USACE Albuquerque District - Client
   - City of Albuquerque, New Mexico (Public Water Supply) - representing affected community (the public).

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7. Lead organization

   - USACE Albuquerque District – Contract and technical management

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8. If any required SAP elements or required information are NA to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion below:

None

QAPP Worksheet #3 – Distribution List

Name of QAPP Recipients	Title/Role	Organization	Telephone Number	E-mail Address or Mailing Address
Walter Migdal	USACE Project Manager	USACE	505-301-2923	Walter.migdal@usace.army.mil
Mark Phaneuf	USACE Technical Lead	USACE	505-342-3295	Mark.j.phaneuf@usace.army.mil
Michael D'Auben	USACE Quality Assurance (QA) Chemist	USACE	256-895-1460	Michael.J.D'Auben@usace.army.mil
James Bearzi William Moats William McDonald Sid Brandwein	New Mexico (NM) State Regulator	NMED-Hazardous Waste Branch	505-476-6000 505-222-9557 505-222-9582 505-222-9504	James.bearzi@state.nm.us William.moats@state.nm.us William.mcdonald@state.nm.us Sid.brandwein@state.nm.us
Tom Cooper, PG, PMP	Shaw Project Manager	Shaw	720-554-8163	Thomas.Cooper@shawgrp.com
Pamela Moss	Shaw Field Team Manager - Chemistry	Shaw	720-554-8252	Pamela.Moss@shawgrp.com
Dr. David Cacciatore, PE, PMP	Shaw Field Team Manager - SVE	Shaw	925-288-2299	Dave.Cacciatore@shawgrp.com
Dr. Gary Hecox, PG,CGWP	Shaw Field Team Manager – In Situ	Shaw	785-218-8782	Gary.Hecox@shawgrp.com
Tim Deignan, PGP	Shaw Field Team Manager – Geophysics	Shaw	720-554-8273	Timothy.Deignan@shawgrp.com
Dr. Charles Schaefer	Shaw Field Team Manager – Bioremediation	Shaw	609-895-5372	Charles.Schaefer@shawgrp.com
Susan Huang	Shaw Project Chemist	Shaw	925-288-2099	Susan.Huang@Shawgrp.com
Terry Rulon	Shaw Site Supervisor	Shaw	303-793-5264	Terry.Rulon@shawgrp.com
Mark Lyons	Shaw Field QA/QC	Shaw	505-262-8920	Mark.Lyons@shawgrp.com
Kimberly Kostzer	Project Manager	Empirical Laboratories, LLC	877-345-1113 x 240	kkostzer@empirlabs.com

Mike Truchan	Project Manager	RTI Laboratories	734-422-8000 x217	mtruchan@rtilab.com
Dana Merrill	Project Manager	Gulf Coast Analytical Laboratories, Inc.	225-214-7044	DanaM@GCAL.com
To Be Determined (TBD)	Project Manager	Microseeps Inc.	412- 826- 5245	TBD

QAPP Worksheet #4 – Project Personnel Sign-Off Sheet

The Project Personnel Sign-Off Sheet will be used to document that all key project personnel performing site work have read the applicable sections of the QAPP/SAP and will perform the sampling and analysis tasks as described.

Project Personnel	Organization/Title/ Role	Telephone Number	Signature	Date QAPP Read
Pamela Moss	Shaw FieldTeam Manager – Chemistry	720-554-8252		
Susan Huang	Shaw Project Chemist	925-288-2099		
Mark Lyons	Shaw Field Quality Control (QC) Manager	505-262-8920		
Tom Cooper, PG, PMP	Shaw Project Manager	509-735-9736		
Terry Rulon	Shaw Site Supervisor	303-793-5264		
Kimberly Kostzer	Empirical Laboratories Project Manager	877-345-1113 x240		
Michael Truchan	RTI Laboratories Project Manager	734-422-8000 x217		
Dana Merrilll	Gulf Coast Analytical Laboratories, Inc. Project Manager	225-214-7044		
Microseeps Project Manager	Microseeps Project Manager	412-826-5245		

QAPP Worksheet #6 – Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Telephone Number and/or Email	Procedure
Point of Contact with USACE Project Manager	Shaw Project Manager	Tom Cooper	720-554-8163	All materials and information about the project will be forwarded to the USACE Project Manager by the Shaw Project Manager
Manage all field phases of project	Shaw Project Manager	Tom Cooper	720-554-8163	Point-of-contact for all field-related activities
QAPP/SAP changes in the field	Shaw Field Team Manager – Chemistry	Pam Moss	720-554-8252	Point-of-contact for all field-related sampling activities, will notify the Shaw Project Chemist or other technical leads of any necessary field sampling changes
Reporting laboratory data quality issues and corrective actions	Shaw Project Chemist	Susan Huang	925-288-2099	Point-of-contact for laboratory, Shaw Project Manager, or Shaw Quality Assurance Officer (QAO) if any laboratory quality assurance/quality control (QA/QC) issues arise with field samples
Field corrective actions	Shaw QC Manager	Mark Lyons	505-262-8920	Based on QA oversight of field work the need for corrective actions will be determined by Shaw QC Manager
Major changes to QAPP/SAP	USACE Chemist	Michael D'Auben	256-895-1460	All major changes to the final QAPP/SAP must in compliance with *Uniform Federal Policy for Quality Assurance Project Plans* and be approved by USACE

SOURCE:

EPA. 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual, Final, Version 1,* EPA-505-B-04-900A, DoD DTIC ADA 427785. Prepared by the Intergovernmental Data Quality Task Force. March.

QAPP Worksheet #7 – Personnel Responsibilities and Qualifications Table

Name	Title	Organizational Affiliation	Responsibility	Education and Experience Qualification
Walter Migdal	USACE Project Manager	USACE	• Manages governmental oversight of the project • Manages project funding and scope	NA
Michael D'Auben	USACE QA Manager	USACE	• Provides governmental oversight of the Shaw QA Program • Provides quality-related directives through Contracting Officer's Technical Representative • Provides technical and administrative oversight of Shaw surveillance audit activities • Acts as point-of-contact on all matters concerning QA and the client's laboratory QA program • Authorized to suspend project execution if QA requirements are not adequately followed	NA
Mark Phaneuf	USACE Technical Lead	USACE	• Provides technical oversight of groundwater monitoring activities • Point of contact for technical matters	NA
Tom Cooper	Project Manager	Shaw	• Manages oversight of the project for Shaw • Ensures that all requirements of project contract are attained in a manner consistent with project plans • Manages project budgets and schedules	MS, Geology 11+ years experience
Pamela Moss	Field Team Manager – Chemistry	Shaw	• Reviews and approves the QAPP/SAP • Guides the selection of subcontract analytical laboratories • Serves as a point-of-contact for the USACE QAO • Develops corrective action as required • Serves as a technical advisor to the project	BS, Chemistry 32+ years experience
Gary Hecox	Shaw Field Team Manager – In Situ	Shaw	• Develops work plans to address project scope of work • Prepares work plan variances, if necessary • Manages technical project elements • Reports to Project Manager	PhD, Geology 32+ years experience
Terry Rulon	Site Supervisor	Shaw	• Advises field personnel on any technical issues that arise during work execution • Reviews field and laboratory data • Authors Quarterly Monitoring Reports and makes recommendations	AS, Construction Management 20 years experience

QAPP Worksheet #7 – Personnel Responsibilities and Qualifications Table (Continued)

Name	Title	Organizational Affiliation	Responsibility	Education and Experience Qualification
Susan Huang	Project Chemist	Shaw	• Develops the project data quality objectives (DQOs) and prepares the QAPP/SAP • Selects qualified subcontract laboratories • Implements chemical data QC procedures and audits field performance • Coordinates laboratory and field sampling activities • Reviews laboratory data prior to use • Performs automated EPA Level III data review • Prepares the appropriate sections of the report summarizing the project activities	BS, Chemical Engineering 15+ years experience
Mark Lyons	QC Manager	Shaw	• Develops the project QC objectives and prepares the QC Plan • Administers the QC Plan • Manages QC documentation and QC deliverables • Lists definable features of work • Conducts inspections (preparatory, initial, follow-up, final)	MA, Geography 23+ years of experience
James Vigerust	Health and Safety Officer	Shaw	• Develops and administers the Site Health and Safety Plan • Manages personnel and environmental monitoring • Coordinates preparation of Job Safety Analyses • Selects appropriate personal protective equipment • Reviews essential health and safety requirements with onsite personnel • Facilitates daily safety meetings	MS, Industrial Safety 19+ years of experience
TBD	Sampling Technician	Shaw	• Performs all sampling in accordance with approved QAPP/SAP • Ensures that field QC samples are collected as specified in the QAPP/SAP • Completes field documentation • Implements field corrective actions as required • Must have Occupational Safety and Health Administration (OSHA) certification • Must have 8-hour OSHA refresher certification	High School Diploma Or Equivalent

Note(s):

DQO denotes data quality objective.

OSHA denotes Occupational Safety and Health Administration.

QAPP Worksheet #8 – Special Personnel Training Requirements Table

Project Function	Specialized Training – Title or Description of Course	Training Provider	Training Date	Personnel/Groups Receiving Training	Personnel Titles/Organizational Affiliation	Location of Training Records and Certificates
Field Team Samplers	OSHA 40 Hour HAZWOPER with Current 8-Hour Refresher	Shaw	Annual	Shaw Field Personnel	Shaw Health and Safety Training Personnel or approved vendor	Shaw Training Web Site & Health Safety Records at project site
Field Team Samplers	Sampling Procedures	Shaw	Preparatory meeting and daily tailgate meeting	Shaw Field Personnel	Shaw Project Chemist/Geologist/Engineer Personnel or approved vendor	Project Files
Shaw Sample Shipping Person(s)	DOT105 - Air Shipment of Dangerous Goods - IATA with Current Refresher	Shaw	Every 3 Years	Shaw Field Personnel	Shaw Shipping Training Personnel	Shaw Training Web Site & Health Safety Records at Project Site

Note(s):

DOT denotes U.S. Department of Transportation.

HAZWOPER denotes hazardous waste operations and emergency response.

IATA denotes International Air Transportation Association.

QAPP Worksheet #9 – Project Scoping Session Participants Sheet

Project Name: Kirtland AFB, BFF, SWMUs ST-106 and SS-111	Site Name: BFF Spill
Projected Date(s) of Sampling: 2011 to 2014 groundwater monitoring, soil vapor, and soil sampling	
	Site Location: Kirtland AFB, New Mexico
Project Manager: Mr. Tom Cooper, PG, PMP	
Date of Session: July 9, 2010	
Scoping Session Purpose: Planning meeting prior to meetings with representatives of NMED and Kirtland AFB	

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Pat McGinnis, PE, PMP	DoD Program Manager	Shaw	720-554-8187	Patrick.mcginnis@shawgrp.com	Program oversight
Steve Moran, PG, PMP	WERS Contract Program Manager	Shaw	865-694-7361	Steve.G.Moran@shawgrp.com	Contract Manager
Tom Cooper, PG, PMP	Project Manager	Shaw	720-554-8163	Thomas.Cooper@shawgrp.com	Project Manager
Gary Hecox	Field Team Manager – In Situ	Shaw	785-218-8782	Gary.Hecox@shawgrp.com	Sr. Technical Lead
Charles Schaefer	Field Team Manager – Bioremediation	Shaw	609-895-5372	Charles.Schaefer@shawgrp.com	Technical Lead
David Cacciatore, PE, PMP	Field Team Manager – SVE	Shaw	925-288-2299	Dave.Cacciatore@shawgrp.com	Technical Lead
Tim Deignan, PGP	Field Team Manager - Geophysics	Shaw	720-554-8273	Timothy.Deignan@shawgrp.com	Technical Lead
Pam Moss	Field Team Manager - Chemistry	Shaw	720-554-8252	Pamela.Moss@shawgrp.com	Technical Lead

Consensus Decisions:

QAPP Worksheet #10 – Problem Definition

10.1 PROBLEM STATEMENT

Several decades ago, an underground fuel pipeline delivery system failed at the BFF Spill site at SWMUs ST-106 and ST-111, Kirtland AFB. The fuels Avgas, JP-4, and JP-8 have percolated to the groundwater table, resulting in a LNAPL plume and a dissolved-phase groundwater plume that is migrating off-base toward the City of Albuquerque municipal water supply wells. The leaks have been investigated since the 1990s, but the fuel plume was not discovered until 2007. The total plume has been estimated to be 2 to 4 million gallons with another five million gallons remaining in the vadose zone.

In 2010, NMED changed oversight of the BFF Spill from the Ground Water Quality Bureau to the Hazardous Waste Bureau, which issued NOD letters. The letters specified prescriptive requirements to investigate the vadose zone and groundwater media, and to implement an IM to contain the fuel plume from migrating further downgradient toward the municipal supply wells, thus protecting human health and the environment. The Air Force prepared and submitted draft work plans responding to the NOD letters. The work plans proposed a less robust investigation monitoring network than required by NMED and a phased IM approach. NMED reviewed the draft work plans and rejected the approach with a NOD letter on August 6, 2010. In that letter, NMED directed the Air Force to meet the original required monitoring network and added monitoring points. They also disapproved of the phased approach to implementing an interim measure to contain the fuel plume and directed the Air Force to install 16 SVE wells with internal-combustion engine (ICE) vacuum units to contain the fuel plume.

QAPP Worksheet #11 – Project Quality Objectives/Systematic Planning Process Statements

11.1 STATE THE PROBLEM

Step 1. Define the problem that necessitates the study. Identify the planning team members, including decision-makers, and determine resources such as budget, personnel, and schedule.

As stated in QAPP/SAP Worksheet #10, groundwater contamination in the form LNAPL and dissolved-phase plumes have been identified at the BFF Spill site (SWMUs ST-106 and SS-111) as a result of the failure of the underground fuel pipeline delivery system at the BFF site.

The planning team consists of the representatives of the USACE and Air Force, Shaw, and regulatory support and oversight from the NMED Hazardous Waste Bureau. The USACE is the lead federal agency for direction of site activities and is the prime decision-maker. The work will be conducted according to the USACE-awarded contract to Shaw, the approved budget, and sampling and reporting schedules described in QAPP/SAP Worksheet #16.

11.2 IDENTIFYING THE GOAL OF THE STUDY

Step 2. The principal BFF Spill objectives consist of the following:

- Determine the location of fine-grained lithologic units within the vadose zone at the BFF Spill, which control LNAPL migration;
- Determine the extent of the LNAPL plume on the water table;
- Determine gradients and flow paths within all three groundwater horizons at the site;
- Delineate contaminated vs. uncontaminated (from LNAPL plume) locations at BFF;
- Determine the extent of the dissolved-phase contaminant plume that exceeds the established EPA maximum contaminant levels (MCLs)/New Mexico Water Quality Control Commission (NMWQCC) standards for groundwater at the site; and
- Characterize nature and extent of contaminants within vadose zone and FFOR.

Groundwater monitoring associated with the BFF Spill will be conducted quarterly from 2011 through 2014 (four events per year). Monitoring will involve the following number of wells:

- 29 wells for January 2011 monitoring event,
- 72 wells for April 2011 monitoring event, and
- 111 wells on a quarterly basis for July 2011 - December 2014 monitoring events.

To maximize efficiency, quarterly vadose-zone monitoring will be conducted along with groundwater monitoring at the following number of wells:

- 15 soil gas monitoring points for January 2011 event,
- 123 soil gas monitoring points for April 2011 event, and
- 230 soil gas monitoring points for July 2011 - December 2014 events.

In addition, to quarterly groundwater and soil vapor monitoring, the following additional sampling and analysis activities will be performed in support of the BFF Spill remediation:

- Groundwater investigation – 72 soil samples/one event,
- Vadose zone investigation – 515 soil samples/one event,
- IM investigation at the FFOR – 400 soil samples/one event,
- LNAPL containment groundwater quality data gap – 6 groundwater samples/one event, and
- Monitored natural attenuation (MNA) assessment – 35 wells/four events.

Monitoring and sampling activities are summarized in QAPP/SAP Worksheets #17, 18, and 20.

11.3 IDENTIFYING INFORMATION INPUTS

Step 3. Identify data and information needed to answer study questions.

The data needed to answer principal study questions are monthly groundwater level and LNAPL measurements, laboratory analytical results from quarterly groundwater samples, quarterly soil gas samples, and soil samples from soil vapor monitoring (SVM) installation and FFOR sampling activities. Groundwater samples will be analyzed at an offsite laboratory for the following list of parameters:

- Volatile organic compounds (VOCs)
- Ethylene dibromide (EDB)
- Total petroleum hydrocarbons (TPH) - gasoline and diesel
- Volatile petroleum hydrocarbons (VPHs) and extractable petroleum hydrocarbons (EPHs) – four (4) quarters only
- Semivolatile organic compounds (SVOCs)
- Total lead, calcium, potassium, sodium, and magnesium

- Dissolved iron and manganese
- Anions – chloride, sulfate, nitrate nitrogen
- Alkalinity – carbonate and bicarbonate
- ammonia nitrogen
- total sulfide
- total organic carbon (TOC)
- total kjeldahl nitrogen (TKN)
- ortho-phosphorous
- dissolved gases – methane, ethane, ethene

Soil gas samples will be analyzed at an offsite laboratory for the following list of parameters:

- VOCs
- TPH gasoline
- Air-phased petroleum hydrocarbons (APHs) – four (4) quarters only
- Fixed gases

Soil samples will be analyzed at an off-site laboratory for the following list of parameters:

- VOCs
- VPH and EPH
- SVOCs
- Lead

Specific analytical methods and target analytes are summarized in QAPP/SAP Worksheet #15a (groundwater), Worksheet #15b (soil gas), and Worksheet #15c (soil).

11.3.1 Comparison Criteria

Analytical results from the quarterly groundwater monitoring events will be compared to EPA MCLs and NMWQCC standards contained in New Mexico Administrative Code Title 20 – Environmental Protection, Chapter 6 – Water Quality, Part 2 – Ground and Surface Water Protection. Soil samples results will be compared to EPA residential regional soil screening levels (RSLs) (EPA, 2010) and NM soil screening levels (SSLs) (NMED, 2006). Currently there are no established regulatory standards for soil gas. Regulatory limits are summarized in QAPP/SAP Worksheet #15a (groundwater) and Worksheet # 15c (soil).

Analytical methods selected for the project will provide sufficient sensitivity to meet the data quality objectives and NMED requirements. As shown in QAPP/SAP Worksheet#15, laboratory reporting limits (RLs) or method detection limits (MDLs) for all but three SVOC compounds in soil, achieve respective EPA MCL, NMWQCC, or NMED SSL regulatory standards. In order to meet the regulatory limits, laboratories will report positive results down to the MDL and results between the MDL and the laboratory RL will be flagged with a J-qualifier and reported as estimated data. Target analytes with RLs greater than the regulatory limits are highlighted in QAPP/SAP Worksheet#15.

11.4 DEFINE THE BOUNDARIES OF THE STUDY

Step 4. Define target population of interest, specify the spatial and temporal boundaries, and determine the practical constraints on collecting data.

11.4.1 Target Population of Interest

The target population of interest is all future groundwater receptors, including workers who will perform Kirtland AFB BFF Spill groundwater monitoring activities and all future human and ecological receptors of the groundwater.

11.4.2 Spatial Boundaries

The approximate study boundaries are indicated on Figure 2.

11.4.3 Temporal Boundaries and Constraints

There are no physical constraints to data collection.

11.5 DEVELOP THE ANALYTIC APPROACH

Step 5. Define the parameter of interest and develop the logic for drawing conclusions from findings.

The following decisions may be made based on the results of the Kirtland AFB BFF Spill pre-remedy groundwater and soil gas monitoring:

- If proposed groundwater and soil gas monitoring wells being used for the purpose of monitoring contamination within the LNAPL plume do not address areas that have been delineated as possible preferential flow paths for LNAPL to the groundwater table, consider modifying proposed SVE well locations within the LNAPL plume.
- If proposed groundwater and soil gas monitoring wells being installed for the purpose of monitoring contamination within the LNAPL plume are not within the plume,

consider adjusting the location of these points or eliminate them from the drilling program.

- If groundwater and soil gas samples in monitoring wells proposed for the purpose of delineating the extent of the groundwater plume are impacted above MCLs, the dissolved-phase plume has not been delineated and additional wells must be installed to complete the delineation.

The following decisions may be made based on the results of the KAFB BFF soil monitoring:

- If soil samples collected during SVM installation are impacted above EPA RSLs /NMED SSLs, consider collecting additional samples or adjusting SVM locations.
- If soil samples collected during groundwater monitoring well installation are impacted above EPA RSLs /NMED SSLs, evaluate adjusting groundwater monitoring well locations.
- If soil samples collected at the FFOR for the purpose of delineating excavation contamination are impacted above EPA RSLs/NMED SSLs, consider collecting samples further from the excavation points.

11.6 SPECIFYING PERFORMANCE OR ACCEPTANCE CRITERIA

Step 6. Develop performance criteria for new data being collected or acceptable criteria for existing data being considered for use. Specify probability limits for false rejection and false acceptance decision errors.

To limit uncertainty in obtained environmental data, criteria for the precision, accuracy, representativeness, completeness, and comparability parameters, and RLs for the parameters have been developed and presented in this QAPP/SAP. Measurement errors will be controlled by using appropriate sampling and analytical methods, adhering to the DoD QSM (2009), following established standard operating procedures (SOPs), and having data review to verify laboratory processes. Field crews will be trained in the appropriate sample collection procedures and will review the QAPP/SAP before sample collection to limit sample collection errors. Subcontract analytical laboratories will have a copy of the QAPP/SAP and will adhere to DoD QSM guidance to limit measurement errors. The data that meet these criteria will be of definitive quality and of less uncertainty than data which was acquired with a less rigorous approach.

11.7 OPTIMIZING THE DESIGN FOR OBTAINING DATA

Step 7. Review DQO outputs; develop data collection design alternatives; formulate mathematical expressions for each design; select sample size that satisfies the DQOs; decide on the most resource-effective design or agreed alternative; and document details in the QAPP.

The sampling and analysis strategy is described in this QAPP/SAP worksheet #17.

QAPP Worksheet #12a – Measurement Performance Criteria Table - Groundwater

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both
Matrix Spikes	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA8015 TPH diesel – EPA 8015 VPH/EPH – MA DEP SVOCs – EPA 8270 Metals – 6010 Anions – EPA 300.0 Ammonia – SM 4500B, D TKN – EPA 351.4 Ortho-Phosphorous – SM 4500 PE Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases – RSK 175	One per 20 field samples collected	Precision and accuracy	Laboratory control sample (LCS) limits specified in the DoD QSM and in QAPP/SAP Worksheets #28a through #28e	A
Field Duplicate	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH diesel – EPA 8015 VPH/EPH – MA DEP SVOCs – EPA 8270 Metals – EPA 6010 Anions – EPA 300.0 Ammonia – SM 4500B, D TKN – EPA 351.4 Ortho-Phosphorus – SM	One per 10 field samples collected	Precision	Relative percent difference (RPD) less than or equal to 35%	S&A

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both
	4500 PE Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases– RSK 175 Stable carbon and hydrogen isotopes - Lab SOP				

QAPP Worksheet #12a – Measurement Performance Criteria Table – Groundwater (Continued)

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both
Equipment Rinse Blanks	VOCs – EPA 8260 TPH gasoline – EPA 8015 TPH diesel – EPA 88015 Metals – EPA 6010	None when dedicated sampling equipment is used to collect groundwater samples. If non-dedicated sampling equipment is used, one equipment rinse blank will be collected per day, regardless of the number of sampling teams working each day.	Representativeness	Analytes not detected (ND) above one-half RL; and acetone and methylene chloride ND above RL	S
Temperature Blanks	VOCs – EPA 8060 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH diesel – EPA 8015 VPH/EPH – MA DEP SVOCs – EPA 8270 Metals – EPA 6010 Anions – EPA 300.0 Ammonia – SM 4500 B, D TKN – EPA 351.4 Ortho-Phosphorous –SM 4500 PE Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175 Stable carbon and hydrogen isotopes (SOP)	Every cooler shipped to the laboratory	Representativeness	0-6 degrees Centigrade (°C)	S

QAPP Worksheet #12a – Measurement Performance Criteria Table – Groundwater (Continued)

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both
Trip Blanks	VOCs – EPA 8260	One per cooler containing liquid samples for VOC analysis	Representativeness	Analytes ND above one-half RL; and acetone and methylene chloride ND above RL	S&A
Ambient Blanks	VOCs – EPA 8260	One per cooler containing liquid samples for VOCs analyses	Representativeness	Analytes ND above one-half RL; and acetone and methylene chloride ND above RL	S&A

Note(s):

In accordance with the DoD QSM requirements, the most current version of the EPA methods will be implemented for each sampling event.

°C denotes degrees Celsius.
LCS denotes laboratory control sample.
RL denotes reporting limit.
RPD denotes relative percent difference.

QAPP Worksheet #12b – Measurement Performance Criteria Table - Soil Gas

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both
Field Duplicate	VOCs/TPH Gas – EPA TO15 APH – MA DEP Fixed Gases – ASTM D2504	One per 10 field samples collected	Precision	RPD less than or equal to 35%	S&A
Trip Blanks	VOCs – EPA TO-15	One per shipment	Representativeness	Analytes ND above one-half RL; and acetone and methylene chloride ND above RL	S&A

Note:

In accordance with the DoD QSM requirements, the most current version of the EPA methods will be implemented for each sampling event.

RL denotes reporting limit

RPD denotes relative percent difference.

QAPP Worksheet #12c – Measurement Performance Criteria Table - Soil

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both
Matrix Spikes	VOCs – EPA 8260 VPH/EPH – MA DEP SVOCs – EPA 8270 Lead – EPA 6010	One per 20 field samples collected	Precision and Accuracy	LCS limits specified in the DoD QSM and QAPP/SAP Worksheets #28a through #28e	A
Field Duplicate	VOCs – EPA 8260 VPH/EPH – MA DEP SVOCs – EPA 8270 Lead – EPA 6010	One per 10 field samples collected	Precision	RPD less than or equal to 50%	A and S
Temperature Blanks	VOCs – EPA 8260 VPH/EPH – MA DEP SVOCs – EPA 8270 Lead – EPA 6010	Every cooler shipped to the laboratory	Representativeness	0-6°C	S

Note(s):

In accordance with the DoD QSM requirements, the most current version of the EPA methods will be implemented for each sampling event.

°C denotes degrees Celsius.
LCS denotes laboratory control sample.
RPD denotes relative percent difference.

QAPP Worksheet #13 – Secondary Data Criteria and Limitations Table

Secondary Data	Data Source (originating organization, report title and date)	Data Generator(s) (originating organization, data types, data generation/ collection dates)	How Data Will Be Used	Limitations on Data Use
VOCs, SVOCs, PAHs, pesticides, PCB, metals, TPH gas/diesel, and anions	Report title(s) and organization(s) unknown. Information is gathered through a review of Kirtland AFB historical data	Soil, May 1994 through November 2007 Organization(s) unknown	Data Evaluation	None
VOCs, SVOCs, PAHs, pesticides, PCB, metals, TPH gas/diesel, anions, ammonia, and total dissolved solids	Report title(s) and organization(s) unknown. Information is gathered through a review of Kirtland AFB historical data	Groundwater, January 2000 through October 2009 Organization(s) unknown	Data Evaluation	None
VOCs	Report title(s) and organization(s) unknown. Information is gathered through a review of Kirtland AFB historical data	Soil Gas, April 2006 through December 2009 Organization(s) unknown	Data Evaluation	None

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QAPP Worksheet #14 – Summary of Project Tasks

14.1 SCOPE OF WORK

The scope of work for activities associated with pre-remedy quarterly monitoring at SWMUs ST-106 and SS-111 includes preparation, submission, and approval of this document. Additional project tasks are summarized below:

- Completion of downhole geophysics of 29 existing wells, installation of 39 deep and 5 shallow SVM wells for vadose zone investigations, installation of 82 groundwater monitoring wells for routine quarterly groundwater monitoring, and installation of 30 groundwater monitoring wells for MNA sampling and analysis.
- Monthly groundwater level and LNAPL measurements starting in January 2011 and continuing for the duration of the field efforts.
- Quarterly groundwater monitoring events starting in January 2011 through 2014.
- Laboratory analyses of quarterly groundwater samples for VOCs, EDB, TPH gas/ diesel, VPH/EPH, SVOCs, dissolved iron and manganese, total lead and cations, anions, alkalinity, ammonia as nitrogen, TKN, ortho-phosphorous, total sulfide, TOC, and dissolved gases. Alkalinity will also initially be measured in the field using a HACH test kit. Results will be compared to the laboratory to determine if this is warranted.
- EPA Level III automated data review (ADR) for each of the quarterly groundwater monitoring events.
- Quarterly soil gas monitoring events starting in January 2011 through 2014 (concurrent with the quarterly groundwater monitoring).
- Laboratory analyses of the soil gas samples for VOCs/TPH, APH, and fixed gases.
- EPA Level III ADR for each of the quarterly soil gas monitoring events.
- Quarterly vapor sampling of the existing SVE systems starting in January 2011 through 2014
- Field analysis of the vapor samples for TPH
- EPA Level III ADR for each of the quarterly vapor monitoring events.
- Soil sampling associated with groundwater monitoring well installation.
- Laboratory analyses of the soil samples associated with groundwater monitoring well installation for VOCs, VPH/EPH, SVOCs, and lead.
- EPA Level III ADR for soil samples associated with groundwater monitoring well installation.

- Soil sampling associated with SVM installation
- Laboratory analyses of the soil samples associated with SVM installation for VOCs, VPH/EPH, SVOCs, and lead.
- EPA Level III ADR for SVM soil sample results.
- IM investigation - FFOR soil sampling.
- Laboratory analyses of FFOR soil samples for VOCs, VPH/EPH, SVOCs, and lead.
- EPA Level III ADR for FFOR soil sample results.
- Waste characterization and disposal for soil wastes generated from SVM installation and FFOR soil sampling activities.
- Laboratory analysis of soil investigation-derived waste (IDW) for toxicity characteristic leaching procedures (TCLP) VOCs; TCLP SVOCs; TCLP metals; TCLP pesticides; TCLP herbicides; reactivity, corrosivity, and ignitability (RCI); total benzene, toluene, ethylbenzene, and xylenes (BTEX); and total TPH gas/diesel.
- Groundwater monitoring associated with the LNAPL containment IM investigations (one sampling event).
- Laboratory analysis of the groundwater samples associated with the LNAPL contaminant IM investigations for VOCs, SVOCs, total cations, and anions.
- EPA Level III ADR for IM groundwater sample results.
- MNA quarterly groundwater monitoring (concurrent with the routine quarterly groundwater monitoring).
- Laboratory analysis of MNA groundwater samples for total cations, anions, ammonia as nitrogen, total sulfide, ortho-phosphorous, and stable carbon and hydrogen isotopes.
- EPA Level III ADR for MNA groundwater sample results.
- Quarterly Environmental Resources Program Information Management System (ERPIMS) data submittal.
- Quarterly monitoring report submittal. The quarterly monitoring report will detail descriptions of installed groundwater and SVM wells, water level and LNAPL measurements, field and laboratory results for groundwater, soil gas, soil, vapor, and data review findings.

14.2 DATA RECORDING AND TRANSFER

This section details the requirements for data reporting and data package formats that will be provided by the laboratory.

14.2.1 Hard Copy Deliverables

All relevant raw data and documentation, including (but not limited to) logbooks, data sheets, electronic files, and final reports, will be maintained by the laboratory for at least 10 years. The laboratory will notify Shaw 30 days before disposal of any relevant laboratory records. In addition, Shaw will maintain laboratory data packages for ten years.

Shaw will maintain copies of all chain-of-custody (COC) forms until receipt of the laboratory report. Laboratory reports will be logged in upon receipt and filed in chronological order. The data deliverable requirements for this project will be 100 percent EPA Level III format for analytical data obtained from quarterly groundwater monitoring, quarterly soil gas monitoring, quarterly vapor monitoring, and soil sampling; and EPA Level II format for IDW soil sampling.

14.2.2 Electronic Deliverables

The electronic data deliverable for use in the validation effort will be in the Staged Electronic Data Deliverable (SEDD) stage 2a (version 5.0-Draft). The SEDDs will meet EPA specifications found at: http://www.epa.gov/superfund/programs/clp/seddspec5.htm. Prior to SEDD submittal, the analytical laboratory will check SEDDs for completeness and accuracy and correct all SEDD errors.

In addition, an ERPTOOLS X data deliverable will be provided by the laboratory for upload to the Air Force data repository.

Field information (e.g., sample collection date and time, sample identification, etc.) will be entered directly into a Shaw's database from the COC form and completed sample collection forms.

14.3 LABORATORY DATA MANAGEMENT

This section describes the data management procedures for data review, verification, reporting, and validation.

14.3.1 Data Reduction, Verification, and Reporting

All analytical data generated by the laboratory projects will be reviewed before reporting to assure the validity of reported data. This internal laboratory data review process will consist of data reduction, three levels of documented review, and reporting. Review processes will be documented using appropriate checklist forms, or logbooks, which will be signed and dated by the reviewer.

14.3.2 Data Reduction

Data reduction involves the mathematical or statistical calculations used by the laboratory to convert raw data to the reported data. The laboratory will perform reduction of analytical data as specified in each of the appropriate analytical methods and laboratory SOPs. For each method, all raw data results will be recorded using method-specific forms or a standardized output from each of the various instruments.

All data calculations will be verified and initialed by personnel both generating and approving them. All raw and electronic data, notebook references, supporting documentation, and correspondence will be assembled, packaged, and stored for a minimum of 10 years for future use. All reports will be held client confidential. If the laboratory is unable to store project-related data for 10 years, then it is the responsibility of the laboratory to contact Shaw to make alternative arrangements.

14.3.3 Laboratory Data Verification and Review

The laboratory analyst who generates the analytical data will have the primary responsibility for the correctness and completeness of data. Each step of this verification and review process will involve the evaluation of data quality based on both the results of the QC data and the professional judgment of those conducting the review. This application of technical knowledge and experience to the evaluation of data is essential in ensuring that data of known quality are generated consistently. All data generated and reduced will follow well-documented in-house protocols.

Level 1. Technical (Peer) Data Review

Analysts will review the quality of their work based on an established set of guidelines, including the QC criteria established in each method, in this QAPP/SAP, and as stated within the laboratory QA Manual. This review will, at a minimum, ensure that the following conditions have been met:

- Sample preparation information is correct and complete
- Analysis information is correct and complete
- Appropriate SOPs have been followed
- Calculations are verified
- There are no data transposition errors
- Analytical results are correct and complete
- QC samples are within established control limits
- Blanks and LCSs are within appropriate QC limits
- Special sample preparation and analytical requirements have been met

Documentation is complete, for example, any anomalies and holding times have been documented and forms have been completed.

Level 2. Technical Data Review

A supervisor or data review specialist whose function is to provide an independent review of data packages will perform this review. This review will also be conducted according to an established set of guidelines and will be structured to verify the following finding of Level 1 data review:

- All appropriate laboratory SOPs have been followed
- Calibration data are scientifically sound, appropriate to the method, and completely documented
- QC samples are within established guidelines
- Qualitative identification of contaminants is correct
- Manual integrations are justified and properly documented
- Quantitative results and calculations are correct
- Data are qualified correctly
- Documentation is complete, for example, any anomalies and holding times have been documented and appropriate forms have been completed
- Data are ready for incorporation into the final report
- The data package is complete and complies with contract requirements

The Level 2 review will be structured so that all calibration data and QC sample results are reviewed and all of the analytical results from at least 10 percent of the samples are checked back to the sample preparation and analytical bench sheets. If no problems are found with the data package, the review will be considered complete.

If any problems are found with the data package, an additional 10 percent of the sample results will be checked back to the sample preparatory and analytical bench sheets. This cycle will then be repeated either until no errors are found in the checked data set or until all data has been checked. All errors and corrections noted will be documented.

Level 3. Administrative Quality Assurance Data Review

The Laboratory QA Manager will review 10 percent of all data packages. This review should be similar to the review as provided in Level 2, except that it will provide a total overview of the data package to ensure its consistency and compliance with project requirements. All errors noted will be corrected and documented.

14.4 EPA LEVEL III DATA REVIEW

A Shaw Project Chemist will use an ADR software developed by Laboratory Data Consultants (LDC) Inc. to perform 100 percent EPA Level III data review. The review will be performed for analytical data obtained from each of the quarterly groundwater, soil gas, and vapor monitoring events, IM groundwater monitoring, and quarterly MNA sampling. In addition, the Shaw Project Chemist will use the same ADR software to conduct 100 percent EPA Level III data review of the analytical data from the soil sampling associated with SVM installation, groundwater monitoring well installation, and FFOR sampling activities. The data review will be performed using the quality control criteria specified in the following:

- This QAPP/SAP
- *DoD Quality Systems Manual for Environmental Laboratories, Version 4.1* (April 2009)
- *USEPA Test Methods for Evaluating Solids Waste, Physical/Chemical Methods* (SW-846, 2006 and updates)
- *USEPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition,* Compendium Method TO-15, Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS) (January 1999)
- Massachusetts Department of Environmental Protection (MA DEP), *Method for the Determination of Volatile Petroleum Hydrocarbons (VPH)*(May 2004)
- MA DEP, *Method for the Determination of Extractable Petroleum Hydrocarbons (EPH)* (May 2004)
- MA DEP, *Method for the Determination of Air-Phase Petroleum Hydrocarbons (APH)* (December 2008)
- American Water Works Association, *Standard Methods for the Examination of Water and Wastewater* (21st Edition)
- USACE 200-1-10, *Guidance for Evaluating Performance-Based Chemical Data* (2005)
- *USEPA Contract Laboratory Program, National Functional Guidelines for Superfund Organic Methods Data Review* (June 2008)
- *USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Data Review, Final* (January 2010)

The following QC elements will be included in the EPA Level III data review:

- Laboratory method blanks
- Sample extraction and analysis holding times
- Surrogate spike recoveries
- LCS/laboratory control sample duplicate (LCSD) recoveries
- Matrix spike (MS)/matrix spike duplicate (MSD) recoveries

- RPD
- Initial calibrations
- Continuing calibrations
- Field blanks
- Field duplicates

Data will be validated and flagged with the following data qualifiers as applicable:

- ***J+ qualifier*** denotes the analyte was positively identified, but the associated numerical value is estimated with a potential high bias.
- ***J- qualifier*** denotes the analyte was positively identified, but the associated numerical value is estimated with a potential low bias.
- ***U qualifier*** denotes the analyte was analyzed for, but was not detected.
- ***R qualifier*** denotes the data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria and data quality objectives.

Before data review, the Shaw Project Chemist will develop a project library in the ADR program for each of the groundwater, soil gas, and soil matrices and set up the required methods, target analytes, RLs, holding time, accuracy, precision and calibration requirements. Once the project libraries are built and verified to be accurate and complete, the Shaw Project Chemist will use the ADR program to review analytical results provided in the SEDDs. As a result of the ADR process, EPA qualifiers will be electronically generated and applied to the affected sample results that were outside the established QC criteria. Note that due to laboratory information system limitations, laboratories may not be able to provide initial and continuing calibration results in the SEDDs. Project-specific laboratory will not be required to provide stable isotope results in the SEDDS. In this case, the Shaw Project Chemist will manually review the calibration data and stable isotope data, and apply qualifiers to the affected sample results. Once the data is reviewed, the final qualified data will then be exported to a Shaw database. EPA level III data review findings will be summarized and documented with each quarterly monitoring report.

QAPP Worksheet #15a – Reference Limits and Evaluation Table – Groundwater

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
VOCs/EPA 8260	1,1,1,2-Tetrachloroethane	630-20-6	µg/L	NE	Note 1	1.0	1.0	0.25
	1,1,1-Trichloroethane	71-55-6	µg/L	60	NMWQCC	1.0	1.0	0.25
	1,1,2,2-Tetrachloroethane	79-34-5	µg/L	NE	Note 1	1.0	1.0	0.25
	1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	µg/L	NE	Note 1	1.0	1.0	0.25
	1,1,2-Trichloroethane	79-00-5	µg/L	5	EPA MCL	1.0	1.0	0.25
	1,1-Dichloroethane	75-34-3	µg/L	25	NMWQCC	1.0	1.0	0.25
	1,1-Dichloroethene	75-35-4	µg/L	5	NMWQCC	1.0	1.0	0.25
	1,1-Dichloropropene	563-58-6	µg/L	NE	Note 1	1.0	1.0	0.25
	1,2,3-Trichlorobenzene	87-61-6	µg/L	NE	Note 1	2.0	2.0	0.5
	1,2,3-Trichloropropane	96-18-4	µg/L	NE	Note 1	2.0	2.0	0.5
	1,2,4-Trichlorobenzene	120-82-1	µg/L	70	EPA MCL	1.0	1.0	0.25
	1,2,4-Trimethylbenzene	95-63-6	µg/L	NE	Note 1	1.0	1.0	0.25
	1,3,5-Trimethylbenzene	108-67-8	µg/L	NE	Note 1	1.0	1.0	0.25
	1,2-Dibromo-3-Chloroprpane	96-12-8	µg/L	NE	Note 1	2.0	2.0	0.5
	1,2-Dibromoethane	106-93-4	µg/L	NE	Note 1	1.0	1.0	0.25
	1,2-Dichlorobenzene	95-50-1	µg/L	600	EPA MCL	1.0	1.0	0.25
	1,2-Dichloroethane	107-06-2	µg/L	5	EPA MCL	1.0	1.0	0.25
	1,2-Dichlorpropane	78-87-5	µg/L	5	EPA MCL	1.0	1.0	0.25
	1,3-Dichlorobenzene	541073-1	µg/L	NE	Note 1	1.0	1.0	0.25
	1,3-Dichloropropane	142-28-9	µg/L	NE	Note 1	1.0	1.0	0.25
	1,4-Dichlorobenzene	106-46-7	µg/L	75	EPA MCL	1.0	1.0	0.25
	1-Chlorohexane	544-10-5	µg/L	NE	Note 1	2.0	2.0	0.5
	2,2-Dichloropropane	594-20-7	µg/L	NE	Note 1	1.0	1.0	0.25

QAPP Worksheet #15a – Reference Limits and Evaluation Table – Groundwater (Continued)

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
VOCs/EPA 8260	2-Butanone	78-93-3	µg/L	NE	Note 1	10	10	2.5
	2-Chloro Vinyl Ether		µg/L	NE	Note 1	5.0	5.0	1.25
	2-Chlorotoluene	95-49-8	µg/L	NE	Note 1	1.0	1.0	0.25
	2-Hexanone	591-78-6	µg/L	NE	Note 1	5.0	5.0	1.25
	4-Chlorotoluene	166-43-4	µg/L	NE	Note 1	1.0	1.0	0.25
	4-Methyl-2-Pentanone	108-10-1	µg/L	NE	Note 1	5.0	5.0	1.25
	Acetone	67-64-1	µg/L	NE	Note 1	10	10	2.5
	Acrolein	107-02-8	µg/L	NE	Note 1	5.0	5.0	1.25
	Acrylonitrile	107-13-1	µg/L	NE	Note 1	10	10	2.5
	Benzene	71-43-2	µg/L	5	EPA MCL	1.0	1.0	0.25
	Bromobenzene	108-86-1	µg/L	NE	Note 1	1.0	1.0	0.25
	Bromochloromethane	74-97-5	µg/L	NE	Note 1	1.0	1.0	0.25
	Bromodichloromethane	75-27-4	µg/L	NE	Note 1	1.0	1.0	0.25
	Bromoform	75-25-2	µg/L	NE	Note 1	2.0	2.0	0.5
	Bromomethane	74-83-9	µg/L	NE	Note 1	1.0	1.0	0.25
	Carbon Disulfide	75-15-0	µg/L	NE	Note 1	1.0	1.0	0.25
	Carbon Tetrachloride	56-23-5	µg/L	5	EPA MCL	1.0	1.0	0.25
	Chlorobenzene	108-90-7	µg/L	100	EPA MCL	1.0	1.0	0.25
	Chloroethane	75-00-3	µg/L	NE	Note 1	1.0	1.0	0.25
	Chloroform	67-66-3	µg/L	100	NMWQCC	1.0	1.0	0.25
	Chloromethane	74-87-3	µg/L	NE	Note 1	1.0	1.0	0.25
	cis-1,2-Dichloroethene	156-59-2	µg/L	70	EPA MCL	1.0	1.0	0.25

QAPP Worksheet #15a – Reference Limits and Evaluation Table – Groundwater

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
VOCs/EPA 8260	cis-1,3-Dichloropropene	10061-01-5	µg/L	NE	Note 1	1.0	1.0	0.25
	Cyclohexane	110-82-7	µg/L	NE	Note 1	1.0	1.0	0.25
	Dibromochloromethane	74-95-3	µg/L	NE	Note 1	1.0	1.0	0.25
	Dibromomethane	74-95-3	µg/L	NE	Note 1	1.0	1.0	0.25
	Dichlorodifluoromethane	75-71-8	µg/L	NE	Note 1	1.0	1.0	0.25
	Di-Isopropyl Ether	108-203	µg/L	NE	Note 1	1.0	1.0	0.25
	Ethyl tert-Butyl Ether	637-92-3-	µg/L	NE	Note 1	1.0	1.0	0.25
	Ethyl Methacrylate	97-63-2	µg/L	NE	Note 1	1.0	1.0	0.25
	Ethylbenzene	100-41-4	µg/L	700	EPA MCL	1.0	1.0	0.25
	Hexachlorobutadiene	87-68-3	µg/L	NE	Note 1	1.0	1.0	0.25
	Iodomethane	74-88-4	µg/L	NE	Note 1	1.0	1.0	0.25
	Isopropylbenzene	98-82-8	µg/L	NE	Note 1	1.0	1.0	0.25
	Methyl Acetate	79-209	µg/L	NE	Note 1	2.0	2.0	0.5
	Methyl Methacrylate	80-62-6	µg/L	NE	Note 1	1.0	1.0	0.25
	Methyl tert-Butyl Ether	1634-04-4	µg/L	NE	Note 1	1.0	1.0	0.25
	Methylcyclohexane	108-87-2	µg/L	NE	Note 1	1.0	1.0	0.25
	Methylene Chloride	75-09-2	µg/L	5	EPA MCL	1.0	1.0	0.25
	Naphthalene	91-20-3	µg/L	NE	Note 1	1.0	1.0	0.25
	n-Butylbenzene	104-51-8	µg/L	NE	Note 1	1.0	1.0	0.25
	n-Propylbenzene	103-65-1	µg/L	NE	Note 1	1.0	1.0	0.25
	p-Isopropyltoluene	99-87-6	µg/L	NE	Note 1	1.0	1.0	0.25
	sec-Butylbenzene	135-98-8	µg/L	NE	Note 1	1.0	1.0	0.25

QAPP Worksheet #15a – Reference Limits and Evaluation Table – Groundwater (Continued)

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
VOCs/EPA 8260	Styrene	100-42-5	µg/L	NE	Note 1	1.0	1.0	0.25
	t-Butyl Alcohol	75-65-0	µg/L	NE	Note 1	5.0	5.0	1.25
	tert-Amyl Methyl Ether	994-05-8	µg/L	NE	Note 1	10	10	2.5
	tert-Butylbenzene	98-06-6	µg/L	NE	Note 1	1.0	1.0	0.25
	Tetrachloroethene	127-18-4	µg/L	5	EPA MCL	1.0	1.0	0.25
	Tetrahydrofuran	109-99-9	µg/L	NE	Note 1	5.0	5.0	1.25
	Toluene	108-88-3	µg/L	750	NMWQCC	1.0	1.0	0.25
	trans-1,2-Dichloroethene	156-60-5	µg/L	100	EPA MCL	1.0	1.0	0.25
	trans-1,3-Dichloropropene	10061-02-6	µg/L	NE	Note 1	1.0	1.0	0.25
	Trichloroethene	79-01-6	µg/L	5	EPA MCL	1.0	1.0	0.25
	Trichlorofluoromethane	75-69-4	µg/L	NE	Note 1	1.0	1.0	0.25
	Vinyl Acetate	108-05-4	µg/L	NE	Note 1	5.0	5.0	1.25
	Vinyl Chloride	75-01-4	µg/L	2	EPA MCL	1.0	1.0	0.25
	Xylenes	1330-20-7	µg/L	620	NMWQCC	3.0	3.0	0.75
EDB/EPA 8011	Ethylene dibromide	1832-54-8	µg/L	0.05	EPA MCL	0.030	0.030	0.010
TPH/EPA 8015	TPH as Gasoline (C6-C10)	2691-41-0	µg/L	NE	Note 1	50	50	150
	TPH Diesel (C10-C28)	121-82-4	µg/L	NE	Note 1	100	100	100
VPH/MA DEP	C5-C8 Alphatics	NA	µg/L	NE	Note 1	100	100	100
	C9-C12 Alphatics	NA	µg/L	NE	Note 1	100	100	100

QAPP Worksheet #15a – Reference Limits and Evaluation Table – Groundwater (Continued)

Analytical Group/ Method	Analyte	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
EPH/MA DEP	C12-C40 Alphatics	NA	µg/L	NE	Note 1	100	100	100
SVOC/EPA 8270	1-Methylnaphthalene	90-12-0	µg/L	NE	Note 1	5.00	5.00	1.25
	1,1'-Biphenyl	92-52-4	µg/L	NE	Note 1	5.00	5.00	1.25
	1,2,4,5-Tetrachlorobenzene	95-94-3	µg/L	NE	Note 1	5.00	5.00	1.25
	1,2,4-Trichlorobenzene	120-82-1	µg/L	NE	Note 1	5.00	5.00	1.25
	1,2-Dichlorobenzene	95-50-1	µg/L	600	EPA MCL	5.00	5.00	1.25
	1,2-Diphenylhydrazine	122-66-7	µg/L	NE	Note 1	5.00	5.00	1.25
	1,3-Dichlorobenzene	541-73-1	µg/L	NE	Note 1	5.00	5.00	1.25
	1,4-Dichlorobenzene	106-46-7	µg/L	75	EPA MCL	5.00	5.00	1.25
	2,3,4,6-Tetrachlorophenol	58-90-2	µg/L	NE	Note 1	5.00	5.00	1.25
	2,4,5-Trichlorophenol	95-95-4	µg/L	NE	Note 1	5.00	5.00	1.25
	2,4,6-Trichlorophenol (TCP)	88-06-2	µg/L	NE	Note 1	5.00	5.00	1.25
	2,4-Dichlorophenol (DCP)	120-83-2	µg/L	NE	Note 1	5.00	5.00	1.25
	2,4-Dimethylphenol	105-67-9	µg/L	NE	Note 1	20.0	20.0	5.00
	2,4-Dinitrophenol	51-28-5	µg/L	NE	Note 1	50.0	50.0	12.5
	2,4-Dinitrotoluene (DNT)	121-14-2	µg/L	NE	Note 1	5.00	5.00	1.25
	2,6-Dinitrotoluene	606-20-2	µg/L	NE	Note 1	5.00	5.00	1.25
	2-Chloronaphthalene	91-58-7	µg/L	NE	Note 1	5.00	5.00	1.25
	2-Chlorophenol	95-57-8	µg/L	NE	Note 1	5.00	5.00	1.25
	2-Methylnaphthalene	91-57-6	µg/L	NE	Note 1	5.00	5.00	1.25
	2-Methylphenol (o-Cresol)	95-48-7	µg/L	NE	Note 1	5.00	5.00	1.25
	2-Nitroaniline	88-74-4	µg/L	NE	Note 1	20.0	20.0	5.00

QAPP Worksheet #15a – Reference Limits and Evaluation Table – Groundwater (Continued)

Analytical Group/ Method	Analyte	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
SVOC/EPA 8270	2-Nitrophenol (ONP)	88-75-5	µg/L	NE	Note 1	5.00	5.00	1.25
	3,3'-Dichlorobenzidine (DCB)	91-94-1	µg/L	NE	Note 1	5.00	5.00	1.25
	3-Methylphenol	108-39-4	µg/L	NE	Note 1	5.00	5.00	1.25
	3-Nitroaniline	99-09-2	µg/L	NE	Note 1	20.0	20.0	5.00
	4,6-Dinitro-2-methylphenol (DNOC)	534-52-1	µg/L	NE	Note 1	20.0	20.0	5.00
	4-Bromophenyl phenyl ether	101-55-3	µg/L	NE	Note 1	5.00	5.00	1.25
	4-Chloro-3-methylphenol	59-50-7	µg/L	NE	Note 1	5.00	5.00	1.25
	4-Chloroaniline	106-47-8	µg/L	NE	Note 1	5.00	5.00	1.25
	4-Chlorophenyl phenyl ether	7005-72-3	µg/L	NE	Note 1	5.00	5.00	1.25
	4-Methylphenol (p-Cresol)	106-44-5	µg/L	NE	Note 1	5.00	5.00	1.25
	4-Nitroaniline (PNA)	100-01-6	µg/L	NE	Note 1	20.0	20.0	5.00
	4-Nitrophenol (PNP)	100-02-7	µg/L	NE	Note 1	20.0	20.0	5.00
	Acenaphthene	83-32-9	µg/L	NE	Note 1	5.00	5.00	1.25
	Acenaphthylene	208-96-8	µg/L	NE	Note 1	5.00	5.00	1.25
	Acetaphenone	98-86-2	µg/L	NE	Note 1	5.00	5.00	1.25
	Aniline	62-53-3	µg/L	NE	Note 1	5.00	5.00	1.25
	Anthracene	120-12-7	µg/L	NE	Note 1	5.00	5.00	1.25
	Benzidine	92-87-5	µg/L	NE	Note 1	50.0	50.0	12.5
	Benzo(a)anthracene	56-55-3	µg/L	NE	Note 1	5.00	5.00	1.25
	Benzo(a)pyrene	50-32-8	µg/L	0.2	EPA MCL	5.00	5.00	1.25

QAPP Worksheet #15a – Reference Limits and Evaluation Table – Groundwater (Continued)

Analytical Group/ Method	Analyte	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific RL	Laboratory-Specific MDL
SVOC/EPA 8270	Benzo(b)fluoranthene	205-99-2	µg/L	NE	Note 1	5.00	5.00	1.25
	Benzo(g,h,i)perylene	191-24-2	µg/L	NE	Note 1	5.00	5.00	1.25
	Benzo(k)fluoranthene	207-08-9	µg/L	NE	Note 1	5.00	5.00	1.25
	Benzoic Acid	65-85-0	µg/L	NE	Note 1	50.0	50.0	12.5
	Benzyl alcohol	100-51-6	µg/L	NE	Note 1	5.00	5.00	1.25
	bis(2-Chloroethoxy)methane	111-91-1	µg/L	NE	Note 1	5.00	5.00	1.25
	bis(2-Chloroethyl)ether (BCEE)	111-44-4	µg/L	NE	Note 1	5.00	5.00	1.25
	Bis(2-chloroisopropyl)ether, or 2,2'-oxybis (1-Chloropropane)	108-60-1	µg/L	NE	Note 1	5.00	5.00	1.25
	bis(2-Ethylhexyl)phthalate (BEHP)	117-81-7	µg/L	NE	Note 1	5.00	5.00	1.25
	Butyl benzyl phthalate (BBP)	85-68-7	µg/L	NE	Note 1	5.00	5.00	1.25
	Carbazole	86-74-8	µg/L	NE	Note 1	5.00	5.00	1.25
	Chrysene	218-01-9	µg/L	NE	Note 1	5.00	5.00	1.25
	Dibenz(a,h)anthracene	53-70-3	µg/L	NE	Note 1	5.00	5.00	1.25
	Dibenzofuran (DBF)	132-64-9	µg/L	NE	Note 1	5.00	5.00	1.25
	Diethyl phthalate (DEP)	84-66-2	µg/L	NE	Note 1	5.00	5.00	1.25
	Dimethyl phthalate (DMP)	131-11-3	µg/L	NE	Note 1	5.00	5.00	1.25
	Di-n-butyl phthalate (DBP)	84-74-2	µg/L	NE	Note 1	5.00	5.00	1.25
	Di-n-octyl phthalate (DNOP)	117-84-0	µg/L	NE	Note 1	5.00	5.00	1.25
	Fluoranthene	206-44-0	µg/L	NE	Note 1	5.00	5.00	1.25
	Fluorene	86-73-7	µg/L	NE	Note 1	5.00	5.00	1.25
	Hexachlorobenzene (HCB)	118-74-1	µg/L	1.0	EPA MCL	5.00	5.00	1.25

QAPP Worksheet #15a – Reference Limits and Evaluation Table – Groundwater (Continued)

Analytical Group/ Method	Analyte	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
SVOC/EPA 8270	Hexachlorobutadiene (HCBD)	87-68-3	µg/L	NE	Note 1	5.00	5.00	1.25
	Hexachlorocyclopentadiene (HCCPD)	77-47-4	µg/L	50	EPA MCL	5.00	5.00	1.25
	Hexachloroethane (HCE)	67-72-1	µg/L	NE	Note 1	5.00	5.00	1.25
	Indeno(1,2,3-cd)pyrene	193-39-5	µg/L	NE	Note 1	5.00	5.00	1.25
	Isophorone	78-59-1	µg/L	NE	Note 1	5.00	5.00	1.25
	Hexachlorobutadiene (HCBD)	87-68-3	µg/L	NE	Note 1	5.00	5.00	1.25
	Naphthalene	91-20-3	µg/L	NE	Note 1	5.00	5.00	1.25
	Nitrobenzene	98-95-3	µg/L	NE	Note 1	5.00	5.00	1.25
	N-Nitrosodimethylamine	62-75-9	µg/L	NE	Note 1	5.00	5.00	1.25
	N-Nitroso-di-n-propylamine (NDPA)	621-64-7	µg/L	NE	Note 1	5.00	5.00	1.25
	N-nitrosodiphenylamine (NDPHA)	86-30-6	µg/L	NE	Note 1	5.00	5.00	1.25
	Pentachlorophenol	87-86-5	µg/L	1.0	EPA MCL	20.0	20.0	5.0
	Phenanthrene	85-01-8	µg/L	NE	Note 1	5.00	5.00	1.25
	Phenol	108-95-2	µg/L	NE	Note 1	5.00	5.00	1.25
	Pyrene	129-00-0	µg/L	NE	Note 1	5.00	5.00	1.25
	Pyridine	110-86-1	µg/L	NE	Note 1	5.00	5.00	1.25
Metals/EPA 6010	Dissolved Iron (field filtered)	2691-41-0	µg/L	300	EPA MCL	100	100	30
	Dissolved Manganese (field filtered)	121-82-4	µg/L	50	EPA MCL	15	15	3.0
	Total Lead	99-35-4	µg/L	15	EPA MCL	3.0	3.0	1.5
Cations/EPA 6010	Sodium	99-65-0	µg/L	NE	Note1	5,000	5,000	1,000
	Potassium	479-45-8	µg/L	NE	Note1	5,000	5,000	1,000

QAPP Worksheet #15a – Reference Limits and Evaluation Table – Groundwater (Continued)

Analytical Group/ Method	Analyte	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
Cation/EPA 6010	Calcium	98-95-3	µg/L	NE	Note1	5,000	5,000	1,000
	Magnesium	118-96-7	µg/L	NE	Note1	5,000	5,000	1,000
Anions//EPA 300.0	Nitrate	14797-55-8	mg/L	10	EPA MCL and NMWQCC	0.20	0.20	0.0330
	Sulfate	14808-79-8	mg/L	250	EPA MCL	2.0	2.0	0.330
	Nitrite	14797-65-0	mg/L	1	EPA MCL	0.20	0.20	0.0330
	Chloride	16887-006	mg/L	250	EPA MCL and NMWQCC	5.00	5.00	0.170
Alkalinity/ SM2320B	Alkalinity	NA	mg/L	NE	Note 1	5.00	5.00	1.0
Ammonia/SM 4500B, D	Ammonia	7664-41-7	mg/L	NE	Note 1	5.00	5.00	0.11
Sulfide/SM4 500 S-2CF	Total Sulfide	18496-25-8	mg/L	NE	Note 1	5.00	5.00	0.80
TKN/EPA 351.4	TKN	NA	mg/L	NE	Note 1	1.5	1.5	0.50
O-Phosphorous/ SM 4500 PE	O-Phosphorous	14265-44-2	mg/L	NE	Note 1	0.040	0.040	0.010
TOC/EPA 9060	TOC	NA	mg/L	NE	Note 1	5.00	5.00	0.25

QAPP Worksheet #15a – Reference Limits and Evaluation Table – Groundwater (Continued)

Analytical Group/ Method	Analyte	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
Dissolved Gases RSK 175	Methane	9004-70-0	µg/L	NE	Note 1	20.0	20.0	1.0
	Ethane	14797-14-0	µg/L	NE	Note 1	5.00	5.00	1.0
	Ethene	74-85-1	µg/L	NE	Note 1	5.00	5.00	1.0
Stable Isotopes/ Laboratory SOP	Stable carbon and hydrogen isotopes	NA	$^{0}/_{00}$	NE	Note 1	NA	NA	NA

Note(s) for project comparison limit reference:

MCL: Maximum Contaminant Level, EPA National Primary Drinking Water Regulations.

NMWQCC: New Mexico Water Quality Control Commission Standards, New Mexico Administrative Code, Attachment 4, Title 20 Environmental Protection, Chapter 6- Water Quality, Part 2- Ground and Surface Water Protection.

Note 1: Project comparison limits not established.

In accordance with the DoD QSM requirements, the most current version of the EPA methods will be implemented for each sampling event.

CAS denotes Chemical Abstract Service.

MDL denote method detection limit.

NE denotes not established.

Stable isotopes will be expressed as $^{13}C/^{12}C$ *as* CO_2 *and* $^{2}H/^{1}H$ *as* H_2

QAPP Worksheet #15b – Reference Limits and Evaluation Table – Soil Gas

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
VOCs/TPH/EPA TO15	1,1,1-Trichloroethane	71-55-6	ppbv	NE	Note 1	1	1	0.33
	1,1,2,2-Tetrachloroethane	79-34-5	ppbv	NE	Note 1	1	1	0.42
	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	ppbv	NE	Note 1	1	1	0.31
	1,1,2-Trichloroethane	79-00-5	ppbv	NE	Note 1	0.5	0.5	0.23
	1,1-Dichloroethane	75-34-3	ppbv	NE	Note 1	1	1	0.38
	1,1-Dichloroethene	75-35-4	ppbv	NE	Note 1	2	2	0.65
	1,2,4-Trichlorobenzene	120-82-1	ppbv	NE	Note 1	2	2	0.52
	1,2,4-Trimethylbenzene	95-63-6	ppbv	NE	Note 1	1	1	0.42
	1,2-Dibromoethane	106-93-4	ppbv	NE	Note 1	0.5	0.5	0.19
	1,2-Dichlorobenzene	95-50-1	ppbv	NE	Note 1	1	1	0.37
	1,2-Dichloroethane	594-20-7	ppbv	NE	Note 1	1	1	0.33
	1,2-Dichloropropane	78-87-5	ppbv	NE	Note 1	0.5	0.5	0.23
	1,3,5-Trimethylbenzene	108-67-8	ppbv	NE	Note 1	1	1	0.38
	1,3-Butadiene	106-99-0	ppbv	NE	Note 1	3	3	1.34
	1,3-Dichlorobenzene	541-73-1	ppbv	NE	Note 1	1	1	0.36
	1,4-Dichlorobenzene	106-46-7	ppbv	NE	Note 1	1	1	0.45
	1,4-Dioxane	123-91-1	ppbv	NE	Note 1	5	5	1.8
	2-Butanone	78-93-3	ppbv	NE	Note 1	2	2	0.54
	2-Hexanone	591-78-6	ppbv	NE	Note 1	5	5	2.16
	2-Propanol	67-63-0	ppbv	NE	Note 1	1	1	0.44
	4-Methyl-2-pentanone	108-10-1	ppbv	NE	Note 1	5	5	1.07

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
	Acetone	67-64-1	ppbv	NE	Note 1	2	2	0.44

Worksheet #15b – Reference Limits and Evaluation Table – Soil Gas (Continued)

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
VOCs/TPH/EPA TO-15	Benzene	71-43-2	ppbv	NE	Note 1	1	1	0.39
	Benzyl chloride	100-44-7	ppbv	NE	Note 1	1	1	0.54
	Bromodichloromethane	75-27-4	ppbv	NE	Note 1	0.5	0.5	0.21
	Bromoform	75-25-2	ppbv	NE	Note 1	1	1	0.41
	Bromomethane	74-83-9	ppbv	NE	Note 1	2	2	0.71
	Carbon disulfide	75-15-0	ppbv	NE	Note 1	2	2	0.41
	Carbon tetrachloride	56-23-5	ppbv	NE	Note 1	1	1	0.35
	Chlorobenzene	108-90-7	ppbv	NE	Note 1	1	1	0.39
	Chlorodibromomethane	124-48-1	ppbv	NE	Note 1	1	1	0.34
	Chloroethane	75-00-3	ppbv	NE	Note 1	1	1	0.49
	Chloroform	67-66-3	ppbv	NE	Note 1	1	1	0.3
	Chloromethane	74-87-3	ppbv	NE	Note 1	2	2	0.68
	cis-1,2-Dichloroethene	156-59-2	ppbv	NE	Note 1	1	1	1
	cis-1,3-dichloropropene	10061-01-5	ppbv	NE	Note 1	0.5	0.5	0.24
	Cyclohexane	110-82-7	ppbv	NE	Note 1	1	1	0.37
	Dichlorodifluoromethane	75-71-8	ppbv	NE	Note 1	1	1	0.4
	Ethanol	64-17-5	ppbv	NE	Note 1	1	1	0.53
	Ethyl acetate	141-78-6	ppbv	NE	Note 1	1	1	0.55
	Ethylbenzene	100-41-4	ppbv	NE	Note 1	1	1	0.35
	Heptane	142-82-5	ppbv	NE	Note 1	1	1	0.37
	Hexachlorobutadiene	87-68-3	ppbv	NE	Note 1	2	2	0.54

Worksheet #15b – Reference Limits and Evaluation Table – Soil Gas (Continued)

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
VOCs/TPH/EPA TO-15	m,p-Xylene	179601-23-1	ppbv	NE	Note 1	2	2	0.75
	Methylene chloride	75-09-2	ppbv	NE	Note 1	2	2	0.31
	n-Hexane	110-54-3	ppbv	NE	Note 1	1	1	0.31
	o-Xylene	95-47.6	ppbv	NE	Note 1	1	1	0.39
	Propylene	115-07-1	ppbv	NE	Note 1	1	1	0.37
	Styrene	100-42-5	ppbv	NE	Note 1	1	1	0.43
	tert-Butyl Methyl Ether	1634-04-4	ppbv	NE	Note 1	2	2	0.61
	Tetrachloroethene	127-18-4	ppbv	NE	Note 1	0.5	0.5	0.21
	Tetrahydrofuran	109-99-9	ppbv	NE	Note 1	2	2	0.58
	Toluene	108-88-3	ppbv	NE	Note 1	0.5	0.5	0.24
	trans-1,2-Dichloroethene	156-60-5	ppbv	NE	Note 1	1	1	0.38
	trans-1,3-dichloropropene	10061-02-6	ppbv	NE	Note 1	1	1	0.31
	Trichloroethene	79-01-6	ppbv	NE	Note 1	1	1	0.35
	Trichlorofluoromethane	75-69-4	ppbv	NE	Note 1	1	1	0.31
	Vinyl acetate	108-05-4	ppbv	NE	Note 1	1	1	0.31
	Vinyl chloride	75-01-4	ppbv	NE	Note 1	1	1	0.41
	Xylenes, Total	1330-20-7	ppbv	NE	Note 1	3	3	1.14
VOC/TPH/EPA TO15	C5-C12, range	NA	ppbv	NE	Note 1	50	50	50

Worksheet #15b – Reference Limits and Evaluation Table – Soil Gas (Continued)

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
APH/Method MA DEP	C5-C8 Aliphatic	NA	Ppbv	NE	Note 1	50	50	50
	C9-C12 Aliphatic	NA	ppbv	NE	Note 1	50	50	50
	Benzene	71-43-2	ppbv	NE	Note 1	1	1	.39
	Toluene	108-88-3	ppbv	NE	Note 1	0.5	0.5	.24
	Ethylbenzene	100-41-4	ppbv	NE	Note 1	1	1	.35
	Xylenes	1330-20-7	ppbv	NE	Note 1	3	3	1.14
	Naphthalene	91-20-3	ppbv	NE	Note 1	5	5	5
Fixed Gases/ASTM D2504	Oxygen	7782-44-7	%	NE	Note 1	0.1	0.1	0.1
	Nitrogen	7727-37-9	%	NE	Note 1	0.1	0.1	0.1
	Carbon Monoxide	630-08-0	%	NE	Note 1	0.1	0.1	0.1
	Carbon Dioxide	124-38-9	%	NE	Note 1	0.1	0.1	0.1
	Methane	74-82-8	%	NE	Note 1	0.5	0.5	0.5

Note 1: Project comparison limits not established.

In accordance with the DoD QSM requirements, the most current version of the EPA methods will be implemented for each sampling event.

CAS denotes Chemical Abstract Service.

MDL denote method detection limit.

NE denotes not established.

QAPP Worksheet #15c – Reference Limits and Evaluation Table – Soil

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
VOCs/EPA 8260	Acetone	67-64-1	µg/kg	2.81E07	NM SSL	5.0	5.0	1.06
	Acrolein	107-02-8	µg/kg	150	EPA SSL	25	25	2.00
	Acrylonitrile	75-05-8	µg/kg	4.27E03	NM SSL	25	25	1.07
	Benzene	71-43-2	µg/kg	1100	EPA SSL	2.0	2.0	0.137
	Bromobenzene	108-86-1	µg/kg	3.7E04	NM SSL	2.0	2.0	0.301
	Bromochloromethane	74-97-5	µg/kg	NE	Note 1	2.0	2.0	0.386
	Bromodichloromethane	75-27-4	µg/kg	270	EPA SSL	2.0	2.0	0.150
	Bromoform	75-25-2	µg/kg	6.1E04	EPA SSL	2.0	2.0	0.231
	Bromomethane	74-83-9	µg/kg	7.3E03	EPA SSL	2.0	2.0	1.46
	2-Butanone (MEK)	78-93-3	µg/kg	2.8E07	EPA SSL	5.0	5.0	0.603
	n-Butylbenzene	104-51-8	µg/kg	6.21E04	NM SSL	2.0	2.0	0.349
	sec-Butylbenzene	135-98-8	µg/kg	6.06E04	NM SSL	2.0	2.0	0.251
	tert-Butylbenzene	98-06-6	µg/kg	1.6E05	NM SSL	2.0	2.0	0.237
	Carbon disulfide	75-15-0	µg/kg	4.6E05	NM SSL	2.0	2.0	0.465
	Carbon tetrachloride	56-23-5	µg/kg	610	EPA SSL	2.0	2.0	0.236
	Chlorobenzene	108-90-7	µg/kg	1.94E05	NM SSL	2.0	2.0	0.188
	Chlorodibromomethane	124-48-1	µg/kg	680	EPA SSL	2.0	2.0	0.140
	Chloroethane	75-00-3	µg/kg	6.33E04	NM SSL	2.0	2.0	0.659
	Chloroform	67-66-3	µg/kg	290	EPA SSL	2.0	2.0	0.246
	Chloromethane	74-87-3	µg/kg	2.81E04	NM SSL	2.0	2.0	0.757
	2-Chlorotoluene	95-49-8	µg/kg	2.02E05	NM SSL	2.0	2.0	0.264
	4-Chlorotoluene	106-43-4	µg/kg	5.5E06	EPA SSL	2.0	2.0	0.306

QAPP Worksheet #15c – Reference Limits and Evaluation Table – Soil (Continued)

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
VOCs/EPA 8260	1,2-Dibromo-3-chloropropane	96-12-8	µg/kg	5.4	EPA SSL	2.0	2.0	0.801
	1,2-Dibromoethane	106-93-4	µg/kg	34	EPA SSL	2.0	2.0	0.239
	Dibromomethane	74-95-3	µg/kg	2.5E04	EPA SSL	2.0	2.0	0.314
	1,2-Dichlorobenzene	95-50-1	µg/kg	3.74E04	NM SSL	2.0	2.0	0.325
	1,3-Dichlorobenzene	541-73-1	µg/kg	3.26E04	NM SSL	2.0	2.0	0.319
	1,4-Dichlorobenzene	106-46-7	µg/kg	2.4E03	EPA SSL	2.0	2.0	0.411
	Dichlorodifluoromethane	75-71-8	µg/kg	1.61E05	NM SSL	2.0	2.0	0.111
	1,1-Dichloroethane	75-34-3	µg/kg	3.3E03	EPA SSL	2.0	2.0	0.332
	1,2-Dichloroethane	107-06-2	µg/kg	430	EPA SSL	2.0	2.0	0.131
	1,1-Dichloroethene	75-35-4	µg/kg	2.06E05	NM SSL	2.0	2.0	0.667
	cis-1,2-Dichloroethene	156-59-2	µg/kg	7.65E04	NM SSL	2.0	2.0	0.172
	trans-1,2-Dichloroethene	156-60-5	µg/kg	1.12E05	NM SSL	2.0	2.0	0.202
	1,2-Dichloropropane	78-87-5	µg/kg	890	EPA SSL	2.0	2.0	0.108
	1,3-Dichloropropane	142-28-9	µg/kg	1.2E04	NM SSL	2.0	2.0	0.179
	2,2-Dichloropropane	594-20-7	µg/kg	NE	Note 1	2.0	2.0	1.16
	1,1-Dichloropropene	563-58-6	µg/kg	NE	Note 1	2.0	2.0	0.208
	cis-1,3-Dichloropropene	10061-01-5	µg/kg	NE	Note 1	2.0	2.0	0.145
	trans-1,3-Dichloropropene	10061-02-6	µg/kg	NE	Note 1	2.0	2.0	0.220
	Ethylbenzene	100-41-4	µg/kg	5.4E03	EPA SSL	2.0	2.0	0.206
	Hexachlorobutadiene	87-68-3	µg/kg	6.2E03	EPA SSL	2.0	2.0	0.233
	2-Hexanone	591-78-6	µg/kg	2.1E05	EPA SSL	5.0	5.0	0.339
	Isopropylbenzene	98-82-8	µg/kg	2.71E05	NM SSL	2.0	2.0	0.195

QAPP Worksheet #15c – Reference Limits and Evaluation Table – Soil (Continued)

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
VOCs/EPA 8260	p-Isopropyltoluene	99-87-6	µg/kg	NE	Note 1	2.0	2.0	0.266
	Methylene chloride	75-09-2	µg/kg	1.1E04	EPA SSL	5.0	5.0	0.348
	Methyl-tert-butyl ether	1634-04-4	µg/kg	4.3E04	EPA SSL	2.0	2.0	0.167
	4-Methyl-2-pentanone	108-10-1	µg/kg	5.3E06	EPA SSL	5.0	5.0	0.341
	Naphthalene	91-20-3	µg/kg	3.6	EPA SSL	2.0	2.0	0.825
	n-Propylbenzene	103-65-1	µg/kg	6.21E04	NM SSL	2.0	2.0	0.271
	Styrene	100-42-5	µg/kg	1.0E05	NM SSL	2.0	2.0	0.264
	1,1,1,2-Tetrachloroethane	630-20-6	µg/kg	1.9E03	EPA SSL	2.0	2.0	0.105
	1,1,2,2-Tetrachloroethane	79-34-5	µg/kg	560	EPA SSL	2.0	2.0	0.276
	Tetrachloroethene	127-18-4	µg/kg	550	EPA SSL	2.0	2.0	0.207
	Toluene	108-88-3	µg/kg	2.52E05	NM SSL	2.0	2.0	0.200
	1,2,3-Trichlorobenzene	87-61-6	µg/kg	4.9E04	EPA SSL	2.0	2.0	0.270
	1,2,4-Trichlorobenzene	120-82-1	µg/kg	2.2E04	EPA SSL	2.0	2.0	0.305
	1,1,1-Trichloroethane	71-55-6	µg/kg	5.63E05	NM SSL	2.0	2.0	0.231
	1,1,2-Trichloroethane	79-00-5	µg/kg	1.1E03	EPA SSL	2.0	2.0	0.235
	Trichloroethene	79-01-6	µg/kg	638	NM SSL	2.0	2.0	0.234
	Trichlorofluoromethane	75-69-4	µg/kg	5.88E05	NM SSL	2.0	2.0	0.134
	1,2,3-Trichloropropane	96-18-4	µg/kg	5	EPA SSL	2.0	2.0	0.347
	1,2,4-Trimethylbenzene	95-63-6	µg/kg	5.8E04	NM SSL	2.0	2.0	0.298
	1,3,5-Trimethylbenzene	108-67-8	µg/kg	2.48E04	NM SSL	2.0	2.0	0.241
	Vinyl acetate	108-05-4	µg/kg	9.7E05	EPA SSL	2.0	2.0	0.222
	Vinyl chloride	75-01-4	µg/kg	60	EPA SSL	2.0	2.0	0.135

QAPP Worksheet #15c – Reference Limits and Evaluation Table – Soil (Continued)

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
VOCs/EPA 8260	o-Xylene	95-47-6	µg/kg	9.95E04	NM SSL	2.0	2.0	0.189
	M,p-Xylene	136777-61-2	µg/kg	8.2E04	NM SSL	4.0	4.0	0.503
	Xylenes, total	1330-20-7	µg/kg	8.2E04	NM SSL	6.0	6.0	0.686
	1-Chlorohexane	544-10-5	µg/kg	NE	Note 1	2.0	2.0	0.141
VPH/MA DEP	C5-C8 Alphatics	NA	µg/kg	NE	Note 1	1,500	1,500	220
	C9-C12 Alphatics	NA	µg/kg	NE	Note 1	1,000	1,000	264
EPH/MA DEP	C9-C18 Alphatics	NA	µg/kg	NE	Note 1	20,000	20,000	1,926
	C19 –C36 Alphatics	NA	µg/kg	NE	Note 1	20,000	20,000	1,112
SVOC/EPA8270	Acenaphthene	83-32-9	µg/kg	3.4E06	EPA SSL	330	330	18.7
	Acenaphthylene	208-96-8	µg/kg	NE	Note 1	330	330	11.1
	Aniline	62-53-3	µg/kg	8.5E04	EPA SSL	330	330	17.7
	Anthracene	120-12-7	µg/kg	1.7E07	EPA SSL	330	330	11.6
	Benzo(a)anthracene	56-55-3	µg/kg	150	EPA SSL	330	330	14.1
	Benzo(b)fluoranthene	205-99-2	µg/kg	150	EPA SSL	330	330	10.3
	Benzo(k)fluoranthene	207-08-9	µg/kg	1.5E03	EPA SSL	330	330	15.1
	Benzo(g,h,i)perylene	191-24-2	µg/kg	NE	Note 1	330	330	9.12
	Benzo(a)pyrene	50-32-8	µg/kg	15	EPA SSL	330	330	19.0
	4-Bromophenyl-phenylether	101-55-3	µg/kg	NE	Note 1	330	330	29.1
	Butyl benzyl phthalate	85-68-7	µg/kg	2.6E05	EPA SSL	330	330	6.96
	Carbazole	86-74-8	µg/kg	NE	Note1	330	330	23.7
	4-Chloroaniline	106-47-8	µg/kg	2.4E03	EPA SSL	330	330	32.9
	4-Chloro-3-methylphenol	59-50-7	µg/kg	6.1E06	EPA SSL	330	330	26.0

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
	Bis(2-chloroethoxy)methane	111-91-1	µg/kg	1.8E05	EPA SSL	330	330	18.2
	bis(2-Chloroethyl)ether	111-44-4	µg/kg	210	EPA SSL	330	330	24.9

QAPP Worksheet #15c – Reference Limits and Evaluation Table – Soil (Continued)

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
SVOC/EPA8270	Bis(2-chloroisopropyl) ether	108-60-1	µg/kg	4.6E03	EPA	330	330	17.0
	2-Chloronaphthalene	91-58-7	µg/kg	3.99E06	NM SSL	330	330	17.9
	2-Chlorophenol	95-47-8	µg/kg	1.66E05	NM SSL	330	330	25.4
	4-Chlorophenyl-phenylether	7005-72-3	µg/kg	NE	Note 1	330	330	36.7
	Chrysene	218-01-9	µg/kg	1.5E04	EPA SSL	330	330	11.1
	Dibenzo(a,h)anthracene	53-70-3	µg/kg	15	EPA SSL	330	330	9.06
	Dibenzofuran	132-64-9	µg/kg	7.8E04	EPA SSL	330	330	11.4
	Di-n-butylphthalate	84-74-2	µg/kg	6.1E06	EPA SSL	330	330	7.97
	1,2-Dichlorobenzene	95-50-1	µg/kg	3.74E04	NM SSL	330	330	17.7
	1,3-Dichlorobenzene	541-73-1	µg/kg	3.26E04	NM SSL	330	330	18.5
	1,4-Dichlorobenzene	106-46-7	µg/kg	2.4E03	EPA SSL	330	330	10.4
	3,3'-Dichlorobenzidine	91-94-1	µg/kg	1.1E03	EPA SSL	660	660	211
	2,4-Dichlorophenol	120-83-2	µg/kg	1.8E05	EPA SSL	330	330	53.1
	2,6-Dichlorophenol	87-65-0	µg/kg	NE	Note 1	330	330	13.3
	Diethylphthalate	84-66-2	µg/kg	4.89E04	NM SSL	330	330	30.5
	2,4-Dimethylphenol	105-67-9	µg/kg	1.22E03	EPA SSL	330	330	42.0
	Dimethylphthalate	131-11-3	µg/kg	NE	Note 1	330	330	7.31
	2,4-Dinitrophenol	51-28-5	µg/kg	1.2E05	EPA SSL	1650	1650	177
	2,4-Dinitrotoluene	121-14-2	µg/kg	1.6E03	EPA SSL	330	330	46.5
	2,6-Dinitrotoluene	606-20-2	µg/kg	1.6E04	EPA SSL	330	330	19.5
	Di-n-octylphthalate	117-84-0	µg/kg	NE	Note 1	330	330	10.8
	Bis(2-ethylhexyl)phthalate	117-81-7	µg/kg	3.5E04	EPA SSL	330	330	12.7

QAPP Worksheet #15c – Reference Limits and Evaluation Table – Soil (Continued)

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
SVOC/EPA 8270	Fluoranthene	206-44-0	µg/kg	2.29E06	NM SSL	330	330	7.30
	Fluorene	86-73-7	µg/kg	2.3E06	NM SSL	330	330	10.1
	Hexachlorobenzene	118-74-1	µg/kg	300	EPA SSL	330	330	39.5
	Hexachlorobutadiene	87-68-3	µg/kg	6.2E03	EPA SSL	330	330	21.7
	Hexachlorocyclopentadiene	77-47-4	µg/kg	3.66E05	NM SSL	330	330	49.3
	Hexachloroethane	67-72-1	µg/kg	3.5E04	EPA SSL	330	330	49.0
	Indeno(1,2,3-cd)pyrene	193-39-5	µg/kg	150	EPA SSL	330	330	13.2
	Isophorone	78-59-1	µg/kg	5.1E05	EPA SSL	330	330	10.8
	2-Methyl-4,6-Dinitrophenol	534-52-1	µg/kg	4.9E03	EPA SSL	1650	1650	32.4
	2-Methylnaphthalene	91-57-6	µg/kg	3.1E05	EPA SSL	330	330	17.7
	2-Methylphenol	95-48-7	µg/kg	3.1E06	EPA SSL	330	330	10.1
	4-Methylphenol (and/or 3-Methylphenol)	1319-77-3	µg/kg	7.5E06	EPA SSL	330	330	58.1
	Naphthalene	91-20-3	µg/kg	3.6E06	EPA SSL	330	330	11.0
	2-Nitroaniline	88-74-4	µg/kg	6.1E05	EPA SSL	1650	1650	37.1
	3-Nitroaniline	99-09-2	µg/kg	NE	Note 1	1650	1650	40.3
	4-Nitroaniline	100-01-6	µg/kg	2.4E04	EPA SSL	1650	1650	61.6
	Nitrobenzene	98-95-3	µg/kg	4.8E03	EPA SSL	330	330	15.3
	2-Nitrophenol	88-75-5	µg/kg	NE	Note 1	330	330	15.1
	4-Nitrophenol	100-02-7	µg/kg	NE	Note 1	1650	1650	114
	N-Nitrosodiethylamine	55-18-5	µg/kg	0.77	EPA SSL	330	330	17.4
	N-Nitrosodimethylamine	62-75-9	µg/kg	2.3	EPA SSL	330	330	17.0

QAPP Worksheet #15c – Reference Limits and Evaluation Table – Soil (Continued)

Analytical Group/ Method	Analyte and Location	CAS Number	Units	Project Comparison Limit	Project Comparison Limit Reference	Project RL	Laboratory-Specific	
							RL	MDL
SVOC/EPA 8270	N-Nitrosodiphenylamine	86-30-6	µg/kg	9.9E04	EPA SSL	330	330	10.5
	N-Nitroso-di-n-propylamine	621-64-7	µg/kg	69	EPA SSL	330	330	16.7
	Pentachlorobenzene	608-93-5	µg/kg	4.89E04	NM SSL	330	330	26.4
	Pentachlorophenol	87-86-5	µg/kg	3.0E06	EPA SSL	1650	1650	27.0
	Phenanthrene	85-01-8	µg/kg	1.83E06	NM SSL	330	330	13.4
	Phenol	108-95-2	µg/kg	1.8E07	NM SSL	330	330	16.0
	Pyrene	129-00-0	µg/kg	1.7E06	EPA SSL	330	330	46.3
	Pyridine	110-86-1	µg/kg	7.8E04	EPA SSL	330	330	18.6
	1,2,4,5-Tetrachlorobenzene	95-94-3	µg/kg	1.8E04	EPA SSL	330	330	7.95
	2,3,4,6-Tetrachlorophenol	58-90-2	µg/kg	1.8E06	EPA SSL	330	330	13.5
	1,2,4-Trichlorobenzene	120-82-1	µg/kg	2.2E04	EPA SSL	330	330	22.0
	2,4,5-Trichlorophenol	95-95-4	µg/kg	6.1E06	EPA SSL	330	330	39.4
	2,4,6-Trichlorophenol	88-06-2	µg/kg	6.11E06	EPA SSL	330	330	51.8
	1,2-Diphenylhydrazine	122-66-7	µg/kg	610	EPA SSL	330	330	7.51
Lead/EPA 6010	Lead	7439-92-1	mg/kg	400	EPA and NM SSL	0.6	0.6	0.0662

Note:
NM SSL denotes New Mexico Soil Screening Level (New Mexico Environmental Department, Technical Background Document for Development of Soil Screening Levels, Revision 4.0, June 2006)
EPA SSL denotes EPA regional soil screening Level (May 2010)
Note 1: project comparison levels not established.

In accordance with the DoD QSM requirements, the most current version of the EPA methods will be implemented for each sampling event.

CAS denotes Chemical Abstract Service.

MDL denote method detection limit.
NE denotes not established.

QAPP Worksheet #16 – Project Schedule/Timeline Table

Activities	Organization	Dates		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
QAPP/SAP Preparation	Shaw	October	October 29, 2010	QAPP/SAP	October 29, 2010
QAPP/SAP Reviews	USACE	November	November	QAPP/SAP	November
First Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	January 2011	March 2011	First Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the first quarter groundwater, soil gas, and vapor data	Shaw	January 2011	March 2011	First Quarter Data Validation Report	within 60 days after collection of the last field sample
First quarter groundwater, soil gas, and vapor data submittal	Shaw	January 2011	March 2011	First Quarter ERMPIS Submittal	within 60 days after collection of the last field sample
Second Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	April 2011	June 2011	Second Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the second quarter groundwater, soil gas, and vapor data	Shaw	April 2011	June 2011	Second Quarter Data Validation Report	within 60 days after collection of the last field sample
Second quarter groundwater, soil gas, and vapor data submittal	Shaw	April 2011	June 2011	Second Quarter ERMPIS Submittal	within 60 days after collection of the last field sample
Third Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	July 2011	September 2011	Third Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the third quarter groundwater, soil gas and vapor data	Shaw	July 2011	September 2011	Third Quarter Data Validation Report	within 60 days after collection of the last field sample

QAPP Worksheet #16 – Project Schedule/Timeline Table (Continued)

Activities	Organization	Dates		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
Third quarter groundwater, soil gas, and vapor data submittal	Shaw	July 2011	September 2011	Third Quarter ERMPIS Submittal	within 60 days after collection of the last field sample
Fourth Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	October 2011	December 2011	Fourth Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the fourth quarter groundwater, soil gas, and vapor data	Shaw	October 2011	December 2011	Fourth Quarter Data Validation Report	within 60 days after collection of the last field sample
Fourth quarter groundwater, soil gas, and vapor data submittal	Shaw	October 2011	December 2011	Fourth Quarter ERMPIS Submittal	within 60 days after collection of the last field sample
First Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	January 2012	March 2012	First Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the first quarter groundwater, soil gas, and vapor data	Shaw	January 2012	March 2012	First Quarter Data Validation Report	within 60 days after collection of the last field sample
First quarter groundwater, soil gas, and vapor data submittal	Shaw	January 2012	March 2012	First Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
Second Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	April 2012	June 2012	Second Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the second quarter groundwater, soil gas, and vapor data	Shaw	April 2012	June 2012	Second Quarter Data Validation Report	within 60 days after collection of the last field sample

QAPP Worksheet #16 – Project Schedule/Timeline Table (Continued)

Activities	Organization	Dates		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
Second quarter groundwater, soil gas, and vapor data submittal	Shaw	April 2012	June 2012	Second Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
Third Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	July 2012	September 2012	Third Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the third quarter groundwater, soil gas and vapor data	Shaw	July 2012	September 2012	Third Quarter Data Validation Report	within 60 days after collection of the last field sample
Third quarter groundwater, soil gas, and vapor data submittal	Shaw	July 2012	September 2012	Third Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
Fourth Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	October 2012	December 2012	Fourth Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the fourth quarter groundwater, soil gas, vapor data	Shaw	October 2012	December 2012	Fourth Quarter Data Validation Report	within 60 days after collection of the last field sample
Fourth quarter groundwater, soil gas, and vapor data submittal	Shaw	October 2012	December 2012	Fourth Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
First Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	January 2013	March 2013	First Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the first quarter groundwater, soil gas, and vapor data	Shaw	January 2013	March 2013	First Quarter Data Validation Report	within 60 days after collection of the last field sample

QAPP Worksheet #16 – Project Schedule/Timeline Table (Continued)

Activities	Organization	Dates		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
First quarter groundwater, soil gas, and vapor data submittal	Shaw	January 2013	March 2013	First Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
Second Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	April 2013	June 2013	Second Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the second quarter groundwater, soil gas, and vapor data	Shaw	April 2013	June 2013	Second Quarter Data Validation Report	within 60 days after collection of the last field sample
Second quarter groundwater, soil gas, and vapor data submittal	Shaw	April 2013	June 2013	Second Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
Third Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	July 2013	September 2013	Third Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the third quarter groundwater, soil gas, and vapor data	Shaw	July 2013	September 2013	Third Quarter Data Validation Report	within 60 days after collection of the last field sample
Third quarter groundwater, soil gas data, and vapor submittal	Shaw	July 2013	September 2013	Third Quarter ERMPIS Submittal	within 60 days after collection of the last field sample
Fourth Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	October 2013	December 2013	Fourth Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the fourth quarter groundwater, soil gas, and vapor data	Shaw	October 2013	December 2013	Fourth Quarter Data Validation Report	within 60 days after collection of the last field sample

QAPP Worksheet #16 – Project Schedule/Timeline Table (Continued)

Activities	Organization	Dates		Deliverable	Deliverable Due Date
Fourth quarter groundwater, soil gas, and vapor data submittal	Shaw	October 2013	December 2013	Fourth Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
First Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	January 2014	March 2014	First Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the first quarter groundwater, soil gas, and vapor data	Shaw	January 2014	March 2014	First Quarter Data Validation Report	within 60 days after collection of the last field sample
First quarter groundwater, soil gas, and vapor data submittal	Shaw	January 2014	March 2014	First Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
Second Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	April 2014	June 2014	Second Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the second quarter groundwater, soil gas, and vapor data	Shaw	April 2014	June 2014	Second Quarter Data Validation Report	within 60 days after collection of the last field sample
Second quarter groundwater, soil gas, and vapor data submittal	Shaw	April 2014	June 2014	Second Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
Third Quarterly Groundwater, Soil Gas, and Vapor Monitoring	Shaw	July 2014	September 2014	Third Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the third quarter groundwater, soil gas, and vapor data	Shaw	July 2014	September 2014	Third Quarter Data Validation Report	within 60 days after collection of the last field sample
Third quarter groundwater, soil gas, vapor data submittal	Shaw	July 2014	September 2014	Third Quarter ERPIMS Submittal	within 60 days after collection of the last field sample

QAPP Worksheet #16 – Project Schedule/Timeline Table (Continued)

Activities	Organization	Dates		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
Fourth Quarterly Groundwater, Soil Gas, Vapor Monitoring	Shaw	October 2014	December 2014	Fourth Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the fourth quarter groundwater, soil gas, and vapor data	Shaw	October 2014	December 2014	Fourth Quarter Data Validation Report	within 60 days after collection of the last field sample
Fourth quarter groundwater, soil gas, and vapor data submittal	Shaw	October 2014	December 2014	Fourth Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
Soil Sampling Associated with SVM Installation	Shaw	January 11, 2011	February 11, 2011	Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the soil SVM data	Shaw	Two weeks after laboratory analysis is completed	Two weeks after laboratory analysis is completed	Data Validation Report	within 60 days after collection of the last field sample
Soil SVM data submittal	Shaw	Within 60 days after collection of the last field samples	Within 60 days after collection of the last field samples	ERPIMS Submittal	within 60 days after collection of the last field sample
FFOR Soil Sampling	Shaw	March 4, 2011	April 7, 2011	Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the FFOR soil data	Shaw	Two weeks after laboratory analysis is completed	Two weeks after laboratory analysis is completed	Data Validation Report	within 60 days after collection of the last field sample

QAPP Worksheet #16 – Project Schedule/Timeline Table (Continued)

Activities	Organization	Dates		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
Soil FFOR data submittal	Shaw	Within 60 days after collection of the last field samples	Within 60 days after collection of the last field samples	ERPIMS Submittal	within 60 days after collection of the last field sample
Soil Sampling associated with monitoring well installation	Shaw	February 14, 2011	April 28, 2011	Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the soil data associated with groundwater monitoring well installation	Shaw	Two weeks after laboratory analysis is completed	Two weeks after laboratory analysis is completed	Data Validation Report	within 60 days after collection of the last field sample
Soil data submittal (monitoring well installation)	Shaw	Within 60 days after collection of the last field samples	Within 60 days after collection of the last field samples	ERPIMS Submittal	within 60 days after collection of the last field sample
Groundwater monitoring to support the LNAPL contaminant IM Investigations (one event)	Shaw	January 2010	April 2010	Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the groundwater data associated with the LNAPL contaminant IM Investigations	Shaw	January 2010	April 2010	Data Validation Report	within 60 days after collection of the last field sample
Groundwater data submittal (LNAPL contaminant IM Investigations)	Shaw	January 2010	April 2010	ERPIMS Submittal	within 60 days after collection of the last field sample
First quarter MNA Groundwater Monitoring	Shaw	January 2011	March 2011	First Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the first quarter MNA data	Shaw	January 2011	March 2011	First Data Validation Report	within 60 days after collection of the last field sample

QAPP Worksheet #16 – Project Schedule/Timeline Table (Continued)

Activities	Organization	Dates		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
First quarter MNA data submittal	Shaw	January 2011	March 2011	First Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
Second quarter MNA Groundwater Monitoring	Shaw	April 2011	June 2011	Second Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the first quarter MNA data	Shaw	April 2011	June 2011	Second Quarter Data Validation Report	within 60 days after collection of the last field sample
Second quarter MNA data submittal	Shaw	April 2011	June 2011	Second Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
Third quarter MNA Groundwater Monitoring	Shaw	July 2011	September 2011	Third Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the first quarter MNA data	Shaw	July 2011	September 2011	Third Quarter Data Validation Report	within 60 days after collection of the last field sample
Third quarter MNA data submittal	Shaw	July 2011	September 2011	Third Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
Fourth quarter MNA Groundwater Monitoring	Shaw	October 2011	December 2011	Fourth Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the first quarter MNA data	Shaw	October 2011When	December 2011	Fourth Quarter Data Validation Report	within 60 days after collection of the last field sample

QAPP Worksheet #16 – Project Schedule/Timeline Table (Continued)

Activities	Organization	Dates		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
Fourth quarter MNA data submittal	Shaw	October 2011When	December 2011	Fourth Quarter ERPIMS Submittal	within 60 days after collection of the last field sample
Soil IDW sampling associated with FFOR and SVM Installation	Shaw	January 11, 2011	April 7, 2011	Quarter Monitoring Report	within 60 days after collection of the last field sample
Automated data review of the soil IDW data	Shaw	Two weeks after laboratory analysis is completed	Two weeks after laboratory analysis is completed	Data Validation Report	within 60 days after collection of the last field sample
Soil IDW data submittal	Shaw	Within 60 days after collection of the last field sample	Within 60 days after collection of the last field sample	ERPIMS Submittal	within 60 days after collection of the last field sample

Note:

ERPIMS denotes Environmental Resources Program Information Management System

QAPP Worksheet #17 – Sampling Design and Rationale

This section discusses the sampling and analysis strategy for groundwater, soil gas, and soil samples required to meet the project DQOs. Locations of the groundwater monitoring wells, soil gas vapor wells, and soil sampling are depicted on the site maps for SWMUs ST-106 and SS-111 (Figure 2).

17.1 WATER LEVEL AND LNAPL MEASUREMENTS

Monthly water level and LNAPL measurements will be conducted at 29 monitoring wells starting in January 2011 and continuing for the duration of the year adding the 78 wells as they become completed. Following Kirtland SOP B5-6 and Shaw's SOP EI-FS108, water levels and LNAPL will be measured, respectively. Results of the monthly water levels and LNAPL measurements will be recorded in log books and Shaw's database.

17.2 PRE-REMEDY QUARTERLY MONITORING PROGRAM – GROUNDWATER

Currently, there are a total of 29 existing groundwater monitoring wells and municipal wells at the BFF site. In compliance with NMED requirements, quarterly groundwater monitoring will be performed at these 29 existing wells during January 2011. In addition, a remedial facility investigation (RFI) of the groundwater associated with the BFF Spill SWMUs ST-106 and ST-111 will be conducted. The RFI will consist of installing monitoring wells, performing down hole geophysics of existing and new monitoring wells, and sampling of existing and new monitoring wells. As part of the groundwater investigation and to further characterize the LNAPL and dissolved-phase plumes, an additional 82 groundwater monitoring wells (including 2 extraction and 2 injection wells) will be installed within five months of work plan approval. These groundwater monitoring wells will be installed in the locations required by NMED to determine the lateral and vertical extent of the LNAPL and dissolved-phase plumes. Following well installation and development, 43 new wells in addition to the 29 existing will be sampled in April 2009. During July 2011 through December 2014, a total of 111 monitoring wells will be sampled on a quarterly basis, includes the 29 existing and the 82 new wells to be installed by July 2011.

All groundwater samples will be collected using the low-flow groundwater sampling procedure described in Kirtland SOP B4.1 "Monitoring Well Sampling". Groundwater samples will be analyzed for the following parameters:

- VOCs - EPA Method 8260
- EDB - EPA Method 8011
- TPH gasoline - EPA Method 8015
- TPH diesel - EPA Method 8015 with silica gel cleanup

- VPH (C5-C8) and (C9-12) - Massachusetts Department of Environmental Protection (MA DEP)
- EPH (C12-C40) - MA DEP with silica gel cleanup
- SVOCs - EPA Method 8270
- Dissolved iron and manganese - EPA Method 6010 (field filtered)
- Total cations (calcium, potassium, manganese, and sodium) and total lead - EPA Method 6010
- Anions (nitrate, chloride, sulfate) - EPA Method 300.0
- Carbonate and bicarbonate alkalinity - Standard Method (SM) 2320B and field measurement by HACH 8203 Method
- Ammonia nitrogen - SM 4500 B, D
- Total kjeldahl nitrogen - EPA Method 351.4
- Ortho-Phosphorous - SM 4500 PE
- Total sulfide - SM 4500 S-2CF
- Total organic carbon - EPA Method 9060
- Dissolved gases (methane, ethane, ethane) - RSK175

For risk evaluation purposes, the VPH/EPH analysis will be conducted for only four quarterly groundwater monitoring events. After sample collection, all samples will be labeled, packaged and shipped to an off-site DoD Environmental Laboratory Accreditation Program (DOD ELAP) approved laboratory for analysis as applicable.

In accordance with the DoD QSM requirements, the most current version of the EPA Methods will be selected for analysis (DoD, 2009). QAPP/SAP Worksheets #18a presents a summary of sampling locations and analytical methods for each of the quarterly groundwater monitoring events. Specific target analytes for the quarterly groundwater monitoring program can be found in QAPP/SAP Worksheets #15a.

17.2.1 LNAPL CONTAINMENT IM INVESTIGATIONS – GROUNDWATER MONITORING

To support the LNAPL containment IM investigation and to complete data gaps, one groundwater sampling event will be conducted in January 2011 at six existing monitoring wells. The samples will be collected using the low flow sampling procedure described in Kirtland SOP B4.1 “Monitoring Well Sampling” and analyzed for the following parameters:

- VOCs - EPA Method 8260
- SVOCs - EPA Method 8270
- TPH – EPA Method 8015
- Total metals and major cations - EPA Method 6010
- Anions - EPA Method 300.0

In addition, NAPL samples will be collected from the same six wells and analyzed by a hydrocarbon specialty laboratory for the following list of hydrocarbon parameters:

- NAPL cleaning – Lab proprietary method
- Density – ASTM D1481
- Viscosity – ASTM D445
- Interfacial tension – ASTM D970
- Flashpoint – ASTM D93
- API gravity – ASTM D287
- PIANO, EDC, EDB – Lab proprietary method

Following sample collections, samples will be labeled, packaged and shipped to an off-site DoD ELAP approved laboratory for analysis. In accordance with the DoD QSM requirements, the most current version of the EPA Methods will be selected for analysis (DoD, 2009). QAPP/SAP Worksheets #18g presents a summary of sampling locations and analytical methods for the groundwater monitoring event. Specific target analytes for the groundwater monitoring program can be found in QAPP/SAP Worksheets #15a.

17.2.2 MNA GROUNDWATER MONITORING

It is planned that 30 groundwater monitoring wells will be installed for the MNA investigation effort. Following well installation and well development, quarterly MNA groundwater sampling will be performed concurrently with the routine quarterly groundwater monitoring. Groundwater samples will be collected from these 30 groundwater wells for a total of four sampling events. Following the low flow sampling procedure, samples will be collected and analyzed for the parameters listed below:

- Filtered cations (calcium, potassium, magnesium, and sodium) - EPA Method 6010
- Filtered manganese – EPA Method 6010
- Anions (chloride, sulfate and nitrate) - EPA Method 300.0
- Ammonia nitrogen - SM 4500 B, D
- Ortho-phosphate - SM 4500 PE
- Total sulfide - SM 4500 S-2CF
- Carbon specific isotope analysis (carbon and hydrogen isotopes) - Laboratory SOP

Additionally, samples will be collected and analyzed in the field for ferrous iron, carbon dioxide, and alkalinity using HACH test kit methods. Laboratory samples will be labeled, packaged and shipped to an off-site DoD ELAP approved laboratory for analysis as applicable. In accordance with the DoD QSM requirements, the most current version of the EPA Methods will be selected for analysis (DoD, 2009) or other appropriate laboratory proprietary methods. QAPP/SAP Worksheets #18h presents a summary of sampling locations and analytical methods for each of the quarterly groundwater monitoring events. Specific target analytes for the quarterly groundwater monitoring program can be found in QAPP/SAP Worksheets #15a.

17.3 PRE-REMEDY QUARTERLY MONITORING PROGRAM – SOIL VAPOR

There are 15 existing soil vapor monitoring wells at the BFF site. In accordance with NMED requirements, quarterly soil gas sampling will be collected at these existing vapor well locations during January 2011. In addition, a RFI of the vadose zone within BFF Spill SWMU ST-106 will be conducted. The RFI will consist of installing SVMs, conducting soil vapor monitoring, and performing down well and borehole geophysics. Within five months of work plan approval, an additional 35 deep SVMs and five shallow SVMs wells will be installed at locations and screen intervals specified in the NMED letters. After the new SVM wells are installed, a total of 123 soil vapor samples will be collected from the new vapor well locations and existing vapor well locations in April 2011. These new vapor well locations will be sampled and then incorporated in the Pre-Remedy Quarterly Monitoring Program. During July 2011 through December 2014, a total of 230 soil gas will be sampled on a quarterly basis. To maximize efficiency, quarterly soil gas monitoring will be conducted concurrently with quarterly groundwater monitoring.

Prior to soil gas sampling, the laboratory will clean and leak check all associated Bottle vac canister sampling equipment including flow controllers and critical orifice assemblies. One vapor sampling canister from each batch of will also be analyzed for VOCs as a laboratory blank.

Soil gas samples will be collected from soil vapor wells following Kirtland SOP B1-7. Bottle vac canister samples will be collected with a flow controller to obtain a time integrated soil gas sample. Following soil gas sample collection, all soil gas samples will be analyzed for the following parameters:

- VOCs and TPH – EPA Method TO15
- APH (C5-C8 and C9-C12) - MA DEP
- Fixed Gases (oxygen, nitrogen, carbon monoxide, carbon dioxide, methane) – ASTM D2504

Note that the APH analysis is required for only four quarterly soil gas monitoring events for risk evaluation purposes. Soil gas samples will be labeled, recorded on COC and shipped to an off - site DoD ELAP approved laboratory for analysis.

Specific analytical parameters for the above methods are summarized in QAPP/SAP worksheet #15b. Sampling locations and methods for each of the quarterly soil gas monitoring events are presented in QAPP/SAP Worksheet #18b.

17.4 OPERATION AND MAINTENANCE OF THE EXISTING SOIL VAPOR EXTRACTION SYSTEMS

Presently there are four ICM soil vapor extraction (SVE) systems operated at the BFF site. Quarterly monitoring and operation of the existing SVE systems will be conducted. SUMMA canister vapor samples will be collected from all SVEs, SVM wells, and the SVE inlet and outlet. It is anticipated that a total of 41 vapor samples will be collected on a quarterly basis from January 2011 through December 2014. Vapor samples from the SVE systems will be collected into passivated Bottle Vac® canisters using the general sampling technique described below:

- Collect vapor samples under standard pressure or minimal vacuum conditions to achieve the lowest reporting limit.
- Obtain canisters and vacuum gauge from the off-site laboratory. Verify the canisters have a vacuum pressure of no less than 27 inches of mercury, prior to sample collection. Record the initial vacuum on the COC or sample collection log.
- Attach the canister to the sampling port using an airtight fitting, then open the value on the sample tap, and then open the canister valve. A slight hissing sound immediately after opening the valve of the canister indicates that vapor is filling the canister. Leave the canister value open for approximately 1 to 2 minutes for sample collection.
- Close the canister valve, and disconnect it from the sampling port.
- Measure and record the final pressure of the canister.
- Label the sample using the tag attached to the canister. Record the serial number on the COC Form next to the sample identification (ID). Store the canister properly to avoid exposure to high temperatures.
- Package and prepare the samples for shipment to the laboratory. SUMMA canisters do not require cold storage and can be returned to the laboratory in the same packaging in which they were delivered.

The vapor samples will be analyzed in the field for the following parameters:

- TPH – EPA TO 3
- Oxygen
- Carbon Monoxide
- Carbon Dioxide

Results of the vapor samples will be used to evaluate VOC destruction efficiency, and to determine optimization and effectiveness of the SVE systems. Sampling locations and methods for each of the quarterly vapor monitoring events are summarized in QAPP/SAP Worksheet #18c. Specific analytical parameters for the methods are summarized in QAPP/SAP worksheet #15b.

17.5 SOIL SAMPLING ASSOCIATED WITH SVM INSTALLATION (VADOSE ZONE INVESTIGATION)

During installation of the 35 deep SVMs and 5 shallow SVMs, soil samples will be collected and analyzed to estimate the amount of residual fuel adsorbed to soil, as soil gas and as residual liquid in the soils. Soil samples will be collected from the nested SVMs borings using a split-spoon sampler at 10 - feet intervals from ground surface to 50 feet below ground surface (bgs) followed by 50 - feet interval samples and at changes in lithology to the total depth (water table). Soil samples from the shallow SVMs will be collected in 4 - feet intervals.

Soil samples will be collected following Kirtland SOP B2-3 –Subsurface Soil Sampling, Split Spoon Sampling Procedure. It is anticipated that a total of 515 soil samples will be collected and analyzed for the following parameters:

- VOCs - EPA Method 8260
- VPH (C5-C8) and (C9-12) – MA DEP
- EPH (C9-C18) and C(19-C36) - MA DEP with silica gel cleanup
- SVOCs - EPA Method 8270
- Lead - EPA Method 6010

Samples will be labeled, packaged, and shipped to off - site DoD ELAP laboratory for analysis. In accordance with the DoD QSM requirements, the most current version of the EPA Methods will be selected for analysis (DoD, 2009). Sampling locations and methods for the soil sampling associated with SVM installation are summarized in QAPP/SAP Worksheet #18d. Specific analytical parameters for the above methods are summarized in QAPP/SAP worksheet #15c.

17.6 FFOR SOIL SAMPLING (IM INVESTIGATION)

Soil samples will be collected to identify the area of shallow soil containing LNAPL or hazardous constituents above the NMED Soil Screening Levels down to 20 ft bgs. Soil samples will be collected along the 350 feet length and 650 feet length of pipeline using a Geoprobe along each side of the excavation. Spacing between samples will not exceed 25 feet. Soil samples will be collected at five foot interval for a total of five samples per borehole.

Soil samples will be collected following Kirtland SOP B2-3 –Subsurface Soil Sampling, Direct Push Sampling Procedure. It is anticipated that a total of 400 soil samples will be collected for the FFOR soil sampling (IM Investigation) and analyzed for the parameters listed below.

- VOCs - EPA Method 8260
- VPH (C5-C8) and (C9-12) – MA DEP
- EPH (C9-C18) and C(19-C36) - MA DEP with silica gel cleanup
- SVOCs - EPA Method 8270
- Lead - EPA Method 6010

Samples will be labeled, packaged, and shipped to off - site DoD ELAP laboratory for analysis. In accordance with the DoD QSM requirements, the most current version of the EPA Methods will be selected for analysis (DoD, 2009). Specific analytical parameters for the above methods are summarized in QAPP/SAP worksheet #15c. Sampling locations and methods are presented in QAPP/SAP worksheet #18e.

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17.7 SOIL SAMPLING ASSOCIATED WITH GROUNDWTAER MONITORING WELL INSTALLATION

During groundwater monitoring well installation, soil samples will be collected to characterize nature and extent of contaminants in new groundwater monitoring well locations. It is anticipated that a total of 72 soil samples will be collected at 4 well locations and 18 depth intervals following Kirtland SOP B2- Subsurface Soil Sampling. All soil samples will be analyzed for the following parameters:

- VOCs - EPA Method 8260
- VPH (C5-C8) and (C9-12) – MA DEP
- EPH (C9-C18) and (19-C36) - MA DEP with silica gel cleanup
- SVOCs - EPA Method 8270
- Lead - EPA Method 6010

Samples will be labeled, packaged, and shipped to off - site DoD ELAP laboratory for analysis. In accordance with the DoD QSM requirements, the most current version of the EPA Methods will be selected for analysis (DoD, 2009). Specific analytical parameters for the above methods are summarized in QAPP/SAP worksheet #15c. Sampling locations and methods for this soil sampling event are presented in QAPP/SAP worksheet #18f.

17.8 DECONTAMINATION PROCEDURE

It is anticipated that dedicated sampling equipment will be used to collect the majority of groundwater and soil samples. Since no cross contamination between samples will occur, no equipment decontamination will be performed. When non-dedicated equipment is used to collect samples, decontamination of non-dedicated sampling equipment that comes in contact with samples will be performed to prevent the introduction of extraneous material into samples, and to prevent cross contamination between samples. All non-dedicated sampling equipment will be decontaminated by washing with a non-phosphate detergent such as Liquinox™ or equivalent and double rinsed with distilled water. Decontamination water will be collected in 55-gallon, Department of Transportation (DOT) -approved drums. Equipment decontamination procedures will be performed in accordance with Kirtland SOP B1.11 - Equipment Decontamination.

17.8 INVESTIGATION-DERIVED WASTE MANAGEMENT

The sampling methods proposed for the quarterly groundwater monitoring typically generate small amounts of investigation-derived waste (IDW). All purge water and equipment decontamination liquid (if any) from the quarterly groundwater monitoring activities will be containerized in approved drums or collected in temporary storage tanks and then transferred to a Baker storage tank pending characterization for discharge or disposal. Environmental samples collected from the monitoring wells will be used to characterize liquid IDW and determine disposition. Purge water will be discharged to ground surface pending approval from Kirtland AFB.

Prior to waste disposal, soil IDW generated from the SVM installation and FFOR soil sampling activities will be collected in lined roll-offs and DOT approved drums. It is estimated that a total of 160 IDW soil samples will be collected from the SVM installation, and 30 soil IDW samples will be collected from the FFOR soil sampling. The IDW soil samples will be collected using the general sampling technique describe below.

- Obtain 8-ounce jars.
- Put on a new (unused) pair of sampling gloves and other appropriate PPE.
- Fill the glass jar with soil for the required analyses.
- Label, package, and prepared the samples for shipment to an-off site laboratory for analysis.

The IDW soil samples will be analyzed for the following parameters per the Kirtland AFB on-site nonhazardous waste landfill disposal requirements:

- TCLP VOCs - EPA Methods 1311/8260
- TCLP SVOCs - EPA Methods 1311/8270
- TCLP pesticides - EPA Methods 1311/8081
- TCLP herbicides - EPA Method 1311/8151
- TCLP Metals - EPA Methods 1311/6010B/7471
- Reactivity, Corrosivity, and Ignitability - SW856, Chapter 7, 7.3.3.2
- BTEX - EPA Method 8260

- TPH gasoline – EPA Method 8015
- TPH diesel - EPA Method 8015 with silica gel cleanup.

The IDW soil samples will be labeled, packaged, and shipped to off - site DoD ELAP laboratory for analysis. In accordance with the DoD QSM requirements, the most current version of the EPA Methods will be selected for analysis (DoD, 2009). Analytical methods and IDW sample quantities are presented in QAPP/SAP Worksheet #18i.

All IDW drums and or rolloffs will be labeled and stored at the site until appropriate disposal is determined. Non-hazardous waste will be disposed of at the Kirtland AFB landfill or appropriate off-site facility. Shaw will coordinate with Kirtland AFB on disposal of all IDW.

17.9 FIELD QUALITY CONTORL SAMPLES

Field QC samples will be collected and analyzed during the project to assess the consistency and performance of the sampling program. Field QC samples for this project will include MS/ MSD, field duplicates, equipment rinsate samples, trip and ambient blanks for aqueous VOC samples, and temperature blanks, discussed below and shown in QAPP Worksheets # 12 and 20.

17.9.1 Matrix Spike and Matrix Spike Duplicate

Matrix spike/matrix spike duplicate samples will be collected at one per 20 groundwater or soil project samples. Matrix spike/matrix spike duplicate analyses will not be performed on IDW soil samples, soil gas samples or vapor samples. Additionally, MS/MSD samples will not be collected for stable carbon and hydrogen isotopes analysis, as MS/MSD analysis for this method and matrix are not applicable. Accuracy of vapor/soil gas, and stable isotope analysis will be assessed through a review of field duplicates, laboratory duplicates and surrogate recoveries (when applicable). Field personnel will collect extra volumes for water and soil for MS/MSD analysis and designate the MS/MSD sample on the COC Form (Figure 3).

17.9.2 Field Duplicates

Field duplicate pairs consist of two samples of the same matrix (a primary and a duplicate) collected at the same time and location to the extent possible, using the same sampling techniques. The purpose of field duplicate samples is to evaluate sampling precision. Field duplicate samples will be collected from the quarterly groundwater monitoring, quarterly soil gas monitoring, quarterly MNA sampling, IM groundwater sampling, soil sampling associated with SVM and groundwater monitoring well installation, and FFOR soil sampling events. Field duplicate samples will be collected at a frequency of 10 percent and will be analyzed for the same analytical parameters as their corresponding primary samples.

17.9.3 Equipment Rinse Blanks

Equipment rinsate blanks are used to evaluate the effectiveness of the decontamination procedure and to identify potential cross-contamination during sampling events. When dedicated or disposal sampling equipment is used to collect samples, equipment rinsate blanks will not be collected. However, if non-disposable sampling equipment is used, equipment rinsate blanks will be collected at one per day regardless of number of sampling teams working on that day. Equipment rinsate blanks consist of distilled water collected from the final rinse of the decontamination process and placed in appropriate pre-cleaned containers supplied by the analytical laboratory. The equipment rinse blanks will be analyzed for VOCs, TPH gasoline and diesel and metals. Results from these analyses will provide sufficient information to evaluate the effectiveness of equipment decontamination procedures.

17.9.4 Trip Blanks

Each cooler containing groundwater samples for VOC analysis will contain a trip blank. Trip blanks are 40-milliliter volatile organic analysis vials that contain analyte-free water, which are kept with the field samples during sampling and shipping to an off-site laboratory. The purpose of trip blanks is to determine whether samples have been contaminated with errant VOCs during transportation or sample collection. One trip blank will be collected for each day of groundwater sampling for VOC samples. One trip blank will also be included with each shipment of soil gas samples for VOC analysis. No trip blanks will be collected for soil samples for VOC analysis.

17.9.5 Ambient Blanks

Ambient blanks serve as a check on environmental contamination from contaminates in air at a sampling location. The ambient blank is prepared by pouring distilled water into a clean sample container either at the laboratory or in the field, and exposing this blank in the field at the time of sample collection and at a particular well location. This blank will be submitted for groundwater samples for VOC analysis. One ambient blank will be collected per day of groundwater sampling.

17.9.6 Temperature Blanks

Each cooler containing soil and groundwater samples will be shipped with a temperature blank. A temperature blank is a sample container filled with tap water and stored in the cooler during sample collection and transportation. The laboratory will record the temperature of the temperature blank immediately upon receipt of the samples. No temperature blank is required for soil gas or vapor samples.

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
First Quarter 2011					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH Diesel – EPA 8015 with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500 B, D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	29	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Second Quarter 2011					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH Diesel – EPA 8015 with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500 B, D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	72	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Third Quarter 2011					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH Diesel – EPA 8015 with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500 B, D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Fourth Quarter 2011					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH Diesel – EPA 8015 with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500 B, D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
First Quarter 2012					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 VPH – MA DEP EPH – MA DEP with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500B,D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Second Quarter 2012					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 VPH – MA DEP EPH – MA DEP with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500B,D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Third Quarter 2012					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 VPH – MA DEP EPH – MA DEP with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500B,D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Fourth Quarter 2012					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 VPH – MA DEP EPH – MA DEP with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500B,D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
First Quarter 2013					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH Diesel – EPA 8015 with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500B,D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Second Quarter 2013					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH Diesel – EPA 8015 with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500B,D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Third Quarter 2013					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH Diesel – EPA 8015 with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500B,D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Fourth Quarter 2013					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH Diesel – EPA 8015 with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500B,D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
First Quarter 2014					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH Diesel – EPA 8015 with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500B,D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Second Quarter 2014					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH Diesel – EPA 8015 with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500B,D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Third Quarter 2014					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH Diesel – EPA 8015 with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500B,D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18a – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Groundwater Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Fourth Quarter 2014					
Groundwater Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH Diesel – EPA 8015 with silica gel cleanup SVOCs – EPA 8270 Dissolved Iron and Manganese –EPA 6010 Total Cations and Lead – EPA 6010 Anions – EPA 300.0 Ammonia as nitrogen – SM 4500B,D TKN by EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases RSK 175	111	QAPP Worksheet #17

QAPP Worksheet #18b – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Soil Gas Monitoring Program

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
First Quarter 2011					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs/TPH gas – EPA TO15 Fixed Gases – ASTM D2504	15	QAPP Worksheet #17
Second Quarter 2011					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs/TPH gas – EPA TO15 Fixed Gases – ASTM D2504	123	QAPP Worksheet #17
Third Quarter 2011					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs/TPH gas – EPA TO15 Fixed Gases – ASTM D2504	230	QAPP Worksheet #17

QAPP Worksheet #18b – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Soil Gas Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Fourth Quarter 2011					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs/TPH gas – EPA TO15 Fixed Gases – ASTM D2504	230	QAPP Worksheet #17
First Quarter 2012					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs – EPA TO15 APH – MA DEP Fixed Gases – ASTM D2504	230	QAPP Worksheet #17
Second Quarter 2012					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs – EPA TO15 APH – MA DEP Fixed Gases – ASTM D2504	230	QAPP Worksheet #17

QAPP Worksheet #18b – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Soil Gas Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Third Quarter 2012					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs – EPA TO15 APH – MA DEP Fixed Gases – ASTM D2504	230	QAPP Worksheet #17
Fourth Quarter 2012					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs – EPA TO15 APH – MA DEP Fixed Gases –ASTM D2504	230	QAPP Worksheet #17
First Quarter 2013					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs/TPH gas – EPA TO15 Fixed Gases – ASTM D2504	230	QAPP Worksheet #17

QAPP Worksheet #18b – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Soil Gas Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Second Quarter 2013					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs/TPH gas – EPA TO15 Fixed Gases – ASTM D2504	230	QAPP Worksheet #17
Third Quarter 2013					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs/TPH gas – EPA TO15 Fixed Gases – ASTM D2504	230	QAPP Worksheet #17
Fourth Quarter 2013					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs/TPH gas – EPA TO15 Fixed Gases –ASTM D2504	230	QAPP Worksheet #17

QAPP Worksheet #18b – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Soil Gas Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
First Quarter 2014					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs/TPH gas – EPA TO15 Fixed Gases – ASTM D2504	230	QAPP Worksheet #17
Second Quarter 2014					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs/TPH gas – EPA TO15 Fixed Gases – ASTM D2504	230	QAPP Worksheet #17
Third Quarter 2014					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs/TPH gas – EPA TO15 Fixed Gases – ASTM D2504	230	QAPP Worksheet #17

QAPP Worksheet #18b – Sampling Locations and Methods/SOP Requirements Table – Pre-Remedy Soil Gas Monitoring Program (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Fourth Quarter 2014					
Soil Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil Gas	VOCs/TPH gas – EPA TO15 Fixed Gases – ASTM D2504	230	QAPP Worksheet #17

QAPP Worksheet #18c – Sampling Locations and Methods/SOP Requirements Table – Operation and Maintenance of Existing SVE Systems

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
First Quarter 2011					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17
Second Quarter 2011					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17
Third Quarter 2011					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17

QAPP Worksheet #18c – Sampling Locations and Methods/SOP Requirements Table – Operation and Maintenance of Existing SVE Systems (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Fourth Quarter 2011					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17
First Quarter 2012					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17
Second Quarter 2012					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17

QAPP Worksheet #18c – Sampling Locations and Methods/SOP Requirements Table – Operation and Maintenance of Existing SVE Systems (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Third Quarter 2012					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17
Fourth Quarter 2012					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17
First Quarter 2013					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17

QAPP Worksheet #18c – Sampling Locations and Methods/SOP Requirements Table – Operation and Maintenance of Existing SVE Systems (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Second Quarter 2013					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17
Third Quarter 2013					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17
Fourth Quarter 2013					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17

QAPP Worksheet #18c – Sampling Locations and Methods/SOP Requirements Table – Operation and Maintenance of Existing SVE Systems (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
First Quarter 2014					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17
Second Quarter 2014					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17
Third Quarter 2014					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17

QAPP Worksheet #18c – Sampling Locations and Methods/SOP Requirements Table – Operation and Maintenance of Existing SVE Systems (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Fourth Quarter 2014					
Vapor Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Vapor	TPH – EPA TO3	41	QAPP Worksheet #17

QAPP Worksheet #18d – Sampling Locations and Methods/SOP Requirements Table – Soil Sampling Associated with SVM Installation (Vadose Zone Investigation)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
SVM Well ID	Each sample will have unique sample number which consists of site ID, well ID, and index number. Sample ID will be assigned prior to sampling	Soil	VOC – EPA 8260 VPH – MA DEP EPH – MA DEP SVOCs – EPA 8270 Lead – EPA 6010	515	QAPP Worksheet #17

QAPP Worksheet #18e – Sampling Locations and Methods/SOP Requirements Table – FFOR Soil Sampling (IM Investigation)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Soil Boring ID	Each sample will have unique sample number which consists of site ID, soil boring ID, and index number. Sample ID will be assigned prior to sampling	Soil	VOC – EPA 8260 VPH- MA DEP EPH – MA DEP SVOCs – EPA 8270 Lead – EPA 6010	400	QAPP Worksheet #17

Worksheet #18f – Sampling Locations and Methods/SOP Requirements Table – Soil Sampling Associated with Groundwater Monitoring Well Installation

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Soil Boring ID	Each sample will have unique sample number which consists of site ID, soil boring ID, and index number. Sample ID will be assigned prior to sampling	Soil	VOC – EPA 8260 VPH -_MA DEP EPH – MA DEP SVOCs - EPA 8270 Lead – EPA 6010	72	QAPP Worksheet #17

Worksheet #18g – Sampling Locations and Methods/SOP Requirements Table – Groundwater Sampling in Support of the LNAPL Containment IM Investigation

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Groundwater Monitoring Well ID	Each sample will have unique sample number which consists of site ID, groundwater well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	VOC – EPA 8260 TPH gas/diesel – EPA 8015M SVOCs - EPA 8270 Metals/Cations – EPA 6010 Anions – EPA 300.0	6	QAPP Worksheet #17

Worksheet #18h – Sampling Locations and Methods/SOP Requirements Table – MNA Groundwater Monitoring

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
First Quarterly Monitoring Event					
Groundwater Monitoring Well ID	Each sample will have unique sample number which consists of site ID, groundwater well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	Cations – EPA 6010 (field filtered) Dissolved manganese – EPA 6010 (field filtered) Anions – EPA 300.0 Ammonia nitrogen – SM 4500B,D o-Phosphate – SM 4500 PE Total Sulfide – SM 4500 S-2CF Stable carbon and hydrogen isotopes – Laboratory SOP	30	QAPP Worksheet #17
Second Quarterly Monitoring Event					
Groundwater Monitoring Well ID	Each sample will have unique sample number which consists of site ID, groundwater well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	Cations – EPA 6010 (field filtered) Dissolved manganese – EPA 6010 (field filtered) Anions – EPA 300.0 Ammonia nitrogen – SM 4500B,D o-Phosphate – SM 4500 PE Total Sulfide – SM 4500 S-2CF Stable carbon and hydrogen isotopes – Laboratory SOP	30	QAPP Worksheet #17

Worksheet #18h – Sampling Locations and Methods/SOP Requirements Table – MNA Groundwater Monitoring (Continued)

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Third Quarterly Monitoring Event					
Groundwater Monitoring Well ID	Each sample will have unique sample number which consists of site ID, groundwater well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	Cations – EPA 6010 (field filtered) Dissolved manganese – EPA 6010 (field filtered) Anions – EPA 300.0 Ammonia nitrogen – SM 4500B,D o-Phosphate – SM 4500 PE Total Sulfide – SM 4500 S-2CF Stable carbon and hydrogen isotopes – Laboratory SOP	30	QAPP Worksheet #17
Fourth Quarterly Monitoring Event					
Groundwater Monitoring Well ID	Each sample will have unique sample number which consists of site ID, groundwater well ID, and index number. Sample ID will be assigned prior to sampling	Groundwater	Cations – EPA 6010 (field filtered) Dissolved manganese – EPA 6010 (field filtered) Anions – EPA 300.0 Ammonia nitrogen – SM 4500B,D o-Phosphate – SM 4500 PE Total Sulfide – SM 4500 S-2CF Stable carbon and hydrogen isotopes – Laboratory SOP	30	QAPP Worksheet #17

QAPP Worksheet #18i – Sampling Locations and Methods/SOP Requirements Table – IDW Soil Sampling

Sampling Location	Sample ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
IDW Soil Sampling Associated with SVM Installation					
NA	Each IDW soil sample will have unique ID and will be assigned prior to sampling	Soil	VOC – EPA 1311/8260 SVOCs - EPA 1311/8270 Pesticides – EPA 1311/8081 Herbicides – EPA 1311/8151 Metals – EPA 1311/6010/7471 RCI – SW846 Chapter 7, 7.3.2 BTEX – EPA 8260 TPH Gasoline – EPA 8015 TPH Diesel – EPA 8015	160	QAPP Worksheet $17
IDW Soil Sampling Associated with FFOR					
NA	Each IDW soil sample will have unique ID and will be assigned prior to sampling	Soil	VOC – EPA 1311/8260 SVOCs - EPA 1311/8270 Pesticides – EPA 1311/8081 Herbicides – EPA 1311/8151 Metals – EPA 1311/6010/7471 RCI – SW846 Chapter 7, 7.3.2 BTEX – EPA 8260 TPH Gasoline – EPA 8015 TPH Diesel – EPA 8015	30	QAPP Worksheet $17

QAPP Worksheet #19a – Analytical SOP Requirements Table – Groundwater

Matrix	Analytical Group	Analytical and Preparation Method/SOP Reference	Sample Volume	Container (number, Size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
Water	VOCs – EPA 8260	Preparation: EPA 5030 Analysis: EPA 8260	40 mL	3 X 40 mL VOA with Teflon® septa	HCL to pH <2 Cool at 0-6°C	14 days for analysis
Water	EDB – EPA 8011	Preparation: EPA 8011 Analysis: EPA 8011	40 mL	3 X 40 mL VOA with Teflon® septa	Sodium Thiosulfate Cool at 0-6°C	14 days for analysis
Water	TPH gasoline – EPA 8015	Preparation: EPA 5030 Analysis: EPA 8015	40 mL	3 X 40 mL VOA with Teflon® septa	HCL Cool at 0-6°C	14 days for analysis
Water	TPH diesel – EPA 8015	Preparation: EPA 3510 and silica gel cleanup Analysis: EPA 8015	1 L	1 X I L Amber	Cool at 0-6°C	7 days for extraction 40 days for analysis
Water	VPH – MA DEP	Preparation: Method MA DEP Analysis: Method MA DEP	40 mL	3 X 40 mL VOA with Teflon® septa	HCL to pH <2 Cool at 0-6°C	14 days for analysis
Water	EPH – MA DEP	Preparation: Method MA DEP and silica gel cleanup Analysis: Method MA DEP	1 L	1 X I L Amber	Cool at 0-6°C	7 days for extraction 40 days for analysis
Water	SVOC – EPA 8270	Preparation: EPA 3510 Analysis: EPA 8270	1 L	1 X I L Amber	Cool at 0-6°C	7 days for extraction 40 days for analysis
Water	Dissolved Iron and Manganese – EPA 6010	Preparation: EPA 3005/3010 Analysis: EPA 6010	100 mL	1 X 250 mL polyethylene(field filtered with 0.45 micrometers filter)	HNO_3 to pH <2 Cool at 0-6°C	180 days for analysis
Water	Total Cations and Lead– EPA 6010	Preparation: EPA 3005/3010 Analysis: EPA 6010	100 mL	1 X 250 mL polyethylene	HNO_3 to pH <2 Cool at 0-6°C	180 days for analysis
Water	Anions – EPA 300.0	Preparation: EPA 300.0 Analysis: EPA 300.0	100 mL	1 X 250 mL polyethylene	Cool at 0-6°C	48 hours for nitrate and 28 days for all other anions

QAPP Worksheet #19a – Analytical SOP Requirements Table – Groundwater (Continued)

Matrix	Analytical Group	Analytical and Preparation Method/SOP Reference	Sample Volume	Container (number, Size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
Water	Alkalinity – SM 2320B	Preparation: SM 2320B Analysis: SM 2320B	100 mL	1 X 250 mL polyethylene	Cool at 0-6°C	14 days for analysis
Water	Ammonia – SM 4500B, D	Preparation: EPA 4500B, D Analysis: EPA 4500 B, D	100 mL	1 X 250 mL polyethylene	H_2SO_4 to pH<2 Cool at 0-6°C	28 days for analysis
Water	TKN – EPA 351.4	Preparation: EPA 354.1 Analysis: EPA 354.1	100 mL	1 X 250 mL polyethylene	H_2SO_4 to pH<2 Cool at 0-6°C	28 days for analysis
Water	o-Phosphorous – SM 4500 PE	Preparation: SM 4500 PE Analysis: SM 4500 PE	100 mL	1 X 250 mL polyethylene	H_2SO_4 to pH<2 Cool at 0-6°C	28 days for analysis
Water	Sulfide – SM 4500 S-2CF	Preparation: EPA 4500 S-2CF Analysis: EPA 4500 S-2CF	100 mL	1 X 250 mL polyethylene	Zinc Acetate and Sodium Hydroxide to pH>9 Cool at 0-6°C	7 days for analysis
Water	TOC – EPA 9060	Preparation: EPA 9060 Analysis: EPA 9060	100 mL	1 X 250 mL Amber	H_2SO_4 to pH<2 Cool at 0-6°C	28 days for analysis
Water	Dissolved Gases – RSK 175	Preparation: RSK175 Analysis: RSK 175	40 mL	3 X 40 mL VOA with Teflon® septa	Cool at 0-6°C	7 days for analysis
Water	Stable Carbon and Hydrogen Isotope – Laboratory SOP	Preparation: Lab SOP Analysis: Lab SOP	100 ml	1 x 1 L polyethylene	Cool at 0-6°C	3 months for analysis

Note(s):

In accordance with the DoD QSM requirements, the most current version of the EPA extraction and analytical methods will be implemented for each sampling event.

HNO_3 denotes nitric acid.

H_2SO_4 denotes sulfuric acid.

L denotes liter.

QAPP Worksheet #19b – Analytical SOP Requirements Table – Soil Gas

Matrix	Analytical Group	Analytical and Preparation Method/SOP Reference	Sample Volume	Container (number, Size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
Soil Gas	VOCs/TPH – EPA TO15	Preparation: EPA TO15 Analysis: EPA TO15	1 L	1 L Bottle Vac Canister 1L for Vapor	NA	14 days for analysis
Soil Gas	APH – Method MA DEP	Preparation: Method MA DEP Analysis: Method MA DEPP	1 L	1 L Bottle Vac Canister	NA	14 days for analysis
Soil Gas	Fixed Gases– ASTM D2504	Preparation: ASTM D2504 Analysis: ASTM D2504	1 L	Tedlar Bag	NA	14 days for analysis

Note:

In accordance with the DoD QSM requirements, the most current version of the EPA methods will be implemented for each sampling event.

QAPP Worksheet #19c – Analytical SOP Requirements Table – Soil

Matrix	Analytical Group	Analytical and Preparation Method/SOP Reference	Sample Volume	Container (number, Size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
Soil/Soil IDW	VOCs – EPA 8260	Preparation: EPA 5035 Analysis: EPA 8260	5 gram	3 X 5 gram Encore	Cool at 0-6°C	48 hours for analysis 14 days for analysis if kept frozen
Soil	VPH - MA DEP	Preparation: Method MA DEP Analysis: Method MA DEP	5 gram	3 X 5 gram Encore	Cool at 0-6°C	48 hours for analysis 14 days for analysis if kept frozen
Soil	EPH – MA DEP	Preparation: Method MA DEP Analysis: Method MA DEP	30 gram	1 X 8 oz Jar	Cool at 0-6°C	14 days for extraction 40 days for analysis
Soil IDW	TPH gasoline – EPA 8015	Preparation: EPA 5035 Analysis: EPA 8015	5 gram	3 X 5 gram Encore	Cool at 0-6°C	48 hours for analysis 14 days for analysis if kept frozen
Soil IDW	TPH diesel – EPA 8015	Preparation: EPA3545/3540/3550, and silica gel cleanup Analysis: EPA 8015	30 grams	1 X 8 oz Jar	Cool at 0-6°C	14 days for extraction 40 days for analysis
Soil	SVOCs – EPA 8270	Preparation: EPA3545/3540/3550 Analysis: EPA 8270	30 grams	1 X 8 oz Jar	Cool at 0-6°C	14 days for extraction 40 days for analysis
Soil	Lead – EPA 6010	Preparation: Method 3050 Analysis: 6010	2 grams	1 X 8 oz Jar	Cool at 0-6°C	180 days for analysis
Soil IDW	VOCs – EPA 1311/8260	Preparation: EPA 1311/5035 Analysis: EPA 8260	25 grams	1 X 8 oz. Jar	Cool at 0-6°C	48 hours for analysis 14 days for analysis
Soil IDW	SVOCs – EPA 1311/8270	Preparation: EPA 1311/3545/3540/3550 Analysis: EPA 8270	30 grams	1 X 8 oz Jar	Cool at 0-6°C	14 days for extraction 40 days for analysis

Soil IDW	Pesticides – EPA 1311/8081	Preparation: EPA 1311/3545/3540/3550 Analysis: EPA 8081	30 grams	1 X 8 oz Jar	Cool at 0-6°C	14 days for extraction 40 days for analysis
Soil IDW	Herbicides – EPA 1311/8151	Preparation: EPA 1311/3545/3540/3550 Analysis: EPA 8151	30 grams	1 X 8 oz Jar	Cool at 0-6°C	14 days for extraction 40 days for analysis

Worksheet #19c – Analytical SOP Requirements Table – Soil (Continued)

Matrix	Analytical Group	Analytical and Preparation Method/SOP Reference	Sample Volume	Container (number, Size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
Soil IDW	Metals – EPA 1311/6010/7471	Preparation: EPA 1311/3050 Analysis: EPA 6010/7471	2 grams	1 X 8 oz Jar	Cool at 0-6°C	28 days for mercury and 180 days for all other metals
Soil IDW	RCI – SW846 Chapter 7, 7.3.2	Preparation: SW846 Chapter 7, 7.3.2 Analysis: SW846 Chapter 7, 7.3.2	2 grams	1 X 8 oz Jar	Cool at 0-6°C	14 days for reactivity and ignitability, and 24 hours for corrosivity

Note:

In accordance with the DoD QSM requirements, the most current version of the EPA extraction and analytical methods will be implemented for each sampling event.

QAPP Worksheet #20a – Field Quality Control Sample Summary Table – 2011 Pre-Remedy Groundwater Monitoring

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
First Quarter 2011 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	29	3	2	1 per day	1 per day if needed	1 per cooler	34 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	29	3	2	0	0	0	34
Water	TPH gasoline – EPA 8015	QAPP Worksheet #19	29	3	2	0	1 per day if needed	0	34 and blanks
Water	TPH diesel – EPA 8015	QAPP Worksheet #19	29	3	2	0	1 per day if needed	0	34 and blanks
Water	SVOCs – 8270	QAPP Worksheet #19	29	3	2	0	0	0	34
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	29	3	2	0	1 per day if needed	0	34 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	29	3	2	0	1 per day if needed	0	34 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	29	3	2	0	0	0	34
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	29	3	2	0	0	0	34
Water	TNK – EPA 351.4	QAPP Worksheet #19	29	3	2	0	0	0	34
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	29	3	2	0	0	0	34
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	29	3	2	0	0	0	34
Water	TOC – EPA 9060	QAPP Worksheet #19	29	3	2	0	0	0	34
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	29	3	2	0	0	0	34

QAPP Worksheet #20a – Field Quality Control Sample Summary Table – 2011 Pre-Remedy Groundwater Monitoring (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Second Quarter 2011 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	72	8	4	1 per day	1 per day if needed	1 per cooler	84 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	72	8	4	0	0	0	84
Water	TPH gasoline – EPA 8015	QAPP Worksheet #19	72	8	4	0	1 per day if needed	0	84 and blanks
Water	TPH diesel – EPA 8015	QAPP Worksheet #19	72	8	4	0	1 per day if needed	0	84 and blanks
Water	SVOCs – 8270	QAPP Worksheet #19	72	8	4	0	0	0	84
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	72	8	4	0	1 per day if needed	0	84 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	72	8	4	0	1 per day if needed	0	84 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	72	8	4	0	0	0	84
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	72	8	4	0	0	0	84
Water	TNK – EPA 351.4	QAPP Worksheet #19	72	8	4	0	0	0	84
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	72	8	4	0	0	0	84
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	72	8	4	0	0	0	84
Water	TOC – EPA 9060	QAPP Worksheet #19	72	8	4	0	0	0	84
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	72	8	4	0	0	0	84

QAPP Worksheet #20a – Field Quality Control Sample Summary Table – 2011 Pre-Remedy Groundwater Monitoring (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Third Quarter 2011 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TPH gasoline – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	TPH diesel – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20a – Field Quality Control Sample Summary Table – 2011 Pre-Remedy Groundwater Monitoring (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Fourth Quarter 2011 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TPH gasoline – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	TPH diesel – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20b – Field Quality Control Sample Summary Table – 2012 Pre-Remedy Groundwater Monitoring

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
First Quarter 2012 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	VPH – MA DEP	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	EPH – MA DEP	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20b – Field Quality Control Sample Summary Table – 2012 Pre-Remedy Groundwater Monitoring (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Second Quarter 2012 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	VPH – MA DEP	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	EPH – MA DEP	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20b – Field Quality Control Sample Summary Table – 2012 Pre-Remedy Groundwater Monitoring (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Third Quarter 2012 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	VPH – MA DEP	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	EPH – MA DEP	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20b – Field Quality Control Sample Summary Table – 2012 Pre-Remedy Groundwater Monitoring (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Fourth Quarter 2012 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	VPH – MA DEP	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	EPH – MA DEP	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20c – Field Quality Control Sample Summary Table – 2013 Pre-Remedy Groundwater Monitoring

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
First Quarter 2013 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TPH gasoline – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	TPH diesel – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20c – Field Quality Control Sample Summary Table – 2013 Pre-Remedy Groundwater Monitoring (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Second Quarter 2013 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TPH gasoline – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	TPH diesel – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20c – Field Quality Control Sample Summary Table – 2013 Pre-Remedy Groundwater Monitoring (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Third Quarter 2013 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB/DBCP – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TPH gasoline – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	TPH diesel – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	0	0	0	0	122
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20c – Field Quality Control Sample Summary Table – 2013 Pre-Remedy Groundwater Monitoring (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Fourth Quarter 2013 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TPH gasoline – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	TPH diesel – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20d – Field Quality Control Sample Summary Table – 2014 Pre-Remedy Groundwater Monitoring

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
First Quarter 2014 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TPH gasoline – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	TPH diesel – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20d – Field Quality Control Sample Summary Table – 2014 Pre-Remedy Groundwater Monitoring (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Second Quarter 2014 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TPH gasoline – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	TPH diesel – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20d – Field Quality Control Sample Summary Table – 2014 Pre-Remedy Groundwater Monitoring (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Third Quarter 2014 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TPH gasoline – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	TPH diesel – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20d – Field Quality Control Sample Summary Table – 2014 Pre-Remedy Groundwater Monitoring (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Fourth Quarter 2014 Groundwater Monitoring Event									
Water	VOCs – EPA 8260	QAPP Worksheet #19	111	11	6	1 per day	1 per day if needed	1 per cooler	128 and blanks
Water	EDB – EPA 8011	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TPH gasoline – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	TPH diesel – EPA 8015	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	SVOCs – 8270	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Iron and Manganese – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Total Cations and Lead – EPA 6010	QAPP Worksheet #19	111	11	6	0	1 per day if needed	0	128 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Ammonia – SM 4500B, D	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TNK – EPA 351.4	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	o-Phosphorous – SM 4500 PE	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	TOC – EPA 9060	QAPP Worksheet #19	111	11	6	0	0	0	128
Water	Dissolved Gases - RSK 175	QAPP Worksheet #19	111	11	6	0	0	0	128

QAPP Worksheet #20e – Field Quality Control Sample Summary Table – 2011 Pre-Remedy Soil Gas Monitoring

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
First Quarter 2011 Soil Gas Monitoring Event									
Soil Gas	VOCs/TPH gas – EPA TO15	QAPP Worksheet #19	15	2	0	0	0	1 per trip	17 and blanks
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	15	2	0	0	0	0	17
Second Quarter 2011 Soil Gas Monitoring Event									
Soil Gas	VOCs/TPH gas – EPA TO15	QAPP Worksheet #19	123	13	0	0	0	1 per trip	136 and blanks
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	123	13	0	0	0	0	136
Third Quarter 2011 Soil Gas Monitoring Event									
Soil Gas	VOCs/TPH gas – EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253
Fourth Quarter 2011 Soil Gas Monitoring Event									
Soil Gas	VOCs/TPH gas – EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253

.

Worksheet #20f – Field Quality Control Sample Summary Table – 2012 Pre-Remedy Soil Gas Monitoring

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
First Quarter 2012 Soil Gas Monitoring Event									
Soil Gas	VOCs – EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	APH – Method MA DEP	QAPP Worksheet #19	230	23	0	0	0	0	253
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253
Second Quarter 2012 Soil Gas Monitoring Event									
Soil Gas	VOCs – EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	APH – Method MA DEP	QAPP Worksheet #19	230	23	0	0	0	0	253
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253
Third Quarter 2012 Soil Gas Monitoring Event									
Soil Gas	VOCs – EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	APH – Method MA DEP	QAPP Worksheet #19	230	23	0	0	0	0	253
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253
Fourth Quarter 2012 Soil Gas Monitoring Event									
Soil Gas	VOCs – EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	APH – Method MA DEP	QAPP Worksheet #19	230	23	0	0	0	0	253

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253

QAPP Worksheet #20g – Field Quality Control Sample Summary Table – 2013 Pre-Remedy Soil Gas Monitoring

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
First Quarter 2013 Soil Gas Monitoring Event									
Soil Gas	VOCs/TPH gas – EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253
Second Quarter 2013 Soil Gas Monitoring Event									
Soil Gas	VOCs/TPH gas – EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253
Third Quarter 2013 Soil Gas Monitoring Event									
Soil Gas	VOCs/TPH gas – EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253
Fourth Quarter 2013 Soil Gas Monitoring Event									
Soil Gas	VOCs/TPH gas– EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253

QAPP Worksheet #20h – Field Quality Control Sample Summary Table – 2014 Pre-Remedy Soil Gas Monitoring

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
First Quarter 2014 Soil Gas Monitoring Event									
Soil Gas	VOCs/TPH gas – EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253
Second Quarter 2014 Soil Gas Monitoring Event									
Soil Gas	VOCs/TPH gas – EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253
Third Quarter 2014 Soil Gas Monitoring Event									
Soil Gas	VOCs/TPH gas – EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253
Fourth Quarter 2014 Soil Gas Monitoring Event									
Soil Gas	VOCs/TPH gas – EPA TO15	QAPP Worksheet #19	230	23	0	0	0	1 per trip	253 and blanks
Soil Gas	Fixed Gases – ASTM D2504	QAPP Worksheet #19	230	23	0	0	0	0	253

QAPP Worksheet #20i – Field Quality Control Sample Summary Table – 2011 Operation and Maintenance of Existing SVE Systems

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
First Quarter 2011 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41
Second Quarter 2011 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41
Third Quarter 2011 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41
Fourth Quarter 2011 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41

Note: TPH vapor samples from the SVE systems will be measured in the field using a field monitor.

QAPP Worksheet #20j – Field Quality Control Sample Summary Table – 2012 Operation and Maintenance of Existing SVE Systems

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
First Quarter 2012 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41
Second Quarter 2012 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41
Third Quarter 2012 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41
Fourth Quarter 2012 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41

Note: TPH vapor samples from the SVE systems will be measured in the field using a field monitor.

QAPP Worksheet #20k – Field Quality Control Sample Summary Table – 2013 Operation and Maintenance of Existing SVE Systems

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
First Quarter 2013 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41
Second Quarter 2013 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41
Third Quarter 2013 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41
Fourth Quarter 2013 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41

Note: TPH vapor samples from the SVE systems will be measured in the field using a field monitor

QAPP Worksheet #20l – Field Quality Control Sample Summary Table – 2014 Operation and Maintenance of Existing SVE Systems

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
First Quarter 2014 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41
Second Quarter 2014 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41
Third Quarter 2014 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41
Fourth Quarter 2014 Vapor Monitoring Event									
Vapor	TPH – EPA TO3	QAPP Worksheet #19	41	0	0	0	0	0	41

Note: TPH vapor samples from the SVE systems will be measured in the field using a field monitor

QAPP Worksheet #20m – Field Quality Control Sample Summary Table – Soil Sampling

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Soil Sampling associated with SVM Installation (Vadose Zone Investigation)									
Soil	VOCs – EPA 8260	QAPP Worksheet #19	515	52	26	0	26	0	619
Soil	VPH – MA DEP	QAPP Worksheet #19	515	52	26	0	26	0	619
Soil	EPH – MA DEP	QAPP Worksheet #19	515	52	26	0	26	0	619
Soil	SVOCs – EPA 8270	QAPP Worksheet #19	515	52	26	0	26	0	619
Soil	Lead – EPA 6010	QAPP Worksheet #19	515	52	26	0	26	0	619
FFOR Soil Sampling (IM Investigation)									
Soil	VOCs – EPA 8260	QAPP Worksheet #19	400	40	20	0	20	0	480
Soil	VPH – MA DEP	QAPP Worksheet #19	400	40	20	0	20	0	480
Soil	EPH – MA DEP	QAPP Worksheet #19	400	40	20	0	20	0	480
Soil	SVOC – EPA 8270	QAPP Worksheet #19	400	40	20	0	20	0	480
Soil	Lead – EPA 6010	QAPP Worksheet #19	400	40	20	0	20	0	480
Soil Sampling Associated with Groundwater Monitoring Well Installation									
Soil	VOCs – EPA 8260	QAPP Worksheet #19	72	8	4	0	2	0	86
Soil	VPH – MA DEP	QAPP Worksheet #19	72	8	4	0	2	0	86
Soil	EPH – MA DEP	QAPP Worksheet #19	72	8	4	0	2	0	86
Soil	SVOC – EPA 8270	QAPP Worksheet #19	72	8	4	0	2	0	86
Soil	Lead – EPA 6010	QAPP Worksheet #19	72	8	4	0	2	0	86

QAPP Worksheet #20j – Field Quality Control Sample Summary Table – Soil Sampling (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Soil IDW Sampling Associated with SVM Installation (Vadose Zone Investigation)									
Soil IDW	VOCs – EPA 1311/8260	QAPP Worksheet #19	160	0	0	0	0	0	160
Soil IDW	SVOCs – EPA 1311/8270	QAPP Worksheet #19	160	0	0	0	0	0	160
Soil IDW	Pesticides – EPA 1311/8081	QAPP Worksheet #19	160	0	0	0	0	0	160
Soil IDW	Herbicides – EPA 1311/8151	QAPP Worksheet #19	160	0	0	0	0	0	160
Soil IDW	RCI – SW846, Chapter 7, 7.3.2	QAPP Worksheet #19	160	0	0	0	0	0	160
Soil IDW	Metals – EPA 1311/6010/7471	QAPP Worksheet #19	160	0	0	0	0	0	160
Soil IDW	BTEX – EPA 8260	QAPP Worksheet #19	160	0	0	0	0	0	160
Soil IDW	TPH gasoline – EPA 8015	QAPP Worksheet #19	160	0	0	0	0	0	160
Soil IDW	TPH diesel – EPA 8015	QAPP Worksheet #19	160	0	0	0	0	0	160
Soil IDW Sampling Associated with FFOR Sampling (IM Investigation)									
Soil IDW	VOCs – EPA 1311/8260	QAPP Worksheet #19	30	0	0	0	0	0	30
Soil IDW	SVOCs – EPA 1311/8270	QAPP Worksheet #19	30	0	0	0	0	0	30
Soil IDW	Pesticides – EPA 1311/8081	QAPP Worksheet #19	30	0	0	0	0	0	30
Soil IDW	Herbicides – EPA 1311/8151	QAPP Worksheet #19	30	0	0	0	0	0	30
Soil IDW	RCI – SW846, Chapter 7, 7.3.2	QAPP Worksheet #19	30	0	0	0	0	0	30
Soil IDW	Metals – EPA 1311/6010/7471	QAPP Worksheet #19	30	0	0	0	0	0	30

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Soil IDW	BTEX – EPA 8260	QAPP Worksheet #19	30	0	0	0	0	0	30
Soil IDW	TPH gasoline – EPA 8015	QAPP Worksheet #19	30	0	0	0	0	0	30
Soil IDW	TPH diesel – EPA 8015	QAPP Worksheet #19	30	0	0	0	0	0	30

QAPP Worksheet #20m – Field Quality Control Sample Summary Table – Groundwater Monitoring in Support of the LNAPL Containment IM Investigation

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Water	VOCs – EPA 8260	QAPP Worksheet #19	6	1	1	1 per day	1 per day if needed	1 per cooler	8 and blanks
Water	SVOCs – EPA 8270	QAPP Worksheet #19	6	1	1	0	1 per day if needed	0	8 and blanks
Water	TPH – EPA 8015M	QAPP Worksheet #19	6	1	1	0	1 per day if needed	0	8 and blanks
Water	Metals/Cations – EPA 6010	QAPP Worksheet #19	6	1	1	0	1 per day if needed	0	8 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	6	1	1	0	0	0	8

QAPP Worksheet #20n – Field Quality Control Sample Summary Table – MNA Groundwater Monitoring

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
First Quarter Monitoring									
Water	Dissolved Total Cations – EPA 6010	QAPP Worksheet #19	30	3	2	0	1 per day if needed	0	35 and blanks
Water	Dissolved Manganese – EPA 6010	QAPP Worksheet #19	30	3	2	0	1 per day if needed	0	35 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	Ammonia nitrogen– SM 4500B, D	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	o-Phosphate – SM 4500 PE	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	Stable carbon and hydrogen isotope – Laboratory SOP	QAPP Worksheet #19	30	3	0	0	0	0	33
Second Quarter Monitoring									
Water	Dissolved Total Cations – EPA 6010	QAPP Worksheet #19	30	3	2	0	1 per day if needed	0	35 and blanks
Water	Dissolved Manganese – EPA 6010	QAPP Worksheet #19	30	3	2	0	1 per day if needed	0	35 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	Ammonia nitrogen– SM 4500B, D	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	o-Phosphate – SM 4500 PE	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	Stable carbon and hydrogen isotope – Laboratory SOP	QAPP Worksheet #19	30	3	0	0	0	0	33

QAPP Worksheet #20n – Field Quality Control Sample Summary Table – MNA Groundwater Monitoring (Continued)

Matrix	Analytical Group	Analytical and Preparation QAPP Reference	# of Primary Sampling Locations	# of Field Duplicates[a]	# of MS/MSDs	# of Field Blanks[b]	# of Equipment Rinsates[c]	# of Trip Blanks[d]	Total # of Samples to Laboratory
Third Quarter Monitoring									
Water	Dissolved Total Cations – EPA 6010	QAPP Worksheet #19	30	3	2	0	1 per day if needed	0	35 and blanks
Water	Dissolved Manganese – EPA 6010	QAPP Worksheet #19	30	3	2	0	1 per day if needed	0	35 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	Ammonia nitrogen– SM 4500B, D	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	o-Phosphate – SM 4500 PE	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	Stable carbon and hydrogen isotope – Laboratory SOP	QAPP Worksheet #19	30	3	0	0	0	0	33
Fourth Quarter Monitoring									
Water	Dissolved Total Cations – EPA 6010	QAPP Worksheet #19	30	3	2	0	1 per day if needed	0	35 and blanks
Water	Dissolved Manganese – EPA 6010	QAPP Worksheet #19	30	3	2	0	1 per day if needed	0	35 and blanks
Water	Anions – EPA 300.0	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	Ammonia nitrogen– SM 4500B, D	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	Total Sulfide – SM 4500 S-2CF	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	o-Phosphate – SM 4500 PE	QAPP Worksheet #19	30	3	2	0	0	0	35
Water	Stable carbon and hydrogen isotope – Laboratory SOP	QAPP Worksheet #19	30	3	0	0	0	0	33

QAPP Worksheet #21 – Project Sampling SOP References

Reference Number	Title	Date, Revision and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
Kirtland SOP B1-1	Borehole and Sampling Logging	April 2004	Kirtland AFB	Borehole logging procedures	N	
Kirtland SOP B1-3	Monitoring Well Installation	April 2004	Kirtland AFB	Well installation procedures	N	
Kirtland SOP B1-4	Monitoring Well Development	April 2004	Kirtland AFB	Well development procedure	N	
Kirtland SOP B1-7	Soil Gas Investigation	April 2004	Kirtland AFB	Soil Gas sampling procedures	N	SOP will be reviewed and may be updated
Kirtland SOP B1-17	Equipment Decontamination	April 2004	Kirtland AFB	Equipment Decontamination Procedures	N	
Kirtland SOP B2-3	Subsurface Soil Sampling	April 2004	Kirtland AFB	Subsurface Soil Sampling procedures	N	SOP will be reviewed and may be updated
Kirtland SOP B3-1	PID and Organic Vapor Analyzer	April 2004	Kirtland AFB	PID and Organic Vapor Analyzer	N	
Kirtland SOP B4-1	Monitoring Well Sampling	April 2004	Kirtland AFB	pump and water level meter	N	SOP will be reviewed and may be updated
Kirtland SOP B4-4	Field Filtration	April 2004	Kirtland AFB	filter	N	
Kirtland SOP B5-6	Water Levels	April 2004	Kirtland AFB	Measuring tap	N	
Shaw SOP EI-FS108	Measurement of Water and LNAPL in Monitoring Wells	September 2006	Kirtland AFB	Oil/water interface probe	N	

Note(s):

QAPP Worksheet #22 – Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Calibration Verification Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Photoionization Detector	Check calibration to 100 parts per million isobutylene	Once per day before first use	± 5% of standard value	Recalibrate	Shaw Sampler	Manufactures Operation Manual
YSI (or equivalent) water quality meter with flow cell	Check calibration against two of the following three traceable standards with nominal pH of 4.0, 7.00 and 10.00	Once per day before first use	± 0.05 pH units	Recalibrate	Shaw Sampler	Manufactures Operation Manual
	Check calibration against specific conductance standard	Once per day before first use	± 5% of standard value	Recalibrate	Shaw Sampler	Manufactures Operation Manual
	Check calibration against turbidity standards	Once per day before first use	± 5% of standard value	Recalibrate	Shaw Sampler	Manufactures Operation Manual
	Check calibration against dissolved oxygen (ambient air)	One per day before first use	± 10% of 100% saturation	Recalibrate	Shaw Sampler	Manufactures Operation Manual
	Check calibration against oxygen reduction potential standards	One per day before first use	± 10% standard value	Recalibrate	Shaw Sampler	Manufactures Operation Manual

QAPP Worksheet #23a – Analytical SOP References Table - Groundwater

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
Empirical SOP-202	GC/MS Volatiles by EPA Method 624 and SW846 Method 8260B 9/09/2010 Rev 23	Definitive	Water – VOCs/EPA 8260	GC/MS	Empirical Laboratories	N
Empirical SOP-218	GC/ECD 1,2-Dibromoethane and 1,2-Dibromo-3-Chloropropane by EPA Methods 504.1 and SW-846 8011 9/07/2010 Rev7	Definitive	Water – EDB/EPA 8011	GC	Empirical Laboratories	N
Empirical SOP-219	GC/FID Nonhalogenated Volatile Organics And TPH by Method 8015B/8015C/ TN EPH/GRO 9/20/2010 Rev 13	Definitive	Water – TPH gasoline/EPA 8015	GC	Empirical Laboratories	N
Empirical SOP-322 and Empirical SOP 219	TPH (Total Petroleum Hydrocarbons) Aqueous Matrix by USEPA SW846 Method 8015B 9/09/2010 Rev 10 GC/FID Nonhalogenated Volatile Organics And TPH by Method 8015B/8015C/ TN EPH/GRO 9/20/2010 Rev 13	Definitive	Water –TPH diesel/EPA 8015	GC	Empirical Laboratories	N
Empirical SOP 226 and Empirical SOP 335	Method for the Determination of Extractable Hydrocarbons (EPH) MA DEP– EPH-04-1.1 4/7/2009 Rev3 Massachusetts EPH (Extractable Petroleum Hydrocarbons) MA DEP-EPH-04-1.1 Aqueous Matrix 6/18/2009 Rev 3	Definitive	Water – EPH/MA DEP	GC	Empirical Laboratories	N

QAPP Worksheet #23a – Analytical SOP References Table - Groundwater (Continued)

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
Empirical SOP-227	Method for the Determination of Volatile Petroleum Hydrocarbons (VPH) MA DEP– VPH-04-1.1 12/30/2009 Rev 5	Definitive	Water – VPH/MA DEP	GC	Empirical Laboratories	N
Empirical SOP-300 and Empirical SOP-201	GC/MS-Semi-Volatile BNA-Aqueous Matrix Extraction Using SW-846 Method 3510C for 8270C/625 Analysis, 4/26/2010 Rev 18 GC/MS SEMIVOLATILES and LOW-CONCENTRATION PAHs BY EPA METHOD 625 AND SW846 METHOD 8270C AND 8270D INCLUDING ADDITIONAL APPENDIX IX COMPOUNDS,4/26/2010 Rev 20	Definitive	Water – SVOCs/EPA 8270	GC/MS	Empirical Laboratories	N
Empirical SOP-100 and Empirical SOP-105	Metals Digestion/Preparation Methods 3005A, 3010A,3020A,3030,3040A,3050B USEPA CLPILMO 04.1 Aqueous and Soil/Sediment USEPA CLPILMO 05.2 Aqueous and Soil/Sediment, USEPA Method 200.7 (Standard Methods) 3030C 9/1/2010 Rev 21 Metals Analysis by ICP Technique Methods 200.7, (SW846) 6010B, (SW-846) 6010C, (SM 19th Edition 2340B) USEPA CLP ILMO 4. 4/11/2010 Rev 16	Definitive	Water – Metals/EPA 6010	ICP	Empirical Laboratories	N
Empirical SOP-145	Determination of Inorganic Anions in water by ION Chromatography using Dionex DX-500 Ion Chromatograph with Hydroxide Eluent And Dionex Column AS18, Method 300.0 Guidance, 3/25/2010 Rev 7	Definitive	Water – Anions/EPA 300.0	Ion Chromatography	Empirical Laboratories	N

QAPP Worksheet #23a – Analytical SOP References Table - Groundwater (Continued)

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
Empirical SOP-154	Alkalinity by EPA Method 310.1, SM2320B, 9/21/2010 Rev 7	Definitive	Water – Alkalinity/SM 2320B	Titration	Empirical Laboratories	N
Empirical SOP-176	Ammonia (Phenolate) Potable and Surface Waters Method 10-107-06-1-A 0.1 to 20 mg N/L as NH3, SM4500NH3 G, 20th Ed. and USEPA Method 350.1 10/05/2010 Rev10	Definitive	Water – Ammonia/SM 4500B, D	Lachet Autoanalyzer	Empirical Laboratories	N
Empirical SOP-153	Sulfide Method 376.1 and Standard Methods SM4500S-2 F(19th ED) (Titrimetric, Iodine) with Sample Pretreatment to Remove Interfering Substances or to Concentrate the Sulfide,9/7/2010 Rev 4	Definitive	Water – Sulfide/SM 4500S-2CF	Titration	Empirical Laboratories	N
Empirical SOP-221	Total Organic Carbon SM5310C, USEPA Method 415.1 and SW846 Method 9060/9060A and Lloyd Kahn Method,7/12/2010 Rev 9	Definitive	Water – TOC/EPA 9060	TOC Analyzer	Empirical Laboratories	N
Empirical SOP-236	Methane, Ethane, Ethene in Aqueous Samples by Modified RSK-175 (Automated Headspace) 9/7/2010 Rev 2	Definitive	Water – Dissolved Gases /RSK 175	GC	Empirical Laboratories	N
Empirical SOP 182	Total Kjeldahl Nitrogen in Waters Method 10-107-06-2-D 0.02 to 20.0 mg N/L by USEPA Method 351.2 9/7/2010 Rev 7	Definitive	Water – TKN/EPA 351.4	Lachet Autoanalyzer	Empirical Laboratories	N
Empirical SOP 165	Phosphorous, Total and Ortho Standard Methods(20th edition) Method SM4500P B5E and Method SM4500PE/ (USEPA) Method 365.2 (Colorimetric, Ascorbic Acid, Single Reagent) 9/7/2010 Rev 8	Definitive	Water – O Phosphorous /SM 4500 PE	Spectrophotometer	Empirical Laboratories	N

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
TBD	TBD	Definitive	Water – Stable carbon and hydrogen isotopes	TBD	Microseeps Inc.	N

QAPP Worksheet #23b – Analytical SOP References Table - Soil Vapor

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
TO15_083109_R0_1_v1	ANALYSIS OF VOLATILE ORGANIC COMPOUNDS IN AIR SAMPLES; Revision 0, v1, 08/31/09	Definitive	Soil Gas – VOCs and TPH/EPA TO15	GC/MS	RTI Laboratories	N
TO15_083109_R0_1_v1	ANALYSIS OF VOLATILE ORGANIC COMPOUNDS IN AIR SAMPLES; Revision 0, v1, 08/31/09	Definitive	Soil Gas – APH/MA DEP	GC/MS	RTI Laboratories	N
RSKSOP_092310_R0_v1.pdf	ANALYSIS OF DISSOLVED GASES; Revision o, v1, 092310	Definitive	Soil Gas – Fixed Gases/ASTM D2504	GC	RTI Laboratories	N

QAPP Worksheet #23c – Analytical SOP References Table - Soil

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
GCMSV-003	SOP for the Analysis of Volatile Mass Spec Samples Method 8260, Rev 20, 7/9/10	Definitive	Soil – VOCs/EPA 8260	GC/MS	Golf Coast Analytical Laboratories	N
GC-032	SOP for Determination of Volatile Petroleum Hydrocarbons Rev 2, 7/10/2009	Definitive	Soil – VPH /MA DEP	GC	Golf Coast Analytical Laboratories	N
GC-025	SOP for Characterization of Extractable Petroleum Hydrocarbons Rev 5, 9/101/2009	Definitive	Soil – EPH/MA DEP	GC	Golf Coast Analytical Laboratories	N
GCMSSV-001	SOP for the Analysis of Semi-Volatile Mass Spec Samples for 8270C, Rev 16, 5/21/10	Definitive	Soil – SVOCs/EPA 8270	GC/MS	Golf Coast Analytical Laboratories	N
MET-010	SOP for Analysis of Samples by ICP, Rev 18, 5/19/10	Definitive	Soil – Lead EPA 6010	ICP	Golf Coast Analytical Laboratories	N

QAPP Worksheet #24a – Analytical Instrument Calibration Table (Gas Chromatography/Mass Spectrometry)

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	VOCs, SVOCs, and APH
Analytical Method	EPA Methods 8260, 8270, MA DEP, TO15

Instrument	Calibration Procedure	Frequency	Acceptance Criteria	Corrective Action	Person(s) Responsible for Corrective Actions	SOP Reference
GC/MS	EPA 8260, MA DEP and TO15: Check of mass spectral ion intensities (tuning procedure) using bromofluorobenzene EPA 8270: Check of mass spectral ion intensities (tuning procedure) using decafluorotriphenylophosphine in accordance with DoD QSM requirements	EPA 8260 and EPA 8270: Prior to initial calibration and every 12 - hour during sample analysis TO15 and MA DEP: prior to initial calibration and meet frequency requirements specified in the method.	Must meet the method requirements before samples are analyzed	Retune instrument and verify the tune acceptability, rerun the affected samples	Lab Manager/Analyst	QAPP Worksheet #23
	Five-point initial calibration for target analytes, lowest calibration standard at or near the RL in accordance with DoD QSM requirements	Initial calibration prior to sample analysis	EPA 8260: The minimum average system performance check compound response factor is 0.1 for chloromethane, 1,1-dichloroethane, and bromoform and 0.30 for chlorobenzene and 1,1,2,2-tetrachloroethane. EPA 8270: The minimum average system performance check compound response factor is 0.05. EPA 8260 and EPA 8270: Relative standard deviation (RSD) is less than 30% in accordance	Correct problem, then rerun initial calibration in accordance with DoD QSM/method requirements	Lab Manager/Analyst	QAPP Worksheet #23

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	VOCs, SVOCs, and APH
Analytical Method	EPA Methods 8260, 8270, MA DEP, TO15

Instrument	Calibration Procedure	Frequency	Acceptance Criteria	Corrective Action	Person(s) Responsible for Corrective Actions	SOP Reference
			with DoD QSM requirements TO15 and MA DEP: RSD is less than 30%per method requirements			

QAPP Worksheet #24a – Analytical Instrument Calibration Table (Gas Chromatography/Mass Spectrometry) (Continued)

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	VOCs, SVOCs, and APH
Analytical Method	EPA Methods 8260, 8270, MA DEP, TO15

Instrument	Calibration Procedure	Frequency	Acceptance Criteria	Corrective Action	Person(s) Responsible for Corrective Actions	SOP Reference
GC/MS	Second-source calibration verification in accordance with DoD QSM requirements	Once per five-point initial calibration	EPA 8260 and EPA 8270: Less than 20% difference for all target analytes in accordance with DoD QSM requirements MA DEP: 70-130% recovery through LCS analysis per method requirements	Correct problem, then rerun second source calibration verification in accordance with DoD QSM/method requirements	Lab Manager/Analyst	QAPP Worksheet #23
	Daily calibration verification in accordance with DoD QSM requirements	Before sample analysis and every 12 hours of analysis	EPA 8260: The minimum average system performance check compound response factor is 0.1 for chloromethane, 1,1-dichloroethane, and bromoform and 0.30 for chlorobenzene and 1,1,2,2-tetrachloroethane. EPA 8270: The minimum average system performance check compound response factor is 0.05. EPA 8260 and EPA 8270: Less than 20% difference for all target analytes in accordance with DoD QSM requirements TO15 and MA DEP: Less than 30% difference for all target analytes per method requirements.	Correct problem, then rerun calibration verification in accordance with DoD QSM/method requirements	Lab Manager/Analyst	QAPP Worksheet #23

QAPP Worksheet #24a – Analytical Instrument Calibration Table (Gas Chromatography/Mass Spectrometry) (Continued)

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	VOCs, SVOCs, and APH
Analytical Method	EPA Methods 8260, 8270, and MA DEP

Instrument	Calibration Procedure	Frequency	Acceptance Criteria	Corrective Action	Person(s) Responsible for Corrective Actions	SOP Reference
GC/MS	Breakdown check	Before sample analysis and every 12 hours of analysis	EPA 8270: Degradation less than 20% for DDT. Benzidine and pentachlorophenol are present at normal response and not greater than a tailing factor of 2.	Correct problem, then rerun breakdown check	Lab Manager/Analyst	QAPP Worksheet #23

QAPP Worksheet #24b – Analytical Instrument Calibration Table (Gas Chromatography)

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	EDB/DBCP, TPH, VPH/EPH, Dissolved Gases
Analytical Method	EPA Methods 8011 and 8015, MA DEP, RSK 175

Instrument	Calibration Procedure	Frequency	Acceptance Criteria	Corrective Action	Person(s) Responsible for Corrective Actions	SOP Reference
GC	Minimum five-point initial calibration for target analytes, lowest calibration standard at or near the reporting limit in accordance with DoD QSM requirements.	Initial calibration prior to sample analysis	EPA 8011, EPA 8015, RSK 175: RSD less than or equal to 20% for all target analytes in accordance with DoD QSM requirements MA DEP: RSD less than 25% for all target analytes per method requirements.	Correct problem, then rerun initial calibration in accordance with DoD QSM requirements	Lab Manager / Analyst	QAPP Worksheet #23
	Second-source calibration verification	Once per five-point initial calibration	EPA 8011, EPA 8015, RSK 175: Less than 20% of expected values from the initial calibration for all target analytes in accordance with DoD QSM requirements MA DEP: Less than 25% of expected values from the initial calibration for all target analytes per method requirements.	Correct problem, then rerun second source calibration verification in accordance with DoD QSM requirements	Lab Manager / Analyst	QAPP Worksheet #23
	Daily calibration verification	EPA 8011 and EPA 8015: Before sample analysis	EPA 8011, EPA 8015, , RSK 175: Less than 20% of expected values from the initial	Correct problem, then rerun calibration verification in	Lab Manager / Analyst	QAPP Worksheet #23

	and every 10 samples TO3 and MA DEP: Before sample analysis and at frequency specified in the method.	calibration for all target analytes in accordance with DoD QSM requirements MA DEP: Less than 25% of expected values from the initial calibration for all target analytes per method requirements	accordance with DoD QSM requirements		

QAPP Worksheet #24c – Analytical Instrument Calibration Table (Inductively Coupled Plasma Atomic Emission Spectrometry)

Matrix	Groundwater and Soil
Analytical Group	Metals
Analytical Method	EPA Method 6010

Instrument	Calibration Procedure	Frequency	Acceptance Criteria	Corrective Action	Person(s) Responsible for Corrective Actions	SOP Reference
ICP	EPA 6010: initial calibration with a minimum of one high standard and one calibration blank in accordance with DoD QSM requirements	EPA 6010: Initial calibration prior to sample analysis	EPA 6010: Correlation coefficient greater than 0.995 in accordance with DoD QSM requirements	EPA 6010: Correct problem, then repeat initial calibration in accordance with DoD QSM requirements	Lab Manager/Analyst	QAPP Worksheet # 23
	EPA 6010: Low standard at or near the RL in accordance with DoD QSM requirements (ICP/MS only)	EPA 6010: Daily after one-point initial calibration	EPA 6010: within 20% difference from initial calibration for all target analytes in accordance with DoD QSM requirements	EPA 6010: Correct problem, then rerun low standard in accordance with DoD QSM requirements	Lab Manager/Analyst	QAPP Worksheet # 23
	EPA 6010: Second source calibration standard, prepared at the calibration midpoint in accordance with DoD QSM requirements	EPA 6010: Once per initial calibration, prior to sample analysis	EPA 6010: within 10% difference from the expected value for all target analytes in accordance with DoD QSM requirements	EPA 6010: Correct problem, then rerun second source calibration in accordance with DoD QSM requirements	Lab Manager/Analyst	QAPP Worksheet # 23

QAPP Worksheet #24c – Analytical Instrument Calibration Table (Inductively Coupled Plasma Atomic Emission Spectrometry (Continued)

Matrix	Groundwater and Soil
Analytical Group	Metals
Analytical Method	EPA Method 6010

Instrument	Calibration Procedure	Frequency	Acceptance Criteria	Corrective Action	Person(s) Responsible for Corrective Actions	SOP Reference
ICP	EPA 6010: CCV in accordance with DoD QSM requirements	EPA 6010: Following initial calibration, after every 10 samples and the end of the sequence	EPA 6010: within 10% difference from initial calibration for all target analytes	EPA 6010: Correct problem, then repeat CCV in accordance with DoD QSM requirements	Lab Manager/Analyst	QAPP Worksheet # 23

Note(s):

CCV denotes continuing calibration verification.

QAPP Worksheet #24d – Analytical Instrument Calibration Table (Ion Chromatography/Colorimetric/TOC Analyzer)

Matrix	Groundwater
Analytical Group	Anions, TOC, and Ammonia, TKN
Analytical Method	EPA Methods 300.0, 351.4, and 9060, SM4500B, D

Instrument	Calibration Procedure	Frequency	Acceptance Criteria	Corrective Action	Person(s) Responsible for Corrective Actions	SOP Reference
IC/Colorimetric/TOC Analyzer	EPA 300.0 and 351.4, SM4500B, D, and EPA 9060: Initial calibration with a minimum of three calibration standards and one calibration blank	EPA 300.0 and 351.4, SM4500B, D, and EPA 9060: Initial calibration prior to sample analysis	EPA 300.0 and 351.4, SM4500B, D, and EPA 9060: Correlation coefficient greater than 0.995	EPA 300.0 and 351.4, SM4500B, D, and EPA 9060: Correct problem, then repeat initial calibration	Lab Manager/Analyst	QAPP Worksheet # 23
	EPA 300.0 and 351.4, SM4500B, D, and EPA 9060: Initial calibration verification, prepared at the calibration midpoint.	EPA 300.0 and 351.4, SM4500B, D, and EPA 9060: Once after initial calibration, before sample analysis	EPA 300.0 and 351.4, SM4500B, D, and EPA 9060: Less than 10% difference from initial calibration for all target analytes	EPA 300.0 and 351.4, SM4500B, D, and EPA 9060: Correct problem, then rerun initial calibration verification	Lab Manager/Analyst	QAPP Worksheet # 23
	EPA 300.0 and 351.4, SM4500B, D, and EPA 9060: CCV	EPA 300.0 and 351.4, SM4500B, D, and EPA 9060: Following initial calibration, after every 10 samples and the end of the sequence	EPA 300.0 and 351.4, SM4500B, D, and EPA 9060: Less than 10% difference from initial calibration for all target analytes	EPA 300.0 and 351.4, SM4500B, D, and EPA 9060: Correct problem, then repeat CCV	Lab Manager/Analyst	QAPP Worksheet # 23

Note(s):

IC denotes ion chromatography.

QAPP Worksheet #25 – Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table – Groundwater

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person[2]	SOP Reference[1]
GC/MS - VOC	Check pressure and gas supply daily. Bake out trap and column, manual tune if BFB not in criteria, change septa as needed, cut column as needed, change trap as needed.	VOC's	Ion source, injector liner, column, column flow, purge lines, purge flow, trap.	Prior to initial calibration and/or as necessary.	Acceptable tune and Calibration or CCV.	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data.	Empirical Analyst and Laboratory Manager	Empirical SOP 202
GC/MS - SVOC	Check pressure and gas supply daily. Manual tune if DFTPP not in criteria, change septa as needed, change liner as needed, cut column as needed.	SVOC's	Ion source, injector liner, column, column flow.	Prior to initial calibration and/or as necessary.	Acceptable tune and Calibration or CCV.	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data.	Empirical Analyst and Laboratory Manager	Empirical SOP 201/300

QAPP Worksheet #25 – Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table – Groundwater (Continued)

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person[2]	SOP Reference[1]
GC	Check pressure and gas supply daily. Change septa and/or liner as needed, replace or cut column as needed.	RSK175 dissolved Gases, GRO 8015B, EPH/VPH MA, 8011,DRO 8015B	Liner, seal, septum, column	Prior to initial calibration or as necessary	Acceptable Calibration or CCV.	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data.	Empirical Analyst and Laboratory Manager	Empirical SOP's 218, 219, 322, 227,236
ICP-AES	Clean torch assembly and spray chamber when discolored or when degradation in data quality is observed. Clean nebulizer, check argon, replace peristaltic pump tubing as needed.	Metals	Torch, nebulizer chamber, pump, pump tubing.	Prior to initial calibration and as necessary.	Acceptable Calibration or CCV.	Correct the problem and repeat Calibration or CCV.	Empirical Analyst and Laboratory Manager	Empirical SOP 100/105

QAPP Worksheet #25 – Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table – Groundwater (Continued)

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person[2]	SOP Reference[1]
Lachet	Check and clean segments weekly, clean reagent tubes monthly. Change lamp, change dilutent and wash tubes, change mixing paddles and syringes, and change dispensing needle, all as needed.	Ammonia/ TKN	Tubing and rollers.	Prior to ICAL or as necessary.	Acceptable ICAL and CCV.	Recalibrate and/or perform necessary equipment maintenance. Reanalyze samples not bracketed by passing CCV.	Empirical Analyst and Laboratory Manager	Empirical SOP 176 and 182
IC	Replace column	Anions	Check gas supply, check for leaks, check pistons	Daily or as needed	Must meet ICAL and continuing calibration criteria.	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data	Empirical Analyst and Laboratory Manager	Empirical SOP 145
Buret	Check Buret for any cracks or chips. Rinse buret prior to each use and at the end of each day.	Sulfide	Visual inspection for cracks or chips.	Each Use	NA	Remove from service.	Empirical Analyst and Laboratory Manager	Empirical SOP 153

QAPP Worksheet #25 – Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table – Groundwater (Continued)

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person[2]	SOP Reference[1]
TOC Analyzer	Replace sample tubing, clean sample boat, replace syringe	TOC	Tubing, sample boat, syringe	As needed	Must meet ICAL and continuing calibration criteria.	Repeat maintenance activity or remove from service.	Empirical Analyst and Laboratory Manager	Empirical SOP 221
pH Meter	Keep probe wet at all times and inspect prior to use. Rinse thoroughly between uses.	Alkalinity	Visual inspection of probe.	Each use	Must meet factory specified start up limits.	Remove from service.	Empirical Analyst and Laboratory Manager	Empirical SOP 154
Spectrophotometer	Clean reagent tubes. Change lamp.	Ortho Phosphate	Check wavelength	At the beginning of every run.	Must meet ICAL and continuing calibration criteria.	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Empirical Analyst and Laboratory Manager	Empirical SOP 165
TBD	TBD	TBD	TBD	TBD	TBD	TBD	Microseeps Analyst and Laboratory Manager	TBD

QAPP Worksheet #25 – Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table – Soil Gas

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
GC/MS	Daily/Regular as specified	Air samples	Inst operating parameters	Daily	Per SOP	Recalibrate/ stop for service on failure.	RTI Laboratory Analyst and Laboratory Manager	RTI SOP TO15_083109_R0_1_v1
GC	Daily during use	Air/gas samples	Inst operating parameters	Daily	Per SOP	Recalibrate/ stop for service on failure.	RTI Laboratory Analyst and Laboratory Manager	RTI SOP TO15_083109_R0_1_v1
Decon/Cleaning oven	Vacuum/Helium adjust	None	Temp/Flow	Daily	1 clean check per batch		RTI Laboratory Analyst and Laboratory Manager	RTI SOP TO15_083109_R0_1_v1

QAPP Worksheet #25 -- Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table - Soil

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person[2]	SOP Reference[1]
Gas Chromatograph / Mass Spectrometer (GC/MS)	Check for leaks, replace gas line filters, recondition or replace trap, replace column, clean injection port/liner	Volatiles	Monitor instrument performance via Continuing Calibration Verification	As needed	No maintenance is required as long as instrument QC meets DOD criteria	Replace connections, clean source, replace gas line filters, replace trap, replace GC column, clip column, replace injection port liner, clean injection port, replace Electron Multiplier	Gulf Coast Analytical Analyst and Supervisor	Gulf Coast Analytical SOP GCMSV-003
Gas Chromatograph / Mass Spectrometer (GC/MS)	Clean Injection port and replace liner Clip Column Leak check Maintain pumps by checking replacing pump oil	Semi-volatiles	Monitor instrument performance via Continuing Calibration Verification DFTPP tune, breakdown and tailing	Daily	No maintenance is required as long as instrument QC meets DOD criteria	Change column Clean source	Gulf Coast Analytical Analyst and Supervisor	Gulf Coast Analytical SOP GCMSSV-001
Gas Chromatograph	Check for leaks, replace gas line filters, replace column, clean injection port/liner	EPH	Monitor instrument performance via Continuing Calibratioin Verification	As needed	No maintenance is required as long as instrument QC meets DOD criteria	Replace connections, replace gas line filters, replace GC column, clip column, replace injection port liner, clean injection port	Gulf Coast Analytical Analyst and Supervisor	Gulf Coast Analytical SOP GC-032

QAPP Worksheet #25 -- Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table – Soil (Continued)

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person2	SOP Reference1
Gas Chromatograph	Check for leaks, replace gas line filters, recondition or replace trap, replace column, clean injection port/liner	VPH	Monitor instrument performance via Continuing Calibration Verification	As needed	No maintenance is required as long as instrument QC meets DOD criteria	Replace connections, replace gas line filters, replace trap, replace GC column, clip column, replace injection port liner, clean injection port	Gulf Coast Analytical Analyst and Supervisor	Gulf Coast Analytical SOP GC-025
ICP - Metals	Perform leak test, change pump tubing, change torch and window, clean filters	Metals	Monitor instrument performance via Continuing Calibration Verification and CCBlank	As needed	No maintenance is required as long as instrument QC meets DOD criteria	Change pump tubing, change torch and window, clean filters; recalibrate and reanalyze affected data	Gulf Coast Analytical Analyst and Supervisor	Gulf Coast Analytical SOP MET-010

QAPP Worksheet #26 – Sample Handling System

Sample Handling System
GROUNDWATER, SOIL GAS, AND SOIL SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): Shaw Field Technician
Sample Packaging (Personnel/Organization): Shaw Field Technician or QC Manager
Coordination of Shipment (Personnel/Organization): Shaw Field Technician or QC Manager
Type of Shipment/Carrier: FedEx or UPS
GROUNDWATER, SOIL GAS, AND SOIL SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Empirical for groundwater sample analyses, RTI for soil gas sample analyses, Golf Coast Analytical for soil sample analyses, and Microseeps for stable isotope analysis
Sample Custody and Storage (Personnel/Organization): Empirical for groundwater sample analyses, RTI for soil gas sample analyses, Golf Coast Analytical for soil sample analyses, and Microseeps for stable isotope analysis
Sample Preparation (Personnel/Organization): Empirical for groundwater sample analyses, RTI for soil gas sample analyses, Golf Coast Analytical for soil sample analyses, and Microseeps for stable isotope analysis
Sample Determinative Analysis (Personnel/Organization): Empirical for groundwater sample analyses, RTI for soil gas sample analyses, Golf Coast Analytical for soil sample analyses, and Microseeps for stable isotope analysis
GROUNDWATER, SOIL GAS, AND SOIL SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): On the day of sampling, samples will be shipped to Empirical Laboratories for groundwater sample analysis, RTI for soil gas sample analysis, Golf Coast Analytical for soil sample analyses, and Microseeps for stable isotope analysis on the day of sampling. In cases when samples can't be shipped to the laboratories on the same day due to field conditions, samples will be kept in a refrigerator at the site for a maximum of one day. Samples with short holding time requirements will be shipped to the laboratories on the day of sampling.
Sample Extract/Digestate Storage (No. of days from extraction/digestion): See QAPP/SAP Worksheet #19 for various analyses
Biological Sample Storage (No. of days from sample collection): NA
GROUNDWATER, SOIL, AND SOIL GAS SAMPLE DISPOSAL
Personnel/Organization: Empirical, RTI, Golf Coast Analytical, and Microseeps
Number of Days from Analysis: Hold samples for 120 days

QAPP Worksheet #27 – Sample Custody Requirements Table

27.1 SAMPLE CUSTODY AND DOCUMENTATION

Sampling information will be recorded on a COC form and sample collection forms. All entries will be legible and recorded in indelible ink. Sampling information will be recorded on a COC form and sample collection forms. All entries will be legible and recorded in indelible ink. Because samples will be analyzed by multiple laboratories, the terms laboratory and Sample Custodian are generic. The custody procedures described herein apply to all laboratories which are involved in the analysis of groundwater, soil gas, and soil samples.

27.2 CHAIN OF CUSTODY

An example COC form is shown on Figure 3, "Typical Chain-of-Custody." In addition to providing a custody exchange record for the samples, the COC serves as a formal request for sample analyses. The COC form will be completed, signed, and distributed as follows:

- One copy retained by the sample coordinator 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 COC 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 Project Chemist will also notify the Project Manager if the project budget and schedule may be impacted.

The laboratory will initiate an internal COC that will track the sample within the various areas of the laboratory. The relinquishing signature of the Sample Custodian and the custody acceptance signature of the laboratory personnel transfer custody of the sample. This procedure is followed each time a sample changes hands. 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 returned to the project for disposal, or disposed by the laboratory.

27.3 FIELD SAMPLE CUSTODY

The COC Form will be the controlling document to assure that sample custody is maintained. Upon collecting a sample, sampling personnel will initiate the COC in the field. Each individual who has the sample(s) in their possession will sign the COC. Each time the sample custody is transferred, the former custodian will sign the COC on the "Relinquished by" line, and the new custodian will sign the COC on the "Received by" line. The date, time, and name of their project or company affiliation will accompany each signature.

The waybill number or courier name will be recorded on the COC form when a commercial carrier is used. The shipping container will be secured with two custody seals, thereby allowing shipping personnel to maintain custody until receipt by the laboratory.

If the laboratory sample custodian judges sample custody to be invalid (*e.g.*, custody seals have been broken), the laboratory will initiate a Nonconformance Report. The Project Chemist will be immediately notified. The Project Chemist will notify in turn, the Project Manager and the Project QC Manager. The Project Manager will make a decision, in consultation with the client, as to the fate of the sample(s) in question on a case-by-case basis. The sample(s) will either be processed "as-is" with custody failure noted along with the analytical data, or rejected with resampling scheduled, if necessary. The nonconformance associated with the samples will be noted on the appropriate certificate of analysis or case history.

27.4 SAMPLE COLLECTION FORMS

Sample Collection Forms will be used to document every sample collected. All entries will be recorded in indelible ink. Corrections will be made following the procedure described below.

At a minimum, the sample collection form will contain the following information:

- Project name and location
- Sampler name
- Date and time of collection for each sample
- Sampling method (bailer or low flow)
- Sample number
- Sample location (i.e., soil boring or sampling point)
- Sample matrix (i.e., soil and water)
- Sample type (i.e., normal sample, field duplicate, blank)
- Composite or grab
- Composite type (the number of grab samples)
- Depth of sample
- Weather information (e.g., rain, sunny, approximate temperature, etc.)
- Containers used (e.g., brass liners, glass bottles, etc.)

- Requested analyses
- Field analyses performed, including results, instrument checks, problems, and calibration records for field instruments (i.e., photoionization detector reading)
- Descriptions of deviations from this QAPP/SAP
- Problems encountered and corrective action taken
- Verbal or written instructions from the USACE and Shaw Project QC Manager
- Any other events that may affect the samples

The sampler will cross out the unused portion and sign each page.

27.5 LOW-FLOW GROUNDWATER PURGE AND SAMPLE LOG

Low-Flow Groundwater Purge and Sample Logs (purge and sample log) will be used to document every sample collected. All entries will be recorded in indelible ink. Corrections will be made following the procedure described in Section 27.6.

At a minimum, the sample purge logs will contain the following information:

- Project name and site
- Well identification number
- Sampler name
- Sample date and time
- Water level
- Screen interval
- PID reading
- Purge information (time, purge rate, volume purged, depth to water, temperature, pH, DO, ORP, conductivity, turbidity)
- VOC sample rate, sample number and requested analysis
- Sample type (i.e., normal sample, field duplicate, blank)

27.6 DOCUMENT CORRECTIONS

Changes or corrections on any project documentation will be made by crossing out the item with a single line, initialing by the person performing the correction, and dating the correction. The original item, although erroneous, will remain legible beneath the cross out. The new information will be written above the crossed-out item. Corrections will be written clearly and legibly with indelible ink.

QAPP Worksheet #28a – Laboratory QC Samples Table (Gas Chromatography/Mass Spectrometry)

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	VOCs, SVOCs, and APH
Analytical Method	EPA Methods 8260, 8270, MA DEP, and TO15

QC Sample	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
Internal standards	Every field sample and QC samples	RT within ±30 seconds from RT of initial calibration midpoint standard; area counts within -50% to +100% of initial calibration midpoint standard	Correct problem, then re-reanalyze affected samples.	Lab Manager/Analyst	Accuracy	RT within ±30 seconds and area count within -50% to +100%
Method blank	One per preparation batch	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater). No laboratory common contaminants detected greater than RL.	Correct problem, then re-reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/Analyst	Representativeness	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater). No laboratory common contaminants detected greater than RL.

QAPP Worksheet #28a – Laboratory QC Samples Table (Gas Chromatography/Mass Spectrometry) (Continued)

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	VOCs, SVOCs, and APH
Analytical Method	EPA Methods 8260, 8270, MA DEP, and TO15

QC Sample	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
MS/MSD	One MS/MSD pair per preparation batch per matrix	EPA 8260 and EPA 8270: LCS control limits specified in the DoD QSM (also presented in Appendix A) RPD less than 30% between MS and MSD	Identify problem; if not related to matrix interference, re-reanalyze MS/MSD and all associated batch samples	Lab Manager/Analyst	Precisions and Accuracy	EPA 8260 and EPA 8270: LCS control limits specified in the DoD QSM RPD less than 30% between MS and MSD
LCS or LCS/LCSD pair	One LCS or LCS/LCSD pair per preparation batch per matrix	EPA 8260 and EPA 8270: LCS control limits specified in the DoD QSM (also presented in Appendix A) TO15 and MA DEP: Laboratory in-house LCS control limits (also presented in Appendix A) RPD less than 30% between LCS and	Correct problem, then re-reanalyze the LCS and all associated batch samples	Lab Manager/Analyst	Precisions and Accuracy	EPA 8260 and EPA 8270: LCS control limits specified in the DoD QSM TO15 and MA DEP: Laboratory in-house LCS control limits. RPD less than 30% between LCS and LCSD

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	VOCs, SVOCs, and APH
Analytical Method	EPA Methods 8260, 8270, MA DEP, and TO15

QC Sample	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
		LCSD				

QAPP Worksheet #28a – Laboratory QC Samples Table (Gas Chromatography/Mass Spectrometry) (Continued)

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	VOCs, SVOCs, and APH
Analytical Method	EPA Methods 8260, 8270, MA DEP, and TO15

QC Sample	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
Surrogate standards	Every field sample and QC sample	EPA 8260 and EPA 8270: Surrogate recovery acceptance criteria specified in the DoD QSM (also presented in Appendix A). TO15: Laboratory in-house surrogate control limits (also presented in Appendix A)	Correct problem, then re-reanalyze all affected samples	Lab Manager/Analyst	Accuracy	EPA 8260 and EPA 8270: Surrogate recovery acceptance criteria specified in the DoD QSM TO15: Laboratory in-house surrogate control limits
Sample duplicate	Every 20 samples	TO15: RPD less than 25% per method requirements. MA DEP: RPD less than 30% per method requirements	NA	Lab Manager/Analyst	Accuracy	TO15: RPD less than 25% per method requirements. MA DEP: RPD less than 30% per method requirements
MDL study	Initial setup, once per 12-month period or quarterly MDL verification	Detection limits established will be below the RLs	Correct problem, then repeat the MDL study	Lab Manager/Analyst	Sensitivity	

QAPP Worksheet #28a – Laboratory QC Samples Table (Gas Chromatography/Mass Spectrometry) (Continued)

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	VOCs, SVOCs, and APH
Analytical Method	EPA Methods 8260 and 8270, and8270, MA DEP, and TO15

QC Sample	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
LOD study	Initial setup and quarterly LOD verification	Signal to noise ratio at the LOD will be greater than 3 and meet method requirements.	Correct problem, then repeat detection limit study and LOD verification at a higher concentration, or pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration in accordance with DoD QSM requirements.	Lab Manager/Analyst	Sensitivity	
LOQ study	Annually and quarterly LOQ verification	LOQ will be greater than LOD and within calibration range. Laboratory procedure for establishing the LOQ will empirically demonstrate precision and bias at the LOQ		Lab Manager/Analyst	Sensitivity	

Note(s):

LOD denotes limit of detection.
LOQ denotes limit of quantitation.
RPD denotes relative percent difference.

QAPP Worksheet #28b – Laboratory QC Samples Table (Gas Chromatography)

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	EDB/DBCP, TPH, VPH/EPH, Dissolved Gases
Analytical Method	EPA Methods 8011 and 8015, MA DEP, and RSK 175

QC Sample	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
Method blank	One per preparation batch	No target analytes detected greater than one-half RL and >1/10 amount detected in project samples or 1/10 the regulatory limit (whichever is greater).	Correct problem, then re-extract and reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/Analyst	Representativeness	No target analytes detected greater than one-half RL and >1/10 amount detected in project samples or 1/10 the regulatory limit (whichever is greater).
MS/MSD	One MS/MSD pair per preparation batch per matrix	EPA 8011 and EPA 8015, MA DEP ,RSK 175: Laboratory in-house LCS control limits (also presented in Appendix A) RPD less than 30% between MS and MSD	Identify problem; if not related to matrix interference, re-extract and reanalyze MS/MSD and all associated batch samples	Lab Manager/Analyst	Precisions and Accuracy	EPA 8011 and EPA 8015, MA DEP ,RSK 175: Laboratory in-house LCS control limits RPD less than 30% between MS and MSD

QAPP Worksheet #28b – Laboratory QC Samples Table (Gas Chromatography (Continued)

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	EDB/DBCP, TPH, VPH/EPH, Dissolved Gases
Analytical Method	EPA Methods 8011 and 8015, MA DEP, SRK 175

QC Sample	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
LCS or LCS/LCSD pair	One LCS or LCS/LCSD pair per preparation batch per matrix	EPA 8011 and EPA 8015, MA-DEP, , and RSK 175: Laboratory in-house LCS control limits (also presented in Appendix A) RPD less than 30% between LCS and LCSD	Correct problem, then re-extract and reanalyze the LCS and all associated batch samples	Lab Manager/Analyst	Precisions and Accuracy	EPA 8011 and EPA 8015, MA-DEP, RSK 175: Laboratory in-house LCS control RPD less than 30% between LCS and LCSD
Surrogate standards	Every field sample and QC sample	EPA 8015, and MA-DEP: Laboratory in-house surrogate acceptance criteria (Also presented in Appendix A)	Correct problem, then re-extract and reanalyze all affected samples	Lab Manager/Analyst	Accuracy	EPA 8015, and MA-DEP : Laboratory in-house surrogate acceptance criteria

QAPP Worksheet #28b – Laboratory QC Samples Table (Gas Chromatography) (Continued)

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	EDB/DBCP, TPH, VPH/EPH, Dissolved Gases
Analytical Method	EPA Methods 8011 and 8015, MA DEP, RSK 175

QC Sample	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
Confirmation of positive results using second column or second detector	All positive results must be confirmed	EPA 8011: Same calibration and QC requirements as for initial or primary column analysis. RPD between primary and second column results less than 40%	NA	Lab Manager/Analyst	Precision	EPA 8011: RPD between primary and second column results less than 40%
MDL study	Initial setup, once per 12-month period or quarterly MDL verification	Detection limits established will be below the RLs	Correct problem, then repeat the MDL study in accordance with DoD QSM requirements	Lab Manager/Analyst	Sensitivity	
LOD study	Initial setup and quarterly LOD verification	Signal to noise ratio at the LOD will be greater than 3 and meet method requirements.	Correct problem, then repeat detection limit study and LOD verification at a higher concentration, or pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration per DoD QSM	Lab Manager/Analyst	Sensitivity	

QAPP Worksheet #28b – Laboratory QC Samples Table (Gas Chromatography) (Continued)

Matrix	Groundwater, Soil, and Soil Gas
Analytical Group	EDB/DBCP, TPH, VPH/EPH, Dissolved Gases
Analytical Method	EPA Methods 8011 and 8015, MA DEP, RSK 175

QC Sample	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
LOQ study	Annually and quarterly LOQ verification	LOQ will be greater than LOD and within calibration range. Laboratory procedure for establishing the LOQ will empirically demonstrate precision and bias at the LOQ		Lab Manager/Analyst	Sensitivity	

QAPP Worksheet #28c – Laboratory QC Samples Table (Inductively Coupled Plasma Atomic Emission Spectrometry)

Matrix	Groundwater and Soil
Analytical Group	Metals
Analytical Method	EPA Method 6010

QC Check	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
EPA 6010: Calibration blank	EPA 6010: After initial calibration, before CCV calibration, after every 10 samples, and at the end of the sequence	EPA 6010: No target analytes detected greater than LOD in accordance with DoD QSM requirements	EPA 6010: Re-prepare and reanalyze the blank and the affected samples in accordance with DoD QSM requirements	Lab Manager/Analyst	Representativeness	EPA 6010: No target analytes detected greater than LOD
EPA 6010: Method blank	EPA 6010: One per preparation batch	EPA 6010: No target analytes detected greater than one-half RL and greater than 1/10 amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	EPA 6010: Correct problem, then re-prepare and reanalyze the method blank and all samples processed with the contaminated blank in accordance with DoD QSM requirements	Lab Manager/Analyst	Representativeness	EPA 6010: No target analytes detected greater than one-half RL and greater than 1/10 amount measured in any sample or 1/10 the regulatory limit (whichever is greater).
EPA 6010: Interference check solution	EPA 6010: At the beginning of an analytical run and every 12 hours	EPA 6010: Within ±20% of expected value in accordance with DoD QSM requirements	EPA 6010: Identify and correct problem, then reanalyze the interference check solution and all affected samples in accordance with DoD QSM requirements	Lab Manager/Analyst	Accuracy	EPA 6010: within ±20% of expected value

QAPP Worksheet #28c – Laboratory QC Samples Table (Inductively Coupled Plasma Atomic Emission Spectrometry) (Continued)

Matrix	Groundwater and Soil
Analytical Group	Metals
Analytical Method	EPA Method 6010

QC Check	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
EPA 6010: MS/MSD for all analytes	EPA 6010: One MS/MSD pair per preparation batch per matrix	EPA 6010: LCS control limits specified in the DoD QSM (also presented in Appendix A) RPD less than 20% between MS and MSD	EPA 6010: Identify problem, if not related to matrix interference, then re-prepare and reanalyze the MS/MSD pair and all samples in the associated batch in accordance with DoD QSM requirements	Lab Manager/Analyst	Precision and Accuracy	EPA 6010: LCS control limits specified in the DoD QSM
EPA 6010: LCS for all analytes	EPA 6010: One LCS per each preparation batch	EPA 6010: LCS control limits specified in the DoD QSM (also presented in Appendix A) RPD less than 20% between LCS and LCSD	EPA 6010: Identify and correct the problem, then reanalyze the LCS and all affected samples in accordance with DoD QSM requirements	Lab Manager/Analyst	Precision and Accuracy	EPA 6010: LCS control limits specified in the DoD QSM

QAPP Worksheet #28c – Laboratory QC Samples Table (Inductively Coupled Plasma Atomic Emission Spectrometry (Continued)

Matrix	Groundwater and Soil
Analytical Group	Metals
Analytical Method	EPA Methods 6010

QC Check	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
EPA 6010: Dilution test	EPA 6010: Each preparation batch	EPA 6010: Five-fold dilution results within ±10% of the original results in accordance with DoD QSM requirements	EPA 6010: Perform post-digestion spike	Lab Manager/Analyst	Accuracy	EPA 6010: within ±10% difference
EPA 6010: Post digestion spike addition	EPA 6010: When dilution test fails	EPA 6010: Recovery within 75% -125% of expected results in accordance with DoD QSM requirements	EPA 6010: Correct problem, then rerun samples by method of standard addition in accordance with DoD QSM requirements	Lab Manager/Analyst	Accuracy	EPA 6010: Recovery within 75% -125% of expected values
MDL study	Initial setup, once per 12-month period or quarterly MDL verification	Detection limits established will be below the RLs	Correct problem, then repeat the MDL study in accordance with DoD QSM requirements	Lab Manager/Analyst	Sensitivity	

QAPP Worksheet #28c – Laboratory QC Samples Table (Inductively Coupled Plasma Atomic Emission Spectrometry) (Continued)

Matrix	Groundwater and Soil
Analytical Group	Metals
Analytical Method	EPA Method 6010

QC Check	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
LOD study	Initial setup and quarterly LOD verification	Signal to noise ratio at the LOD will be greater than 3 and meet method requirements.	Correct problem, then repeat detection limit study and LOD verification at a higher concentration, or pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration per DoD QSM	Lab Manager/Analyst	Sensitivity	
LOQ study	Annually and quarterly LOQ verification	LOQ will be greater than LOD and within calibration range. Laboratory procedure for establishing the LOQ will empirically demonstrate precision and bias at the LOQ		Lab Manager/Analyst	Sensitivity	

Note(s):

ICS denotes interference check solution.

ICV denotes initial calibration verification.

QAPP Worksheet #28d – Laboratory QC Samples Table (Wet Chemistry)

Matrix	Groundwater
Analytical Group	Anions, TKN , Ammonia, Sulfide, TOC, , and o-Phosphorous
Analytical Method	EPA Methods 300.0, 351.4, 4500B, D, 4500S-2CF, 4500PE, and EPA 9060

QC Check	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
EPA 300.0, 351.4, 4500B, 4500PE, 4500S-2CF and EPA 9060: Method blank	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA 9060: One per preparation batch	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA 9060: No target analytes detected greater than one-half RL and 1/10 the amount measured in any samples or 1/10 the regulatory limit (whichever is greater)	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA 9060: Correct problem, then re-prepare and reanalyze the method blank and all samples processed with the contaminated blank.	Lab Manager/ Analyst	Representativeness	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA 9060: No target analytes detected greater than one-half RL and 1/10 the amount measured in any samples or 1/10 the regulatory limit (whichever is greater)
EPA 300.0, 351.4, 4500B, 4500PE, 4500S-2CF and EPA 9060: MS/MSD	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA 9060: One MS/MSD pair per preparation batch	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA 9060: Laboratory in-house LCS control limits (also presented in Appendix A) RPD less than 15% between MS and MSD	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA 9060: Identify problem, if not related to matrix interference, then re-prepare and reanalyze the MS/MSD pair and all samples in the associated batch	Lab Manager/ Analyst	Precision and Accuracy	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA 9060: Laboratory in-house LCS control limits RPD less than 15% between MS and MSD
EPA 300.0, 351.4, SM 4500B,	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA	Lab Manager/ Analyst	Precision and Accuracy	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-

Matrix	Groundwater
Analytical Group	Anions, TKN , Ammonia, Sulfide, TOC, , and o-Phosphorous
Analytical Method	EPA Methods 300.0, 351.4, 4500B, D, 4500S-2CF, 4500PE, and EPA 9060

QC Check	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
4500PE, 4500S-2CF and EPA 9060: LCS	2CF and EPA 9060: One LCS per each preparation batch	2CF and EPA 9060: Laboratory in-house LCS control limits (also presented in Appendix A) RPD less than 15% RPD less than 15% between LCS and LCSD	9060: Identify and correct the problem, then reanalyze the LCS and all affected samples			2CF and EPA 9060: Laboratory in-house LCS control limits not to exceed ±20% RPD less than 15% between LCS and LCSD

QAPP Worksheet #28d – Laboratory QC Samples Table (Wet Chemistry) (Continued)

Matrix	Groundwater
Analytical Group	Anions, TKN , Ammonia, Sulfide, TOC, , and o-Phosphorous
Analytical Method	EPA Methods 300.0, 351.4, SM 4500B, D, 4500S-2CF, 4500PE, and EPA 9060

QC Check	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA 9060: Sample duplicate	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA 9060: One per every 10 samples	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA 9060: Within 10% difference between sample and duplicate	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA 9060: Correct problem, reanalyze sample and duplicate	Lab Manager/ Analyst	Accuracy	EPA 300.0, 351.4, SM 4500B, 4500PE, 4500S-2CF and EPA 9060: Within 10% difference
MDL study	Initial setup, once per 12-month period or quarterly MDL verification	Detection limits established will be below the RLs	Correct problem, then repeat the MDL study	Lab Manager/ Analyst	Sensitivity	
LOD study	Initial setup and quarterly LOD verification	Signal to noise ratio at the LOD will be greater than 3 and meet method requirements.	Correct problem, then repeat detection limit study and LOD verification at a higher concentration, or pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration per DoD QSM	Lab Manager/ Analyst	Sensitivity	
LOQ study	Annually and quarterly LOQ verification	LOQ will be greater than LOD and within calibration range.		Lab Manager/ Analyst	Sensitivity	

Matrix	Groundwater
Analytical Group	Anions, TKN , Ammonia, Sulfide, TOC, , and o-Phosphorous
Analytical Method	EPA Methods 300.0, 351.4, SM 4500B, D, 4500S-2CF, 4500PE, and EPA 9060

QC Check	Frequency	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Actions	Data Quality Indicators	Measurement Performance Criteria
		Laboratory procedure for establishing the LOQ will empirically demonstrate precision and bias at the LOQ				

QAPP Worksheet #29 – Project Documents and Records Table

Document	Where Maintained
Daily QC reports	Project file and Quarterly Monitoring Report
Descriptions of installed groundwater and soil gas monitoring wells and surveyed locations	Project file and Quarterly Monitoring Report
Geologic and geophysical logs of wells ad boreholes	Project file and Quarterly Monitoring Report
Water levels and water level maps	Project file and Quarterly Monitoring Report
LNAPL measurements	Project file and Quarterly Monitoring Report
Plume contaminant maps and cross-sections	Project file and Quarterly Monitoring Report
SVE maintenance and monitoring	Project file and Quarterly Monitoring Report
Field notes/sample collection forms	Project file and Quarterly Monitoring Report
COC forms	Project file and Quarterly Monitoring Report
Field Equipment Calibration Logs	Project file
EPA Level III ADR worksheets	Project file and Quarterly Monitoring Report
Laboratory Level III data packages	Project file
Audit/assessment checklists/reports	Project file and laboratory
Corrective action forms/reports	Project file and laboratory
Laboratory equipment calibration logs	Laboratory
Sample preparation logs	Laboratory
Run logs	Laboratory
Sample disposal records	Laboratory

QAPP Worksheet #30 – Analytical Services Table - Groundwater

Matrix	Analytical Group	Sample Locations/ID Numbers	Analytical SOP(s)	Data Package Turnaround Time	Laboratory/Organization (Name, Address, Contact, & Telephone #)	Backup Laboratory (Name, Address, Contact, & Telephone #)
Groundwater	VOCs – EPA 8260	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for VOCs analysis
	EDB – EPA 8011	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for EDB analysis
	TPH gasoline – EPA 8015	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for TPH gasoline analysis
	TPH diesel – EPA 8015	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for TPH diesel analysis
	VPH – MA DEP	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for VPH analysis
	EPH – MA DEP	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for EPH analysis

QAPP Worksheet #30 – Analytical Services Table – Groundwater (Continued)

Matrix	Analytical Group	Sample Locations/ID Numbers	Analytical SOP(s)	Data Package Turnaround Time	Laboratory/Organization (Name, Address, Contact, & Telephone #)	Backup Laboratory (Name, Address, Contact, & Telephone #)
Groundwater	SVOCs – EPA 8270	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for SVOCs analysis
	Metals – EPA 6010	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for metals analysis
	Anions – EPA 300.0	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for anions analysis
	Alkalinity – SM 2320B	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for alkalinity analysis Alkalinity may be measured in the field
	Ammonia – SM 4500B, D	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for ammonia analysis
	TKN – EPA 351.4	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228	Only one laboratory will be used for TKN analysis

Matrix	Analytical Group	Sample Locations/ID Numbers	Analytical SOP(s)	Data Package Turnaround Time	Laboratory/Organization (Name, Address, Contact, & Telephone #)	Backup Laboratory (Name, Address, Contact, & Telephone #)
					(877) 345-1113	

QAPP Worksheet #30 – Analytical Services Table – Groundwater (Continued)

Matrix	Analytical Group	Sample Locations/ID Numbers	Analytical SOP(s)	Data Package Turnaround Time	Laboratory/Organization (Name, Address, Contact, & Telephone #)	Backup Laboratory (Name, Address, Contact, & Telephone #)
Groundwater	o-Phosphorous - SM 4500 PE	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for o-Phosphorous analysis
	Total Sulfide – SM 4500S-2CF	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for total sulfide analysis
	TOC – EPA 9060	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for TOC analysis
	Dissolved Gases – RSK 175	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (877) 345-1113	Only one laboratory will be used for dissolved gases analysis
	Stable carbon and hydrogen isotope – Laboratory SOP	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Days	Microseeps Inc. 220 William Pitt Way Pittsburgh, PA 15238 412 826 5245	Only one laboratory will be used for stable isotope analysis

QAPP Worksheet #30 – Analytical Services Table – Soil Gas

Matrix	Analytical Group	Sample Locations/ID Numbers	Analytical SOP(s)	Data Package Turnaround Time	Laboratory/Organization (Name, Address, Contact, & Telephone #)	Backup Laboratory (Name, Address, Contact, & Telephone #)
Soil Gas	VOCs/TPH gas – EPA TO15	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	RTI Laboratories 31628 Glendale Ave. Livonia, MI 48150 (734) 422-8000	Only one laboratory will be used for VOCs/TPH gas analysis
	APH – MA DEP	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	RTI Laboratories 31628 Glendale Ave. Livonia, MI 48150 (734) 422-8000	Only one laboratory will be used for APH analysis
	Fixed Gases – ASTM D2504	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	RTI Laboratories 31628 Glendale Ave. Livonia, MI 48150 (734) 422-8000	Only one laboratory will be used for fixed gases analysis

QAPP Worksheet #30 – Analytical Services Table – Soil

Matrix	Analytical Group	Sample Locations/ID Numbers	Analytical SOP(s)	Data Package Turnaround Time	Laboratory/Organization (Name, Address, Contact, & Telephone #)	Backup Laboratory (Name, Address, Contact, & Telephone #)
Soil and IDW soil	VOCs – EPA 8260	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Golf Coast Analytical Laboratories 7979 GSRI Avenue Baton Rouge, LA 70820 931-636-1019	Only one laboratory will be used for VOCs analysis
	SVOCs – EPA 8270	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Golf Coast Analytical Laboratories 7979 GSRI Avenue Baton Rouge, LA 70820 931-636-1019	Only one laboratory will be used for SVOC analysis
	VPH – MA DEP	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Golf Coast Analytical Laboratories 7979 GSRI Avenue Baton Rouge, LA 70820 931-636-1019	Only one laboratory will be used for VPH analysis
	EPH –MA DEP	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Golf Coast Analytical Laboratories 7979 GSRI Avenue Baton Rouge, LA 70820 931-636-1019	Only one laboratory will be used for EPH analysis
	TPH gasoline – EPA 8015	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Golf Coast Analytical Laboratories 7979 GSRI Avenue Baton Rouge, LA 70820 931-636-1019	Only one laboratory will be used for TPH gasoline analysis
	TPH diesel – EPA 8015	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Golf Coast Analytical Laboratories 7979 GSRI Avenue Baton Rouge, LA 70820 931-636-1019	Only one laboratory will be used for TPH diesel analysis
	Lead – EPA 6010	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Golf Coast Analytical Laboratories 7979 GSRI Avenue Baton Rouge, LA 70820 931-636-1019	Only one laboratory will be used for lead analysis

QAPP Worksheet #30 – Analytical Services Table – Soil

Matrix	Analytical Group	Sample Locations/ID Numbers	Analytical SOP(s)	Data Package Turnaround Time	Laboratory/Organization (Name, Address, Contact, & Telephone #)	Backup Laboratory (Name, Address, Contact, & Telephone #)
Soil and IDW Soil	VOCs – EPA 1311/8260	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Golf Coast Analytical Laboratories 7979 GSRI Avenue Baton Rouge, LA 70820 931-636-1019	Only one laboratory will be used for VOCs analysis
	SVOCs – EPA 1311/8270	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Golf Coast Analytical Laboratories 7979 GSRI Avenue Baton Rouge, LA 70820 931-636-1019	Only one laboratory will be used for SVOCs analysis
	Pesticides – EPA 1311/8081	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Golf Coast Analytical Laboratories 7979 GSRI Avenue Baton Rouge, LA 70820 931-636-1019	Only one laboratory will be used for pesticides analysis
	Herbicides – EPA 1311/8151	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Golf Coast Analytical Laboratories 7979 GSRI Avenue Baton Rouge, LA 70820 931-636-1019	Only one laboratory will be used for herbicides analysis
	Metals – EPA 1311/6010/7471	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Golf Coast Analytical Laboratories 7979 GSRI Avenue Baton Rouge, LA 70820 931-636-1019	Only one laboratory will be used for metals analysis
	RCI –SW846 Chapter 7, 7.3.2	QAPP Worksheet #18	QAPP Worksheet #23	21 Business Day	Golf Coast Analytical Laboratories 7979 GSRI Avenue Baton Rouge, LA 70820 931-636-1019	Only one laboratory will be used for RCI analysis

QAPP Worksheet #31 – Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing Corrective Actions	Person(s) Responsible for Monitoring Effectiveness of Corrective Actions
NELAP lab assessment	Every 18 months The laboratory must hold a current Utah NELAP certification throughout the project duration	External	NELAP	NELAP	Laboratory QAO	Laboratory QAO	Laboratory QAO
DoD ELAP assessment	After October 1, 2009, the laboratory must receive DoD ELAP approval. The laboratory must hold a current DoD ELAP certification throughout the project duration	External	Independent accrediting bodies on behalf of DoD	Independent accrediting bodies on behalf of DoD	Laboratory QAO	Laboratory QAO	Laboratory QAO
Laboratory Technical Systems Audit (TSA)	If deemed necessary prior to start of sampling activities	External	Shaw	Shaw Project or Program Chemist	Laboratory QAO	Laboratory QAO	Laboratory QAO and Shaw Project Chemist
Performance Evaluation (audit	If deemed necessary prior to the start of or during sampling activities	External	Shaw - submission of blind performance evaluation samples to laboratory	Shaw Project or Program Chemist	Laboratory QAO	Laboratory QAO	Laboratory QAO and Shaw Project Chemist

QAPP Worksheet #31 – Planned Project Assessments Table (Continued)

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing Corrective Actions	Person(s) Responsible for Monitoring Effectiveness of Corrective Actions
Field audits	every sampling event	Internal	Shaw and/or USACE QAO	Shaw and/or USACE QAO	Shaw Technical Manager; Field Sampling Technician or Project Chemist	Shaw Technical Manager; Field Sampling Technician or Project Chemist	Laboratory QAO and Shaw Project Chemist
Field documentation review	every sampling event	Internal	Shaw	Shaw Program Chemist or Field QC Manager	Shaw Technical Manager; Field Sampling Technician or Project Chemist	Shaw Technical Manager; Field Sampling Technician or Project Chemist	Shaw Program Chemist or Field QC Manager

Note(s):

ELAP denotes Environmental Laboratory Accreditation Program

NELAP denotes National Environmental Laboratory Accreditation Program.

QAPP Worksheet #32 – Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response	Timeframe for Response
Field Sampling TSA	Written Audit Report	Shaw QC Manager	48 hours after audit	Email or letter	Shaw field technician, Shaw Project Chemist (Susan Huang) Shaw Program Chemist (Pam Moss)	24 hours after notification
Off-Site Laboratory Audit (if performed for project)	Written Audit Report	Empirical, Golf Coast Analytical, RTI, and Microseeps QA Managers and Project Managers	5 days after Audit	Corrective Action Plan	Shaw Project Chemist (Susan Huang) or Shaw Program Chemist (Pam Moss)	10 business days after receiving report
Laboratory Data Review Findings	Memo	Empirical, Golf Coast Analytical , RTI, and Microseeps QA Managers and Project Managers	48 hours after audit	Email or letter	Shaw Project Chemist (Susan Huang) or Shaw Program Chemist (Pam Moss)	3 days after notification

QAPP Worksheet #33 – QA Management Reports Table

Type of Report	Frequency	Projected Delivery Date(s)	Person's Responsible for Report Preparation	Report Recipient(s)
Field Sampling TSA Report	As needed	Within 24 hours of Field Sampling Audit	Shaw QC Manager or Shaw Project Chemist (Susan Huang)	Shaw Technical Manager or Shaw Project Manager (Tom Cooper)
Off-Site Laboratory TSA Report (if performed)	Prior to sample receipt at laboratory	Within 48 hours of on-site audit	Shaw Project Chemist (Susan Huang) or Shaw Program Chemist (Pam Moss)	Empirical, Golf Coast Analytical RTI, and Microseeps QA Managers and Project Managers
Data Validation Report	After all groundwater, soil gas, and soil data package(s) received from laboratory	Within 2 weeks of data package receipt	Shaw Project Chemist (Susan Huang)	Project file
Quarterly Monitoring Report	Quarterly, QAPP/SAP Worksheet #16	QAPP/SAP Worksheet #16	Shaw Technical Manager and Shaw Project Geologist	USACE Project Manager and NMED Hazardous Branch Project Lead

QAPP Worksheet #34 – Verification (Step I) Process Table

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
COC forms	COC forms will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the COC should be initialed by the reviewer, a copy of the COC retained in the project file, and the original and remaining copies taped inside the cooler for shipment.	Internal	Field team leader (Shaw)
Audit reports	Upon report completion, a copy of all audit reports will be placed in the project file. If corrective actions are required, a copy of the documented corrective action taken will be attached to the appropriate audit report in the project file. At the beginning of each week, and at the completion of the site work, project file audit reports will be reviewed internally to ensure that all appropriate corrective actions have been taken and that corrective action reports are attached. If corrective actions have not been taken, the project manager will be notified to ensure action is taken.	Internal	Technical Manager
Field notes/sample collection forms	Field notes and sample collection forms will be reviewed internally and placed in the project file. A copy of the field notes and sample collection forms will be kept in the project file.	Internal	Field team leader (Shaw)
Laboratory data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal. All received data packages will be validated Shaw Project Chemist (Susan Huang) according to the data validation procedures specified in this QAPP/SAP.	Internal	Laboratory, Shaw Project Chemist (Susan Huang)

QAPP Worksheet #35 – Validation (Steps IIa and IIb) Process Table

Step IIa/IIb	Validation Input	Description	Responsible for Validation
IIa	All definitive data collected for the project	Review data package for compliance with approved QAPP/SAP, DoD QSM requirements, EPA Methods, USACE documents, and EPA Functional guidelines	Shaw Project Chemist (Susan Huang)
IIa	Verify that all sampling procedures (per the QAPP/SAP) were followed	Review field sample collection forms for compliance with the approved QAPP/SAP	Shaw Project Chemist (Susan Huang) or Shaw Project QC Manager
IIa	Documentation of all EPA Method QC sample Results	Determine if all EPA Method required QC samples were analyzed and met required control limits per QAPP/SAP and DoD QSM requirements when applicable.	Shaw Project Chemist (Susan Huang)
IIb	Documentation of all QAPP/SAP QC sample Results	Determine if all QAPP/SAP required QC samples were collected and met required control limits per QAPP/SAP and DoD QSM requirements when applicable.	Shaw Project Chemist (Susan Huang)
IIb	Project RLs met	Review all laboratory data to ensure that project specific RLs specified in the QAPP/SAP are met	Shaw Project Chemist (Susan Huang)

Note(s):

IIa denotes compliance with methods, procedures, and contracts.

IIb denotes comparison with measurement performance criteria in the QAPP/SAP.

QAPP Worksheet #36a – Analytical Data Validation (Steps IIa and IIb) Summary Table

Step IIa/IIb	Matrix	Analytical Group	Validation Criteria	Data Validator
IIa and IIb	Groundwater	VOCs – EPA 8260 EDB – EPA 8011 TPH gasoline – EPA 8015 TPH diesel – EPA 8015 VPH – MA DEP EPH – MA DEP SVOCs – EPA 8270 Metals – EPA 6010 Anions – EPA 300.0 Alkalinity – SM 2320B Ammonia – SM 4500B, D TKN – EPA 351.4 o-Phosphorous – SM 4500 PE Total Sulfide – SM 4500 S-2CF TOC – EPA 9060 Dissolved Gases – RSK 175 Stable carbon and hydrogen isotope – Laboratory SOP	QC criteria specified in the following: QAPP/SAP DoD QSM EPA Methods USACE 200-1-10, Guidance for Evaluating`` Performance Based Data (June 30, 2005) USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (Final, June 2008) USEPA Contract Laboratory Program National Functional guidelines for Superfund Inorganic Data Review (Final January 2010)	Shaw Project Chemist (Susan Huang)
IIa and IIb	Soil Gas	VOCs/TPH gas – EPA TO15 APH – MA DEP Fixed Gases – ASTM D2504	QC criteria specified in the following: QAPP/SAP DoD QSM EPA Methods USACE 200-1-10, Guidance for Evaluating Performance-Based Chemical Data (June 30, 2005) USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (Final, June 2008)	Shaw Project Chemist (Susan Huang)

QAPP Worksheet #36b – Analytical Data Validation (Steps IIa and IIb) Summary Table (Continued)

Step IIa/IIb	Matrix	Analytical Group	Validation Criteria	Data Validator
IIa and IIb	Soil	VOCs – EPA 8260 VPH – MA DEP EPH – MA DEP SVOCs – EPA 8270 Lead – EPA 6010	QC criteria specified in the following: QAPP/SAP DoD QSM EPA Methods USACE 200-1-10, Guidance for Evaluating Performance-Based Chemical Data (June 30, 2005) USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (Final, June 2008) USEPA Contract Laboratory Program National Functional guidelines for Superfund Inorganic Data Review (Final January 2010)	Shaw Project Chemist (Susan Huang)

QAPP Worksheet #37 – Usability Assessment

37.1 DATA QUALITY ASSESSMENT REPORT

Based on data validation and data review findings, the Project Chemist will determine if the project DQOs have been met, and will calculate data completeness. To reconcile the collected data with project DQOs and to establish and document data usability, the data will be reviewed against Data Quality Indicators (Section 37.2).

The Project Chemist will prepare a Data Quality Assessment (DQA) for each of the Quarterly Monitoring Events. The DQA will cover the following topics:

- Implementation of sampling design and analysis according to the approved QAPP/SAP (or sample completeness and representativeness)
- Proper frequency of field QC samples and the adequacy of field decontamination procedures
- Accuracy and precision of the data collected
- Data comparability, if appropriate
- Data usability for project decisions

A DQA assessment will be included in each Quarterly Monitoring Report.

37.2 DATA QUALITY INDICATORS

This section defines the Data Quality Indicators and their use for assessment of data quality.

37.2.1 Precision

Precision measures the reproducibility of measurements under a given set of conditions. The following equation illustrates the method for calculating RPD to assess a method's precision:

$$\text{Precision as RPD} = \frac{\text{Absolute (Result} - \text{Duplicate Result)}}{\text{Average (Result + Duplicate Result)}} \times 100\%$$

The laboratory uses MS/MSD pairs to assess the precision of analytical procedures, with one MS/MSD pair analyzed for every batch of up to 20 samples. According to the USACE requirements, analytical laboratories perform MS/MSD on the project samples. This allows determining whether matrix interferences may be present.

The laboratory uses LCS/LCSD pairs when MSs are not practical due to the nature of sample or analytical method used, and they are prepared and analyzed with each batch of samples instead of MS/MSD. Sufficient sample volume will be obtained in the field to perform the MS/MSD analysis. For inorganic analyses, analytical precision is usually calculated based on the sample and sample duplicate results.

Laboratories will use precision limits specified in the DoD QSM for both LCS and MS analyses (DoD, 2009). When precision limits are not available in the DoD QSM, laboratories may use statistically-based acceptability limits for RPDs established for each method of analysis and sample matrix. The laboratory will review the QC samples to ensure that internal QC data lie within the limits of acceptability. Any suspect trends will be investigated and corrective actions taken.

37.2.2 Accuracy

Accuracy measures the bias of an analytical system by comparing the difference of a measurement with a reference value. The percent recovery of an analyte, which has been added to the environmental samples at a known concentration before extraction and analysis, provides a quantitation tool for analytical accuracy. The spiking solutions used for accuracy determinations are not used for instrument calibrations. The following equation illustrates how accuracy is evaluated:

$$\text{Accuracy as Percent Recovery} = \frac{\text{Spiked Sample Result} - \text{Sample Result}}{\text{Spiked Sample True Value}} \times 100\%$$

Percent recoveries for MS, MSD, and LCS that are analyzed for every batch of up to 20 samples serve as a measure of analytical accuracy. Surrogate standards are added to all samples, blanks, MS, MSD, and LCS analyzed for organic contaminants to evaluate accuracy of the method and help to determine matrix interferences.

Laboratories will use LCS limits specified in the DoD QSM for both LCS and MS analyses (2009). When LCS limits are not available in the DoD QSM, the laboratory may use in-house statistically-based control limits or control limits specified in EPA Methods.

Control limits are defined as the mean recovery, plus or minus three standard deviations, of the 20 data points, with the warning limits set as the mean, plus or minus two standard deviations. The laboratory will review the QC samples and surrogate standard recoveries for each analysis to ensure that internal QC data lay within the limits of acceptability. The laboratory will investigate any suspect trends and take appropriate corrective actions.

37.2.3 Representativeness

Unlike precision and accuracy, which can be expressed in quantitative terms, representativeness is a qualitative parameter. Representativeness is the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. A qualitative parameter depends on proper design of the sampling program.

Field personnel will be responsible for ensuring that samples are representative of field conditions by collecting and handling samples according to the approved QAPP/SAP. Errors in sample collection, packaging, preservation, or COC procedures may result in samples being judged non-representative and may form a basis for rejecting the data.

Data generated by the laboratory must be representative of the laboratory database of accuracy and precision measurements for analytes in different matrices. Laboratory procedures for sample preparation will ensure that aliquots used for analysis are representative of the whole sample. Aliquots to be analyzed for volatile (if any) parameters will be removed before the laboratory composites/homogenizes the samples, to avoid losing volatile compounds during mixing.

37.2.4 Comparability

Comparability is a qualitative parameter expressing the confidence where one data set can be compared with another, whether it was generated by a single laboratory or during inter-laboratory studies. The use of standardized field and analytical procedures ensures comparability of analytical data.

Sample collection and handling procedures will adhere to EPA-approved protocols. Laboratory procedures will follow standard analytical protocols, use standard units and standardized report formats, follow the calculations as referenced in approved analytical methods, and use a standard statistical approach for QC measurements.

37.2.5 Completeness

Completeness goals for each sampling round are defined in the following section.

Contractual Completeness

The contractual completeness goal is set at 95 percent for all methods and is calculated as defined below. Holding time completeness is set at 100 percent for all methods. The following QC elements are typically within the laboratory's control and will be considered contractual deficiencies for the purposes of contractual completeness calculation.

- Holding time
- Laboratory blank contamination
- Initial calibration verification
- CCV
- LCSs

$$\%\ \text{Contract Completeness} = \frac{\text{Number of Unqualified Results*}}{\text{Number of Results Reported}} \times 100\%$$

** Determined by subtracting the results qualified based on contractual deficiencies from the total number of results*

Analytical Completeness

The analytical completeness goal is set at 90 percent for all methods and is calculated as defined below. The following QC elements will be considered analytical deficiencies for the purposes of the analytical completeness calculation.

- Holding time
- Laboratory blank contamination
- Field blank contamination (trip, equipment, ambient and rinse)
- Initial calibration verification
- CCV
- LCSs
- MS recovery
- MS precision
- Surrogate recovery

$$\%\ \text{Analytical Completeness} = \frac{\text{Number of Unqualified Results*}}{\text{Number of Results Reported}} \times 100\%$$

* *Determined by subtracting results qualified for any of the deficiencies from the total number of results.*

Technical Completeness

The technical completeness goal is set at 95 percent for all methods and is calculated as defined below. Results considered unusable (or rejected) for the intended purpose based on contractual or technical deficiencies will be included for the purposes of the technical completeness calculation.

$$\%\ \text{Technical Completeness} = \frac{\text{Number of Useable Results*}}{\text{Number of Results Reported}} \times 100\%$$

** Technical completeness (i.e., usability) will be determined by subtracting results rejected for any reason from the total number of results reported.*

Project-Required Reporting Limits – Sensitivity

Following the DoD QSM requirements, the laboratory will determine the MDLs for each method, instrument, analyte, and matrix by using the procedure described in Title 40 Code of Federal Regulations Part 136B. The MDL is defined as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero.

An MDL study involves preparation/digestion and analysis of seven replicates of a given matrix spiked with target analytes at concentrations two to five times greater than the estimated MDL. The MDLs for metals in soil will be derived from the MDLs for metals in water. At a minimum, the laboratory will conduct annual MDL studies. Alternatively, the laboratory will conduct quarterly MDL verifications.

Additionally, the laboratory will establish LOD and LOQ for each method, analyte, matrix, and instrument in accordance with the DoD QSM requirements (2009). The LOD is the smallest amount of a substance that must be present in a sample in order to be detected at a 99 percent confidence level. The LOQ is the lowest concentration of a substance that produces a quantitative result within specific limits of precision and bias. The laboratory will perform quarterly LOD and LOQ verifications to verify method sensitivity. The LOQ is greater than LOD and must be within the calibration range prior to sample analysis.

Project RL goals are presented in Worksheet #15a through 15d. The actual RLs may be higher when corrected for amount of sample used for analysis. The RLs for individual samples may also be higher if matrix interferences are encountered. For this project, the laboratory will report positive results down to MDL. Results below between the RL and MDL will be reported as estimated values.

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FIGURES

Figure 1. Project Organization Chart

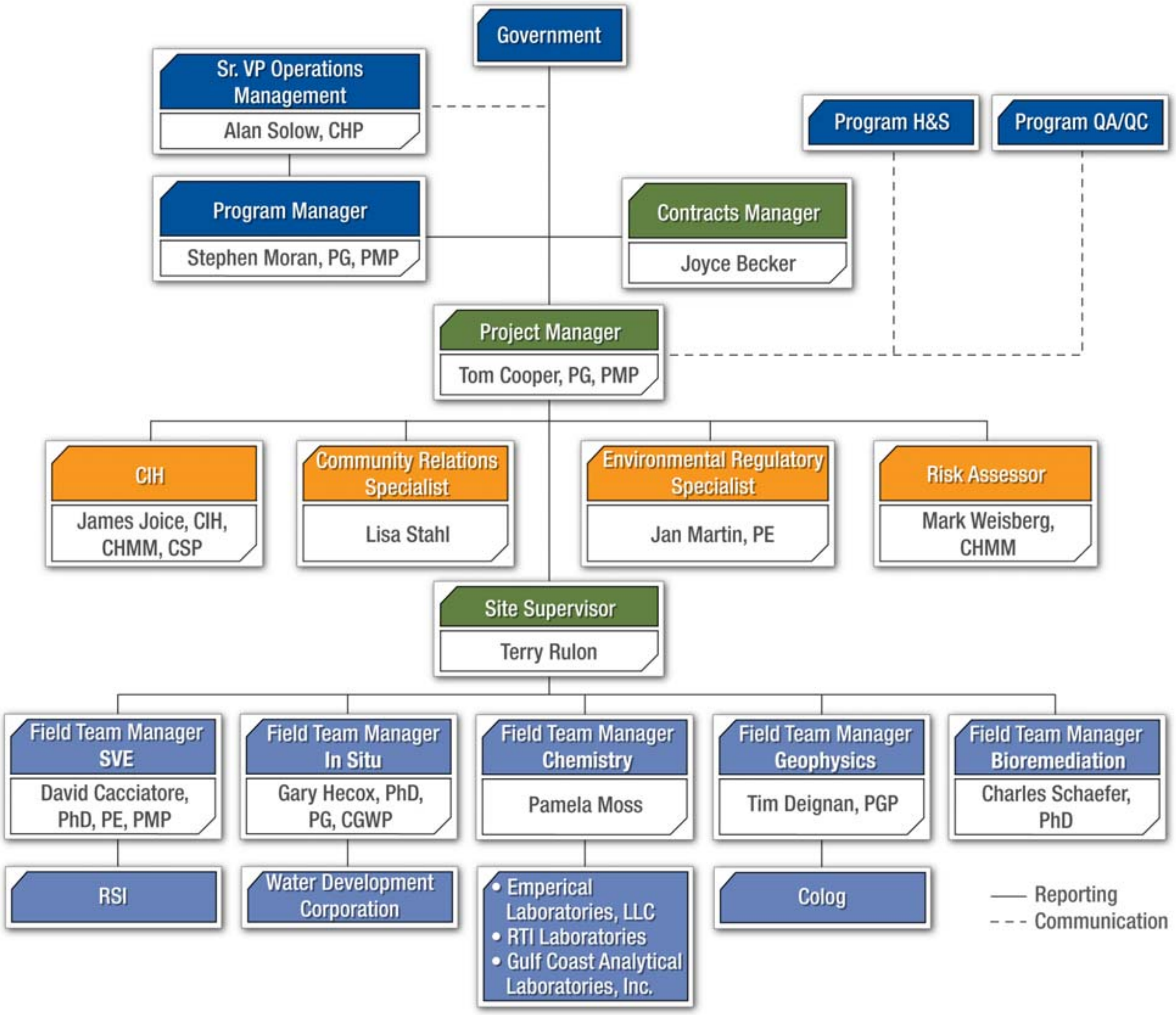

Figure 2. Site Map and Proposed Well Locations

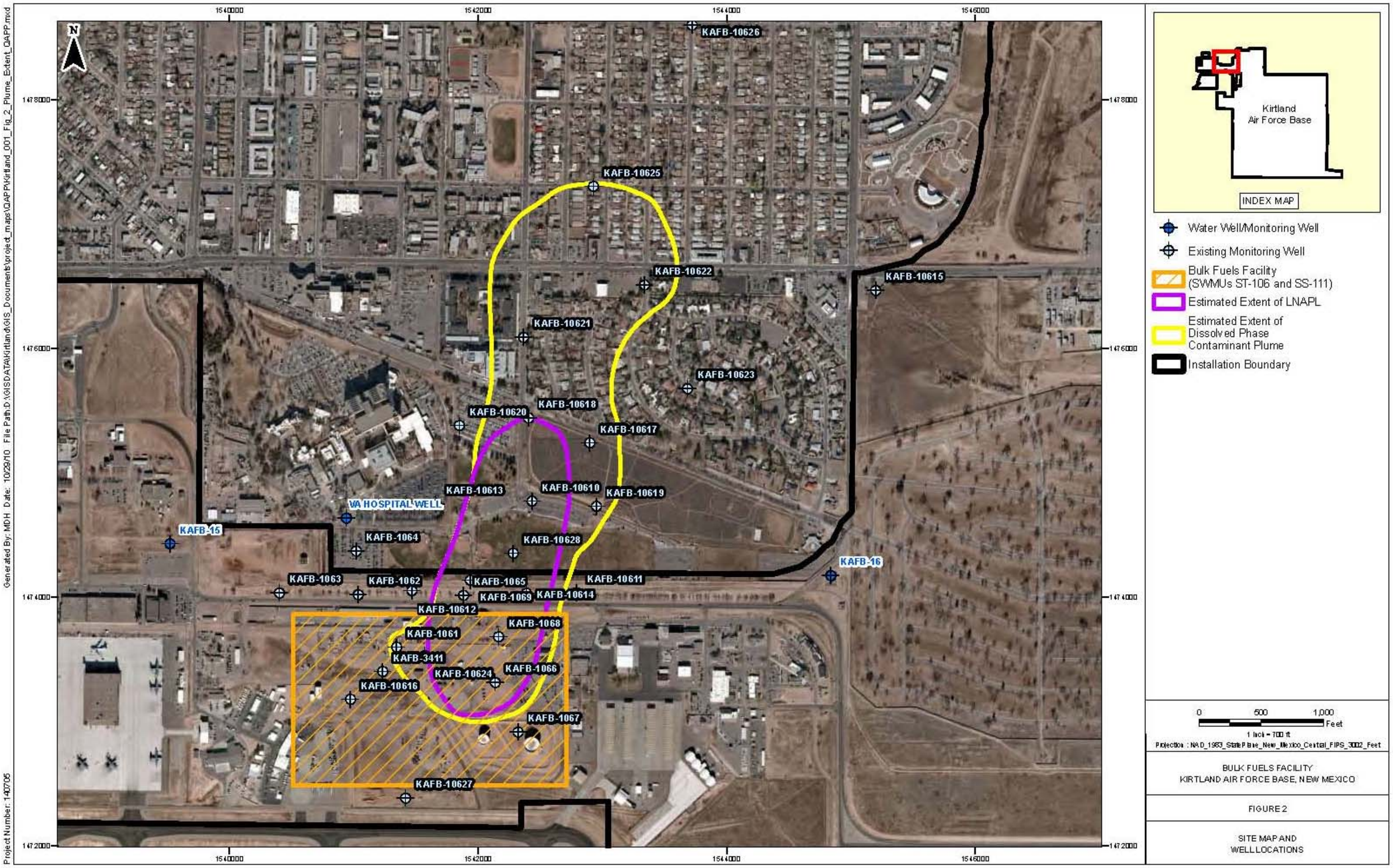

Figure 3. Chain of Custody

Shaw® Shaw E & I

FS003.1_0

Ref. Document # ____________

Page ______ of ___

Shaw E & I Chain of Custody Form

Project Number: ____________

Project Name / Location: ____________

Purchase Order #: ____________

Project Contact: ____________ (Name & phone #)

Shipment Date: ____________

Waybill/Airbill Number: ____________

Lab Destination: ____________

Lab Contact Name / ph. #: ____________

Send Report To: ____________

Phone/Fax Number: ____________

Address: ____________

City: ____________

Sampler's Name(s): ____________

Sample ID Number	Sample Description	Collection Information: Date	Time	G/C	Matrix	# of containers	Container type	Preservative: HCL	NaOH	HNO_3	H_2SO_4	Ice	Analyses Requested										Turn Around Time Requested

Special Instructions:

QC/Data Package Level Required: I II III IV/Project Specific: ____________

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

G/C Codes

C = Composite G = Grab

Matrix Codes

DW = Drinking Water SO = Soil

GW = Ground Water SL = Sludge

WW = Waste Water CP = Chip Samples

SW = Surface Water WP = Wipe Samples

LIQ = Other Liquid SOL = Other Solid

AS = Air Sample SED = Sediment

Figure 3. Chain of Custody

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Shaw E & I COC Continuation Page

COC Ref. Document # ____________ Page ______ of ______

Project Number: ____________ Shipment Date: ____________

Project Name / Location: ____________

		Collection Information						Preservative						Analyses Requested										
Sample ID Number	Sample Description	Date	Time	G/C	Matrix	# of containers	Container type	HCL	NaOH	HNO_3	H_2SO_4	Ice												Turn Around Time Requested

APPENDIX A
SUMMARY OF CONTROL LIMITS FOR GROUNDWATER, SOIL GAS, AND SOIL SAMPLES
(from DoD QSM Version 4.1, April 22, 2009)

DoD Quality Systems Manual for Environmental Laboratories

Version 4.1

Based on NELAC Voted Revision
5 June 2003

4/22/2009

presented in Table G-2. The lower control limit generated for alternative or modified methods must be greater than 10% to be considered acceptable.

G.6 Surrogates

The surrogate compounds for each method are added to all samples, standards, and blanks to assess the ability of the method to recover specific non-target analytes from a given matrix and to monitor sample-specific recovery. Control limits for these compounds were calculated in the same study as the other analytes on the target analyte lists. Below are the limits for some of the surrogates of Methods 8260, 8270, 8081, and 8082, based on 3 standard deviations around the mean (Table G-3). Sufficient data were not received for those analytes during the LCS study to perform statistically significant analyses. No ME limits are presented as marginal exceedances are not acceptable for surrogate spikes.

Note: DoD prefers the use of those surrogates not identified as poor performing analytes in Table G-2 above.

Table G-3. Surrogates

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
8260 Water:				
1,2-Dichloroethane-d_4	95	8	70	120
4-Bromofluorobenzene	98	7	75	120
Dibromofluoromethane	100	5	85	115
Toluene-d_8	102	6	85	120
8260 Solid:				
4-Bromofluorobenzene	101	6	85	120
Toluene-d_8	100	5	85	115
8270 Water:				
2-Fluorobiphenyl	79	10	50	110
Terphenyl-d_{14}	92	14	50	135
2,4,6-Tribromophenol	82	13	40	125
2-Fluorophenol	63	14	20	110
Nitrobenzene-d_5	76	11	40	110
8270 Solid:				
2-Fluorobiphenyl	72	10	45	105
Terphenyl-d_{14}	78	15	30	125
2,4,6-Tribromophenol	80	15	35	125
2-Fluorophenol	70	11	35	105
Phenol-d_5/d_6	71	10	40	100
Nitrobenzene-d_5	69	10	35	100
8081 Water:				
Decachlorobiphenyl	83	17	30	135
TCMX	81	19	25	140
8081 Solid:				
Decachlorobiphenyl	94	13	55	130
TCMX	97	9	70	125
8082 Water:				
Decachlorobiphenyl	88	15	40	135
8082 Solid:				
Decachlorobiphenyl	91	11	60	125

G.7 In-House LCS Control Limits

The acceptability of LCS results within any preparatory batch shall be based on project-specified limits or the following DoD-specified LCS control limits, if project-specific limits are not available. If DoD limits are not available, the laboratory must use its in-house limits for batch acceptance.

DoD strongly believes that it is important for laboratories to maintain their own in-house LCS limits. These in-house limits must be consistent with (i.e., within) the DoD limits (project-specific, if available; otherwise the following LCS-CLs). The laboratory in-house limits shall be calculated from the laboratory's historical LCS data in accordance with a documented procedure (e.g., SOP) that is consistent with good laboratory practice. That document must describe the process for establishing and maintaining LCS limits and the use of control charts.

The laboratory in-house limits are to be used for several purposes:

- Laboratories are expected to utilize their in-house limits as part of their quality control system, and to evaluate trends and monitor and improve performance.
- When a laboratory's in-house limits are outside the DoD control limits (upper and/or lower), they must report their in-house limits in the laboratory report (see Appendix E) even if the LCS associated with the batch fell within the DoD limits. Using this information, DoD will be able to determine how laboratory performance affects the quality of the environmental data.
- DoD may review the laboratory in-house limits and associated trends, as reflected in control charts, to determine whether the laboratory's overall performance is acceptable. If deemed unacceptable, this can allow DoD to decide not to use the laboratory again until substantial improvement has occurred.

Table G-4. LCS Control Limits for Volatile Organic Compounds SW-846 Method 8260 Water Matrix[2]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
1,1,1,2-Tetrachloroethane	105	8	80	130	75	135
1,1,1-Trichloroethane	100	11	65	130	55	145
1,1,2,2-Tetrachloroethane	96	11	65	130	55	140
1,1,2-Trichloroethane	100	8	75	125	65	135
1,1-Dichloroethane	101	11	70	135	60	145
1,1-Dichloroethene	99	10	70	130	55	140
1,1-Dichloropropene	102	10	75	130	65	140
1,2,3-Trichlorobenzene	99	14	55	140	45	155
1,2,3-Trichloropropane	98	9	75	125	65	130
1,2,4-Trichlorobenzene	100	11	65	135	55	145
1,2,4-Trimethylbenzene	103	10	75	130	65	140
1,2-Dibromo-3-chloropropane	91	14	50	130	35	145
1,2-Dibromoethane	100	7	80	120	75	125
1,2-Dichlorobenzene	96	9	70	120	60	130
1,2-Dichloroethane	100	10	70	130	60	140
1,2-Dichloropropane	100	8	75	125	65	135
1,3,5-Trimethylbenzene	102	10	75	130	65	140
1,3-Dichlorobenzene	100	8	75	125	65	130
1,3-Dichloropropane	100	9	75	125	65	135
1,4-Dichlorobenzene	99	8	75	125	65	130
2,2-Dichloropropane	103	11	70	135	60	150
2-Butanone	91	20	30	150	10	170

[2] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits are not available for Total Xylene. Xylene may be reported on a project-specific basis as a total number; however, for the purposes of the DoD QSM, it will be analyzed and reported as m,p-Xylene and o-Xylene. Additional limits for poor performing compounds can be found in section G.5 and for surrogate compounds in section G.6.

Table G-4. LCS Control Limits for Volatile Organic Compounds SW-846 Method 8260 Water Matrix[2] (continued)

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
2-Chlorotoluene	100	9	75	125	65	135
2-Hexanone	92	12	55	130	45	140
4-Chlorotoluene	101	9	75	130	65	135
4-Methyl-2-pentanone	96	13	60	135	45	145
Acetone	91	17	40	140	20	160
Benzene	102	7	80	120	75	130
Bromobenzene	100	8	75	125	70	130
Bromochloromethane	97	11	65	130	55	140
Bromodichloromethane	98	8	75	120	70	130
Bromoform	99	10	70	130	60	140
Bromomethane	88	19	30	145	10	165
Carbon disulfide	100	21	35	160	15	185
Carbon tetrachloride	102	12	65	140	55	150
Chlorobenzene	102	7	80	120	75	130
Chlorodibromomethane	96	13	60	135	45	145
Chloroethane	99	12	60	135	50	145
Chloroform	100	12	65	135	50	150
Chloromethane	83	15	40	125	25	140
cis-1,2-Dichloroethene	99	9	70	125	60	135
cis-1,3-Dichloropropene	100	10	70	130	60	140
Dibromomethane	101	8	75	125	65	135
Dichlorodifluoromethane	93	21	30	155	10	175
Ethylbenzene	100	9	75	125	65	135
Hexachlorobutadiene	97	15	50	140	35	160
Isopropylbenzene	101	9	75	125	65	135
m,p-Xylene	102	9	75	130	65	135
Methyl tert-butyl ether	94	10	65	125	55	135
Methylene chloride	96	14	55	140	40	155
Naphthalene	96	14	55	140	40	150
n-Butylbenzene	103	11	70	135	55	150
n-Propylbenzene	101	9	70	130	65	140
o-Xylene	100	7	80	120	75	130
p-Isopropyltoluene	102	10	75	130	65	140
sec-Butylbenzene	100	9	70	125	65	135
Styrene	100	11	65	135	55	145
tert-Butylbenzene	99	10	70	130	60	140
Tetrachloroethene	96	18	45	150	25	165
Toluene	100	7	75	120	70	130
trans-1,2-Dichloroethene	99	13	60	140	45	150
trans-1,3-Dichloropropene	98	15	55	140	40	155
Trichloroethene	99	9	70	125	60	135
Trichlorofluoromethane	103	15	60	145	45	160
Vinyl chloride	99	16	50	145	35	165

Table G-5. LCS Control Limits for Volatile Organic Compounds SW-846 Method 8260 Solid Matrix[3]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
1,1,1,2-Tetrachloroethane	100	9	75	125	65	135
1,1,1-Trichloroethane	101	11	70	135	55	145
1,1,2,2-Tetrachloroethane	93	13	55	130	40	145
1,1,2-Trichloroethane	95	11	60	125	50	140
1,1-Dichloroethane	99	9	75	125	65	135
1,1-Dichloroethene	100	12	65	135	55	150
1,1-Dichloropropene	102	11	70	135	60	145
1,2,3-Trichlorobenzene	97	12	60	135	50	145
1,2,3-Trichloropropane	97	11	65	130	50	140
1,2,4-Trichlorobenzene	98	11	65	130	55	140
1,2,4-Trimethylbenzene	100	12	65	135	55	145
1,2-Dibromo-3-chloropropane	87	16	40	135	25	150
1,2-Dibromoethane	97	9	70	125	60	135
1,2-Dichlorobenzene	97	7	75	120	65	125
1,2-Dichloroethane	104	11	70	135	60	145
1,2-Dichloropropane	95	8	70	120	65	125
1,3,5-Trimethylbenzene	99	11	65	135	55	145
1,3-Dichlorobenzene	98	9	70	125	65	135
1,3-Dichloropropane	100	8	75	125	70	130
1,4-Dichlorobenzene	98	9	70	125	65	135
2,2-Dichloropropane	101	11	65	135	55	145
2-Butanone	94	22	30	160	10	180
2-Chlorotoluene	98	10	70	130	60	140
2-Hexanone	97	16	45	145	30	160
4-Chlorotoluene	100	9	75	125	65	135
4-Methyl-2-pentanone	97	17	45	145	30	165
Acetone	88	23	20	160	10	180
Benzene	99	9	75	125	65	135
Bromobenzene[4]	93	9	65	120	55	130
Bromochloromethane	99	9	70	125	60	135
Bromodichloromethane	100	9	70	130	60	135
Bromoform	96	13	55	135	45	150
Bromomethane	95	21	30	160	10	180
Carbon disulfide	103	19	45	160	30	180
Carbon tetrachloride	100	11	65	135	55	145
Chlorobenzene	99	8	75	125	65	130
Chlorodibromomethane	98	11	65	130	55	140
Chloroethane	98	20	40	155	20	175

[3] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits are not available for Methyl tert-butyl ether and Total Xylene. Sufficient data to perform statistically significant analyses were not received for MTBE during the LCS study. Xylene may be reported on a project-specific basis as a total number; however, for the purposes of the DoD QSM, it will be analyzed and reported as m,p-Xylene and o-Xylene. Additional limits for poor performing compounds can be found in section G.5 and for surrogate compounds in section G.6.

[4] Provisional limits – outlier analyses during the LCS study resulted in LCS-CLs generated with data from fewer than four laboratories. Limits may be adjusted in the future as additional data become available.

Table G-5. LCS Control Limits for Volatile Organic Compounds SW-846 Method 8260 Solid Matrix[3] (continued)

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
Chloroform	98	9	70	125	65	135
Chloromethane	90	13	50	130	40	140
cis-1,2-Dichloroethene	96	10	65	125	55	135
cis-1,3-Dichloropropene	99	9	70	125	65	135
Dibromomethane	100	9	75	130	65	135
Dichlorodifluoromethane[4]	85	17	35	135	15	155
Ethylbenzene	101	9	75	125	65	135
Hexachlorobutadiene	98	15	55	140	40	155
Isopropylbenzene	103	9	75	130	70	140
m,p-Xylene	102	8	80	125	70	135
Methylene chloride	97	14	55	140	40	155
Naphthalene	84	14	40	125	25	140
n-Butylbenzene	101	12	65	140	50	150
n-Propylbenzene	99	12	65	135	50	145
o-Xylene	101	8	75	125	70	135
p-Isopropyltoluene	104	10	75	135	65	140
sec-Butylbenzene	97	11	65	130	50	145
Styrene	101	9	75	125	65	135
tert-Butylbenzene	99	11	65	130	55	145
Tetrachloroethene	103	12	65	140	55	150
Toluene	99	9	70	125	60	135
trans-1,2-Dichloroethene	100	11	65	135	55	145
trans-1,3-Dichloropropene	96	10	65	125	55	140
Trichloroethene	101	8	75	125	70	130
Trichlorofluoromethane	106	27	25	185	10	215
Vinyl chloride	92	11	60	125	45	140

Table G-6. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270 Water Matrix[5]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
Polynuclear Aromatics						
2-Methylnaphthalene	75.0	9.5	45	105	35	115
Acenaphthene	77.6	10.1	45	110	35	120
Acenaphthylene	78.5	9.4	50	105	40	115
Anthracene	83.0	9.7	55	110	45	120
Benz[a]anthracene	82.7	8.9	55	110	45	120
Benzo[a]pyrene	81.3	9.5	55	110	45	120

[5] A number of sporadic marginal exceedances of the control limits are allowed depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits are not available for Benzidine, 2,6-Dichlorophenol, and N-nitrosopyrrolidine. Sufficient data to perform statistically significant analyses were not received for those analytes during the LCS study. Additional limits for poor performing compounds can be found in section G.5.

Table G-6. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270 Water Matrix[5] (continued)

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
Benzo[b]fluoranthene	81.8	12.1	45	120	35	130
Benzo[k]fluoranthene	84.6	13.2	45	125	30	135
Benzo[g,h,i]perylene	80.5	14.1	40	125	25	135
Chrysene	82.1	8.9	55	110	45	120
Dibenz[a,h]anthracene	84.7	14.1	40	125	30	140
Fluoranthene	85.2	10.4	55	115	45	125
Fluorene	80.6	10.3	50	110	40	120
Indeno[1,2,3-cd]pyrene	84.3	13.6	45	125	30	140
Naphthalene	70.8	10.5	40	100	30	115
Phenanthrene	84.0	11.0	50	115	40	130
Pyrene	88.6	13.2	50	130	35	140
Phenolic/Acidic						
2,4,5-Trichlorophenol	79.7	10.3	50	110	40	120
2,4,6-Trichlorophenol	80.7	10.7	50	115	40	125
2,4-Dichlorophenol	76.3	9.6	50	105	40	115
2,4-Dimethylphenol	68.8	13.5	30	110	15	125
2,4-Dinitrophenol	75.8	20.6	15	140	10	160
2-Chlorophenol	71.3	11.4	35	105	25	115
2-Methylphenol	73.3	11.7	40	110	25	120
2-Nitrophenol	75.8	12.4	40	115	25	125
3-Methylphenol/4-Methylphenol	71.3	13.0	30	110	20	125
4,6-Dinitro-2-methylphenol	84.9	15.0	40	130	25	145
4-Chloro-3-methylphenol	78.6	10.7	45	110	35	120
Pentachlorophenol	77.6	13.3	40	115	25	130
Basic						
3,3'-Dichlorobenzidine	65.2	15.3	20	110	10	125
4-Chloroaniline	62.2	15.6	15	110	10	125
Phthalate Esters						
Bis(2-ethylhexyl) phthalate	84.2	14.0	40	125	30	140
Butyl benzyl phthalate	81.1	11.7	45	115	35	130
Di-n-butyl phthalate	84.8	10.3	55	115	45	125
Di-n-octyl phthalate	87.4	16.6	35	135	20	155
Diethyl phthalate	79.2	12.9	40	120	30	130
Dimethyl phthalate	75.9	16.9	25	125	10	145
Nitrosoamines						
N-Nitrosodi-n-propylamine	80.9	15.7	35	130	20	145
N-Nitrosodimethylamine	67.9	14.1	25	110	10	125
N-Nitrosodiphenylamine	79.6	10.6	50	110	35	120
Chlorinated Aliphatics						
Bis(2-chlorethoxy)methane	76.2	10.2	45	105	35	115
Bis(2-chloroethyl) ether	73.3	12.3	35	110	25	120
Bis(2-chloroisopropyl) ether	78.2	17.5	25	130	10	150
Hexachlorobutadiene	65.2	12.6	25	105	15	115
Hexachloroethane	60.9	11.1	30	100	15	105

Table G-6. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270 Water Matrix[5] (continued)

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
Halogenated Aromatics						
1,2,4-Trichlorobenzene	71.7	11.6	35	105	25	120
1,2-Dichlorobenzene	67.3	11.4	35	100	20	115
1,3-Dichlorobenzene	64.8	10.9	30	100	20	110
1,4-Dichlorobenzene	64.8	10.9	30	100	20	110
2-Chloronaphthalene	76.5	9.3	50	105	40	115
4-Bromophenyl phenyl ether	82.9	10.2	50	115	40	125
4-Chlorophenyl phenyl ether	80.6	10.3	50	110	40	120
Hexachlorobenzene	82.3	10.0	50	110	40	120
Nitroaromatics						
2,4-Dinitrotoluene	84.3	11.2	50	120	40	130
2,6-Dinitrotoluene	82.7	11.3	50	115	35	130
2-Nitroaniline	81.8	11.2	50	115	35	125
3-Nitroaniline	72.6	17.7	20	125	10	145
4-Nitroaniline	77.2	13.7	35	120	20	130
Nitrobenzene	76.8	10.8	45	110	35	120
Neutral Aromatics						
Carbazole	82.5	11.4	50	115	35	130
Dibenzofuran	80.3	8.8	55	105	45	115
Others						
1,2-Diphenylhydrazine	84.8	9.4	55	115	45	120
Benzyl alcohol	71.0	13.8	30	110	15	125
Isophorone	81.0	10.5	50	110	40	125

Table G-7. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270 Solid Matrix[6]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
Polynuclear Aromatics						
2-Methylnaphthalene	77.3	10.0	45	105	35	115
Acenaphthene	77.3	10.3	45	110	35	120
Acenaphthylene	75.7	10.4	45	105	35	115
Anthracene	79.9	9.0	55	105	45	115
Benz[a]anthracene	81.6	9.8	50	110	40	120
Benzo[a]pyrene	80.7	10.3	50	110	40	120
Benzo[b]fluoranthene	79.7	11.4	45	115	35	125
Benzo[k]fluoranthene	83.8	12.9	45	125	30	135
Benzo[g,h,i]perylene	81.8	14.7	40	125	25	140
Chrysene	82.6	9.9	55	110	45	120

[6] A number of sporadic marginal exceedances (ME) of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits are not available for Benzidine, 2,6-Dichlorophenol, 1,2-Diphenylhydrazine, and N-nitrosopyrrolidine. Sufficient data to perform statistically significant analyses were not received for those analytes during the LCS study. Additional limits for poor performing compounds can be found in section G.5.

Table G-7. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270 Solid Matrix[6] (continued)

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
Dibenz[a,h]anthracene	82.9	13.9	40	125	25	140
Fluoranthene	83.9	10.1	55	115	45	125
Fluorene	78.3	9.8	50	110	40	115
Indeno[1,2,3-cd]pyrene	79.7	13.8	40	120	25	135
Naphthalene	73.4	11.1	40	105	30	120
Phenanthrene	80.1	10.0	50	110	40	120
Pyrene	84.4	12.8	45	125	35	135
Phenolic/Acidic						
2,4,5-Trichlorophenol	80.1	10.4	50	110	40	120
2,4,6-Trichlorophenol	76.3	11.0	45	110	30	120
2,4-Dichlorophenol	77.2	10.9	45	110	35	120
2,4-Dimethylphenol	67.3	11.9	30	105	20	115
2,4-Dinitrophenol	72.6	20.0	15	130	10	150
2-Chlorophenol	74.7	10.3	45	105	35	115
2-Methylphenol	71.7	10.6	40	105	30	115
2-Nitrophenol	76.2	11.5	40	110	30	120
3-Methylphenol/4-Methylphenol	73.9	10.9	40	105	30	120
4,6-Dinitro-2-methylphenol	83.1	18.0	30	135	10	155
4-Chloro-3-methylphenol	79.5	11.1	45	115	35	125
4-Nitrophenol	77.0	20.2	15	140	10	160
Pentachlorophenol	71.9	15.6	25	120	10	135
Phenol	69.7	10.2	40	100	30	110
Phthalate Esters						
Bis(2-ethylhexyl) phthalate	87.4	13.3	45	125	35	140
Butyl benzyl phthalate	86.4	12.3	50	125	35	135
Di-n-butyl phthalate	83.2	9.1	55	110	45	120
Di-n-octyl phthalate	86.4	15.2	40	130	25	145
Diethyl phthalate	82.2	10.6	50	115	40	125
Dimethyl phthalate	79.6	10.2	50	110	40	120
Nitrosoamines						
N-Nitrosodi-n-propylamine	76.8	12.3	40	115	30	125
N-Nitrosodimethylamine	66.1	15.9	20	115	10	130
N-Nitrosodiphenylamine	82.4	11.1	50	115	40	125
Chlorinated Aliphatics						
Bis(2-chlorethoxy)methane	75.5	10.9	45	110	30	120
Bis(2-chloroethyl) ether	71.1	11.2	40	105	25	115
Bis(2-chloroisopropyl) ether	68.4	15.7	20	115	10	130
Hexachlorobutadiene	78.2	12.9	40	115	25	130
Hexachloroethane	71.9	12.6	35	110	20	120
Halogenated Aromatics						
1,2,4-Trichlorobenzene	77.4	11.2	45	110	30	120
1,2-Dichlorobenzene	70.9	8.7	45	100	35	105
1,3-Dichlorobenzene	69.7	10.3	40	100	30	110
1,4-Dichlorobenzene	69.0	11.4	35	105	25	115

Table G-7. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270 Solid Matrix (continued)

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
2-Chloronaphthalene	75.2	9.9	45	105	35	115
4-Bromophenyl phenyl ether	81.7	11.8	45	115	35	130
4-Chlorophenyl phenyl ether	79.6	10.7	45	110	35	120
Hexachlorobenzene	82.5	11.7	45	120	35	130
Nitroaromatics						
2,4-Dinitrotoluene	82.0	11.4	50	115	35	130
2,6-Dinitrotoluene	80.2	10.7	50	110	35	125
2-Nitroaniline	81.0	12.2	45	120	30	130
3-Nitroaniline	68.8	13.8	25	110	15	125
4-Nitroaniline	73.6	13.1	35	115	20	125
Nitrobenzene	77.2	11.9	40	115	30	125
Neutral Aromatics						
Carbazole	80.4	12.3	45	115	30	130
Dibenzofuran	77.1	8.8	50	105	40	110
Others						
Benzyl alcohol	70.9	17.4	20	125	10	140
Isophorone	77.0	11.4	45	110	30	125

Table G-8. LCS Control Limits for Chlorinated Herbicides SW-846 Method 8151 Water Matrix[7]

Analyte	Median	Lower Control Limit	Upper Control Limit
2,4-D	88	35	115
2,4-DB	99	45	130
2,4,5-T	83	35	110
2,4,5-TP (Silvex)	87	50	115
Dalapon	62	40	110
Dicamba	86	60	110
Dichloroprop	91	70	120
Dinoseb	65	20	100
MCPA	93	60	145

[7] LCS control limits were generated using non-parametric statistics (see section G.1 for further explanation). LCS control limits are not available for MCPP. Sufficient data to perform statistically significant analyses were not received for the analyte during the LCS study.

Table G-9. LCS Control Limits for Chlorinated Herbicides SW-846 Method 8151 Solid Matrix[8]

Analyte	Median	Lower Control Limit	Upper Control Limit
2,4-D	88	35	145
2,4-DB	108	50	155
2,4,5-T	86	45	135
2,4,5-TP (Silvex)	90	45	125
Dicamba	90	55	110
Dichloroprop	99	75	140

Table G-10. LCS Control Limits for Polynuclear Aromatic Hydrocarbons SW-846 Method 8310 Water Matrix[9]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
Acenaphthene	70	11	35	105	25	115
Acenaphthylene	74	13	35	115	20	125
Anthracene	77	12	40	110	30	125
Benz[a]anthracene	81	11	50	110	40	125
Benzo[a]pyrene	79	11	45	115	35	125
Benzo[b]fluoranthene	82	10	50	110	40	125
Benzo[k]fluoranthene	79	10	50	110	40	120
Benzo[g,h,i]perylene	77	14	35	120	20	135
Chrysene	83	11	50	115	40	125
Dibenz[a,h]anthracene	64	15	20	110	10	125
Fluoranthene	82	11	50	115	35	125
Fluorene	69	11	35	105	25	115
Indeno[1,2,3-cd]pyrene	80	11	45	110	35	125
Naphthalene	68	12	35	105	20	115
Phenanthrene	80	13	40	120	25	135
Pyrene	80	9	50	110	45	115

[8] LCS control limits were generated using non-parametric statistics (see section G.1 for further explanation). LCS control limits are not available for Dalapon, MCPA, and MCPP. Sufficient data to perform statistically significant analyses were not received for those analytes during the LCS study. Additional limits for poor performing compounds can be found in section G.5.

[9] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits.

Table G-11. LCS Control Limits for Polynuclear Aromatic Hydrocarbons SW-846 Method 8310 Solid Matrix[10]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
Acenaphthene	71	12	35	110	20	120
Acenaphthylene	73	13	35	115	20	125
Anthracene	86	13	45	125	35	140
Benz[a]anthracene	78	9	50	105	40	115
Benzo[a]pyrene	86	15	40	135	25	150
Benzo[b]fluoranthene	89	11	55	120	45	130
Benzo[k]fluoranthene	84	12	50	120	35	135
Benzo[g,h,i]perylene[11]	85	10	55	115	45	125
Chrysene	87	11	55	120	45	130
Dibenz[a,h]anthracene	81	11	45	115	35	125
Fluoranthene	88	16	40	135	25	150
Fluorene	76	10	45	105	35	115
Indeno[1,2,3-cd]pyrene	95	13	55	135	45	145
Naphthalene	80	11	50	110	40	120
Phenanthrene	91	12	55	125	45	135
Pyrene	82	11	50	115	40	125

Table G-12. LCS Control Limits for Explosives SW-846 Methods 8330 and 8330A Water Matrix[12]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
1,3,5-Trinitrobenzene	102	13	65	140	50	150
1,3-Dinitrobenzene	103	18	45	160	30	175
2,4-Dinitrotoluene	98	12	60	135	50	145
2,6-Dinitrotoluene	99	13	60	135	50	150
2,4,6-Trinitrotoluene (TNT)	98	15	50	145	35	160
2-Amino-4,6-dinitrotoluene[13]	101	17	50	155	35	170
2-Nitrotoluene	88	15	45	135	30	150
3-Nitrotoluene	90	14	50	130	35	145
4-Amino-2,6-dinitrotoluene[13]	104	16	55	155	40	170
4-Nitrotoluene	90	14	50	130	35	145
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	106	18	50	160	35	180
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)[13]	98	25	20	175	10	200
Nitrobenzene	94	15	50	140	35	155
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	99	6	80	115	75	120

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[10] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits.

[11] Provisional limits – outlier analyses during the LCS study resulted in LCS-CLs generated with data from fewer than four laboratories. Limits may be adjusted in the future as additional data become available.

[12] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits were generated using solid phase extraction with acetonitrile only, without removing outliers from the data set (see section G.1 for further explanation).

[13] Provisional limits – outlier analyses during the LCS study resulted in LCS-CLs generated with data from fewer than four laboratories. Limits may be adjusted in the future as additional data become available.

Table G-13. LCS Control Limits for Explosives SW-846 Methods 8330 and 8330A Solid Matrix[14]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
1,3,5-Trinitrobenzene	99	9	75	125	65	135
1,3-Dinitrobenzene	102	8	80	125	70	135
2,4-Dinitrotoluene	102	7	80	125	75	130
2,6-Dinitrotoluene	100	7	80	120	70	130
2,4,6-Trinitrotoluene (TNT)	99	14	55	140	45	155
2-Amino-4,6-dinitrotoluene	102	7	80	125	75	130
2-Nitrotoluene	101	7	80	125	70	130
3-Nitrotoluene	100	7	75	120	70	130
4-Amino-2,6-dinitrotoluene	101	7	80	125	75	130
4-Nitrotoluene	101	8	75	125	70	135
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	103	10	70	135	65	145
Nitrobenzene	100	8	75	125	70	130
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	100	9	75	125	65	135

Table G-14. LCS Control Limits for Organochlorine Pesticides SW-846 Method 8081 Water Matrix[15]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
4,4'-DDD	88	20	25	150	10	170
4,4'-DDE	87	18	35	140	15	160
4,4'-DDT	92	15	45	140	30	155
Aldrin	83	19	25	140	10	155
alpha-BHC	94	11	60	130	50	140
alpha-Chlordane	93	10	65	125	55	135
beta-BHC	96	10	65	125	55	135
delta-BHC	91	15	45	135	30	150
Dieldrin	95	11	60	130	50	140
Endosulfan I[16]	80	10	50	110	40	120
Endosulfan II	79	17	30	130	10	150
Endosulfan sulfate	96	14	55	135	40	150
Endrin	95	13	55	135	45	145
Endrin aldehyde	96	14	55	135	40	150
Endrin ketone	102	8	75	125	70	135
gamma-BHC	82	18	25	135	10	155
gamma-Chlordane	94	11	60	125	50	135
Heptachlor	87	15	40	130	30	145
Heptachlor epoxide	96	11	60	130	50	140
Methoxychlor	103	16	55	150	40	165

[14] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. Additional limits for poor performing compounds can be found in section G.5.

[15] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits are not available for Hexachlorobenzene and Toxaphane. Sufficient data to perform statistically significant analyses were not received for those analytes during the LCS study. Additional limits for surrogate compounds can be found in section G.6.

[16] Provisional limits – outlier analyses during the LCS study resulted in LCS-CLs generated with data from fewer than four laboratories. Limits may be adjusted in the future as additional data becomes available.

Table G-15. LCS Control Limits for Organochlorine Pesticides SW-846 Method 8081 Solid Matrix [17]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
4,4'-DDD	81	18	30	135	10	155
4,4'-DDE	97	10	70	125	60	135
4,4'-DDT	92	16	45	140	30	155
Aldrin	93	16	45	140	30	155
alpha-BHC	93	10	60	125	50	135
alpha-Chlordane	92	10	65	120	55	130
beta-BHC	95	11	60	125	50	135
delta-BHC	94	12	55	130	45	145
Dieldrin	96	10	65	125	55	135
Endosulfan I	74	20	15	135	10	155
Endosulfan II	89	17	35	140	20	160
Endosulfan sulfate	99	12	60	135	50	145
Endrin	97	12	60	135	50	145
Endrin aldehyde	92	18	35	145	20	165
Endrin ketone	100	11	65	135	55	145
gamma-BHC	91	11	60	125	50	135
gamma-Chlordane	96	10	65	125	55	135
Heptachlor	96	15	50	140	35	155
Heptachlor epoxide	98	11	65	130	55	140
Methoxychlor	100	14	55	145	45	155

Table G-16. LCS Control Limits for Polychlorinated Biphenyls SW-846 Method 8082 Water Matrix[18]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
Aroclor 1016	85	20	25	145
Aroclor 1260	87	19	30	145

Table G-17. LCS Control Limits for Polychlorinated Biphenyls SW-846 Method 8082 Solid Matrix[18]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
Aroclor 1016	90	16	40	140
Aroclor 1260	96	12	60	130

[17] A number of sporadic marginal exceedances of the control limits are allowed, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits. LCS control limits are not available for Hexachlorobenzene, Hexachlorocyclopentadiene, and Toxaphane. Sufficient data to perform statistically significant analyses were not received for those analytes during the LCS study. Additional limits for surrogate compounds can be found in section G.6.

[18] LCS control limits are not available for Aroclors 1221, 1232, 1242, 1248, 1262, and 1268. Sufficient data to perform statistically significant analyses were not received for those analytes during the LCS study. Additional limits for surrogate compounds can be found in section G.6.

Table G-18. LCS Control Limits for Metals SW-846 Methods 6010 and 7470 Water Matrix[19]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
Aluminum	97	5	80	120	80	120
Antimony	98	4	80	120	80	120
Arsenic	98	4	80	120	80	120
Barium	99	4	80	120	80	120
Beryllium	99	4	80	120	80	120
Cadmium	100	4	80	120	80	120
Calcium	98	4	80	120	80	120
Chromium	100	4	80	120	80	120
Cobalt	99	3	80	120	80	120
Copper	99	3	80	120	80	120
Iron	102	4	80	120	80	120
Lead	99	4	80	120	80	120
Magnesium	98	4	80	120	80	120
Manganese	100	4	80	120	80	120
Mercury	100	5	80	120	No ME	No ME
Molybdenum	95	5	80	120	75	120
Nickel	100	4	80	120	80	120
Potassium	98	4	80	120	80	120
Selenium	98	6	80	120	75	120
Silver	97	5	80	120	75	120
Sodium	99	4	80	120	80	120
Thallium	97	4	80	120	80	120
Vanadium	99	4	80	120	80	120
Zinc	100	4	80	120	80	120

[19] The as-generated limits have been adjusted to reflect Method requirements and acceptable calibration uncertainty. A number of sporadic marginal exceedances of the control limits are allowed for Method 6010, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits.

Table G-19. LCS Control Limits for Metals SW-846 Methods 6010 and 7471 Solid Matrix [20]

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
Aluminum	95	5	80	120	75	120
Antimony	96	5	80	120	75	120
Arsenic	95	4	80	120	80	120
Barium	98	3	80	120	80	120
Beryllium	99	4	80	120	80	120
Cadmium	97	4	80	120	80	120
Calcium	97	4	80	120	80	120
Chromium	99	5	80	120	80	120
Cobalt	98	4	80	120	80	120
Copper	97	3	80	120	80	120
Iron	100	4	80	120	80	120
Lead	95	4	80	120	80	120
Magnesium	96	3	80	120	80	120
Manganese	97	4	80	120	80	120
Mercury	100	6	80	120	No ME	No ME
Molybdenum	96	5	80	120	75	120
Nickel	97	4	80	120	80	120
Potassium	96	4	80	120	80	120
Selenium	93	4	80	120	75	120
Silver	96	7	75	120	70	125
Sodium	96	4	80	120	80	120
Thallium	94	4	80	120	80	120
Vanadium	99	3	80	120	80	120
Zinc	95	5	80	120	75	120

[20] The as-generated limits have been adjusted to reflect Method requirements and acceptable calibration uncertainty. A number of sporadic marginal exceedances of the control limits are allowed for Method 6010, depending on the number of analytes spiked in the LCS. Refer to section G.2 and Table G-1 for guidance on the appropriate application of control and ME limits.

Empirical Laboratories, LLC Control Limits

Method	Analyte	Laboratory Specific Control Limits		
		Lower	Upper	RPD
SW846 8260B	1,1,1,2-Tetrachloroethane	80	130	30
Waters	1,1,1-Trichloroethane	65	130	30
	1,1,2,2-Tetrachloroethane	65	130	30
	1,1,2-Ttrichloro-1,2,2-Trifluoroethane	60	130	30
	1,1,2-Trichloroethane	75	125	30
	1,1-Dichloroethane	70	135	30
	1,1-Dichloroethene	70	130	30
	1,1-Dichloropropene	75	130	30
	1,2,3-Trichlorobenzene	55	140	30
	1,2,3-Trichloropropane	75	125	30
	1,2,4-Trichlorobenzene	65	135	30
	1,2,4-Trimethylbenzene	75	130	30
	1,3,5-Trimethylbenzene	75	130	30
	1,2-Dibromo-3-Chloroprpane	50	130	30
	1,2-Dibromoethane	80	120	30
	1,2-Dichlorobenzene	70	120	30
	1,2-Dichloroethane	70	130	30
	1,2-Dichlropropane	75	125	30
	1,3-Dichlorobenzene	75	125	30
	1,3-Dichloropropane	75	125	30
	1,4-Dichlorobenzene	75	125	30
	1-Chlorohexane	75	125	30
	2,2-Dichloropropane	70	135	30
	2-Butanone	30	150	30
	2-Chloro Vinyl Ether	10	165	30
	2-Chlorotoluene	75	125	30
	2-Hexanone	55	130	30
	4-Chlorotoluene	75	130	30
	4-Methyl-2-Pentanone	60	135	30
	Acetone	40	140	30
	Acrolein	10	200	30
	Acrylonitrile	35	180	30
	Benzene	80	120	30
	Bromobenzene	75	125	30
	Bromochloromethane	65	130	30
	Bromodichloromethane	75	120	30
	Bromoform	70	130	30
	Bromomethane	30	145	30
	Carbon Disulfide	35	160	30
	Carbon Tetrachloride	65	140	30
	Chlorobenzene	80	120	30
	Chloroethane	60	135	30
	Chloroform	65	135	30
	Chloromethane	40	125	30

	cis-1,2-Dichloroethene	70	125	30
	cis-1,3-Dichloropropene	70	130	30
	Cyclohexane	60	130	30
	Dibromochloromethane	60	135	30
	Dibromomethane	75	125	30
	Dichlorodifluoromethane	30	155	30
	Di-Isopropyl Ether	60	130	30
	ETBE	50	150	30
	Ethyl Methacrylate	70	135	30
	Ethylbenzene	75	125	30
	Hexachlorobutadiene	50	140	30
	Iodomethane	50	140	30
	Isopropylbenzene	75	125	30
	Methyl Acetate	55	150	30
	Methyl Methacrylate	70	135	30
	Methyl tert-Butyl Ether	65	125	30
	Methylcyclohexane	60	125	30
	Methylene Chloride	55	140	30
	Naphthalene	55	140	30
	n-Butylbenzene	70	135	30
	n-Propylbenzene	70	130	30
	p-Isopropyltoluene	75	130	30
	sec-Butylbenzene	70	125	30
	Styrene	65	135	30
	t-Butyl Alcohol	60	130	30
	tert-Amyl Methyl Ether	50	150	30
Surrogates	Bromofluorobenzene	75	125	
	Dibromofluorobenzene	85	115	
	1,2 Dichloroethane-d4	70	120	
	Toluene-d8	85	120	

Empirical Laboratories, LLC Control Limits

Method	Analyte	Laboratory Specific Control Limits		
		Lower	Upper	RPD
SW846 8270C	1-Methylnaphthalene	30	115	30
Waters	1,1'-Biphenyl	50	110	30
	1,2,4,5-Tetrachlorobenzene	50	125	30
	1,2,4-Trichlorobenzene	35	105	30
	1,2-Dichlorobenzene	35	100	30
	1,2-Diphenylhydrazine	55	115	30
	1,3-Dichlorobenzene	30	100	30
	1,4-Dichlorobenzene	30	100	30
	2,3,4,6-Tetrachlorophenol	50	125	30
	2,4,5-Trichlorophenol	50	110	30
	2,4,6-Trichlorophenol (TCP)	50	115	30
	2,4-Dichlorophenol (DCP)	40	110	30
	2,4-Dimethylphenol	30	110	30
	2,4-Dinitrophenol	15	140	30
	2,4-Dinitrotoluene (DNT)	50	120	30
	2,6-Dinitrotoluene	50	115	30
	2-Chloronaphthalene	50	105	30
	2-Chlorophenol	35	105	30
	2-Methylnaphthalene	45	105	30
	2-Methylphenol (o-Cresol)	40	110	30
	2-Nitroaniline	50	115	30
	2-Nitrophenol (ONP)	40	115	30
	3,3'-Dichlorobenzidine (DCB)	20	110	30
	3-Methylphenol	30	110	30
	3-Nitroaniline	20	125	30
	4,6-Dinitro-2-methylphenol (DNOC)	40	130	30
	4-Bromophenyl phenyl ether	50	115	30
	4-Chloro-3-methylphenol	45	110	30
	4-Chloroaniline	15	110	30
	4-Chlorophenyl phenyl ether	50	110	30
	4-Methylphenol (p-Cresol)	30	110	30
	4-Nitroaniline (PNA)	35	120	30
	4-Nitrophenol (PNP)	0	125	30
	Acenaphthene	45	110	30
	Acenaphthylene	50	105	30
	Acetaphenone	50	110	30
	Aniline	10	110	30
	Anthracene	55	110	30
	Benzidine	0	200	30
	Benzo(a)anthracene	55	110	30
	Benzo(a)pyrene	55	110	30
	Benzo(b)fluoranthene	45	120	30
	Benzo(g,h,i)perylene	40	125	30
	Benzo(k)fluoranthene	45	125	30

	Benzoic Acid	0	125	30
	Benzyl alcohol	30	110	30
	bis(2-Chloroethoxy)methane	45	105	30
	bis(2-Chloroethyl)ether (BCEE)	35	110	30
	Bis(2-chloroisopropyl)ether, or 2,2'-oxybis (1-Chloropropane)	25	130	30
	bis(2-Ethylhexyl)phthalate (BEHP)	40	125	30
	Butyl benzyl phthalate (BBP)	45	115	30
	Carbazole	50	115	30
	Chrysene	55	110	30
	Dibenz(a,h)anthracene	40	125	30
	Dibenzofuran (DBF)	55	105	30
	Diethyl phthalate (DEP)	40	120	30
	Dimethyl phthalate (DMP)	25	125	30
	Di-n-butyl phthalate (DBP)	55	115	30
	Di-n-octyl phthalate (DNOP)	35	135	30
	Fluoranthene	55	115	30
	Fluorene	50	110	30
	Hexachlorobenzene (HCB)	50	110	30
	Hexachlorobutadiene (HCBD)	25	105	30
	Hexachlorocyclopentadiene (HCCPD)	10	110	30
	Hexachloroethane (HCE)	30	95	30
	Indeno(1,2,3-cd)pyrene	45	125	30
	Isophorone	50	110	30
	Naphthalene	40	100	30
	Nitrobenzene	30	110	30
	N-Nitrosodimethylamine	25	110	30
	N-Nitroso-di-n-propylamine (NDPA)	35	130	30
	N-nitrosodiphenylamine (NDPHA)	50	110	30
	Pentachlorophenol	40	115	30
	Phenanthrene	50	115	30
	Phenol	0	115	30
	Pyrene	50	130	30
	Pyridine	10	110	30
Surrogates:	2-Fluorobiphenyl	50	110	
	2-Fluorophenol	20	110	
	Nitrobenzene-d5	40	110	
	Phenol-d5	15	110	
	Terphenyl-d14	50	135	

Empirical Laboratories, LLC Control Limits

Method	Analyte	Laboratory Specific Control Limits		
		Lower	Upper	RPD
SW846 8011	Ethylene Dibromide	70	130	20
Waters				

Empirical Laboratories, LLC Control Limits

Method	Analyte	Laboratory Specific Control Limits		
		Lower	Upper	RPD
SW846 8015B DRO	DRO C10- C28	50	150	50
Waters				
Surrogates:	2-Fluorobiphenyl	50	150	
	o-Terphenyl	30	140	

Method	Analyte	Laboratory Specific Control		
		Lower	Upper	RPD
SW846 8015B GRO	GRO C6-C8	50	150	50
Waters				
Surrogate:	Bromofluorobenzene	50	150	

Empirical Laboratories, LLC Control Limits

Method	Analyte	Laboratory Specific Control Limits LCS			Laboratory Specific Control Limits Matrix Spikes		
		Lower	Upper	RPD	Lower	Upper	RPD
EPH MA DEP	C12 - C40	50	150	20	50	150	50
Waters							
Surrogate:	o-Terphenyl	50	150				

Method	Analyte	Laboratory Specific Control Limits		
		Lower	Upper	RPD
VPH MA DEP	C5-C8 Aliphatics	70	130	40
Waters	C9-C12 Aliphatics	70	130	40
Surrogate:	2,5 Dibromotoluene	70	130	

Empirical Laboratories, LLC Control Limits

Method	Analyte	Laboratory Specific Control Limits		
		Lower	Upper	RPD
SW846 6010B	Dissolved Iron	80	120	20
Waters	Dissolved Manganese	80	120	20
	Lead	80	120	20
	Sodium	80	120	20
	Potassium	80	120	20
	Calcium	80	120	20
	Magnesium	80	120	20

Empirical Laboratories, LLC Control Limits

		Laboratory Specific Control Limits LCS			Laboratory Specific Control Limits MS		
Method	**Analyte**	**Lower**	**Upper**	**RPD**	**Lower**	**Upper**	**RPD**
SW846 9056	Nitrate	90	110	20	80	120	20
Waters	Nitrite	90	110	20	80	120	20
	Sulfate	90	110	20	80	120	20
	Chloride	90	110	20	80	120	20

Empirical Laboratories, LLC Control Limits

Method	Analyte	Laboratory Specific Control Limits LCS			Laboratory Specific Control Limits MS		
		Lower	Upper	RPD	Lower	Upper	RPD
SM2320B	Alkalinity	80	120	20	75	125	20
Waters							

Empirical Laboratories, LLC Control Limits

		Laboratory Specific Control Limits LCS			Laboratory Specific Control Limits MS		
Method	**Analyte**	**Lower**	**Upper**	**RPD**	**Lower**	**Upper**	**RPD**
SM4500SCF	Sulfide	80	120	20	75	125	20
Waters							

Empirical Laboratories, LLC Control Limits

		Laboratory Specific Control Limits LCS			Laboratory Specific Control Limits MS		
Method	**Analyte**	**Lower**	**Upper**	**RPD**	**Lower**	**Upper**	**RPD**
SW846 9060	TOC	80	120	20	75	125	20
Waters							

Empirical Laboratories, LLC Control Limits

Method	Analyte	Laboratory Specific Control Limits LCS		
		Lower	Upper	RPD
RSK175	Methane	80	120	30
Waters	Ethane	80	120	30
	Ethene	80	120	30

Empirical Laboratories, LLC Control Limits

		Laboratory Specific Control Limits LCS			Laboratory Specific Control Limits MS/MSD		
Method	**Analyte**	**Lower**	**Upper**	**RPD**	**Lower**	**Upper**	**RPD**
EPA 351.2	TKN	80	120	20	75	125	20
Waters							

Empirical Laboratories, LLC Control Limits

Method	Analyte	Laboratory Specific Control Limits LCS			Laboratory Specific Control Limits MS/MSD		
		Lower	Upper	RPD	Lower	Upper	RPD
SM4500PE	Ortho phosphate	80	120	20	75	125	20
Waters							

Empirical Laboratories, LLC Control Limits

		Laboratory Specific Control Limits LCS			Laboratory Specific Control Limits MS/MSD		
Method	**Analyte**	**Lower**	**Upper**	**RPD**	**Lower**	**Upper**	**RPD**
SM4500NH3BG	Ammonia	80	120	20	75	125	20
Waters							

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					CCV			DUP	LCS/LCSD			
	&Analyte	Units	MDL	PQL	SPK	Low	High	RPD	SPK	Low	High	RPD
	Carbon dioxide	%	0.1	0.1	1	85	115	20	0.25	70	130	20
	Carbon Monoxide	%	0.1	0.1	1	85	115	20	0.25	70	130	20
	Ethane	%	0.5	0.5	1	85	115	20	0.25	70	130	20
	Hydrogen	%	0.5	0.5	1	85	115	20	0.25	70	130	20
	Methane	%	0.5	0.5	1	85	115	20	0.25	70	130	20
	Nitrogen	%	0.1	0.1	1	85	115	20	0.25	70	130	20
	Oxygen	%	0.1	0.1	1	85	115	20	0.25	70	130	20

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	&Analyte	Units	MDL	PQL	SPK	Low	High	RPD	SPK	Low	High
	1,1,1-Trichloroethane	ppbv	0.33	1	9.6	70	130	25	9.6	70	130
	1,1,2,2-Tetrachloroethane	ppbv	0.42	1	10	70	130	25	10	70	130
	1,1,2-Trichloro-1,2,2-trifluoroethane	ppbv	0.31	1	9.8	70	130	25	9.8	70	130
	1,1,2-Trichloroethane	ppbv	0.23	0.5	9.8	70	130	25	9.8	70	130
	1,1-Dichloroethane	ppbv	0.38	1	9.7	70	130	25	9.7	70	130
	1,1-Dichloroethene	ppbv	0.65	2	9.9	70	130	25	9.9	70	130
	1,2,4-Trichlorobenzene	ppbv	0.52	2	9.1	70	130	25	9.1	70	130
	1,2,4-Trimethylbenzene	ppbv	0.42	1	9.8	70	130	25	9.8	70	130
	1,2-Dibromoethane	ppbv	0.19	0.5	9.6	70	130	25	9.6	70	130
	1,2-Dichlorobenzene	ppbv	0.37	1	9.7	70	130	25	9.7	70	130
	1,2-Dichloroethane	ppbv	0.33	1	9.7	70	130	25	9.7	70	130
	1,2-Dichloropropane	ppbv	0.23	0.5	9.8	70	130	25	9.8	70	130
	1,3,5-Trimethylbenzene	ppbv	0.38	1	9.7	70	130	25	9.7	70	130
	1,3-Butadiene	ppbv	1.34	3	9.8	70	130	25	9.8	70	130
	1,3-Dichlorobenzene	ppbv	0.36	1	9.7	70	130	25	9.7	70	130
	1,4-Dichlorobenzene	ppbv	0.45	1	9.6	70	130	25	9.6	70	130
	1,4-Dioxane	ppbv	1.8	5	9.6	70	130	25	9.6	70	130
	2-Butanone	ppbv	0.54	2	9.9	70	130	25	9.9	70	130
	2-Hexanone	ppbv	2.16	5	9.8	70	130	25	9.8	70	130
	2-Propanol	ppbv	0.44	1	10.1	70	130	25	10.1	70	130
	4-Methyl-2-pentanone	ppbv	1.07	5	10	70	130	25	10	70	130
	Acetone	ppbv	0.44	2	10	70	130	25	10	70	130
	Benzene	ppbv	0.39	1	9.6	70	130	25	9.6	70	130
	Benzyl chloride	ppbv	0.54	1	9.7	70	130	25	9.7	70	130
	Bromodichloromethane	ppbv	0.21	0.5	9.6	70	130	25	9.6	70	130
	Bromoform	ppbv	0.41	1	9.6	70	130	25	9.6	70	130
	Bromomethane	ppbv	0.71	2	9.3	70	130	25	9.3	70	130
	Carbon disulfide	ppbv	0.41	2	9.7	70	130	25	9.7	70	130
	Carbon tetrachloride	ppbv	0.35	1	9.5	70	130	25	9.5	70	130
	Chlorobenzene	ppbv	0.39	1	9.9	70	130	25	9.9	70	130
	Chlorodibromomethane	ppbv	0.34	1	9.2	70	130	25	9.2	70	130
	Chloroethane	ppbv	0.49	1	9.8	70	130	25	9.8	70	130
	Chloroform	ppbv	0.3	1	9.4	70	130	25	9.4	70	130

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	Chloromethane	ppbv	0.68	2	9.8	70	130	25	9.8	70	130
	cis-1,2-Dichloroethene	ppbv	1	1	9.8	70	130	25	9.8	70	130
	cis-1,3-dichloropropene	ppbv	0.24	0.5	9.5	70	130	25	9.5	70	130
	Cyclohexane	ppbv	0.37	1	9.8	70	130	25	9.8	70	130
	Dichlorodifluoromethane	ppbv	0.4	1	9.2	70	130	25	9.2	70	130
	Ethanol	ppbv	0.53	1	9.2	70	130	25	9.2	70	130
	Ethyl acetate	ppbv	0.55	1	9.8	70	130	25	9.8	70	130
	Ethylbenzene	ppbv	0.35	1	9.8	70	130	25	9.8	70	130
	Heptane	ppbv	0.37	1	9.9	70	130	25	9.9	70	130
	Hexachlorobutadiene	ppbv	0.54	2	9.4	70	130	25	9.4	70	130
	m,p-Xylene	ppbv	0.75	2	19.2	70	130	25	19.2	70	130
	Methylene chloride	ppbv	0.31	2	10	70	130	25	10	70	130
	n-Hexane	ppbv	0.31	1	10.1	70	130	25	10.1	70	130
	o-Xylene	ppbv	0.39	1	10	70	130	25	10	70	130
	Propylene	ppbv	0.37	1	10.2	70	130	25	10.2	70	130
	Styrene	ppbv	0.43	1	9.8	70	130	25	9.8	70	130
	tert-Butyl Methyl Ether	ppbv	0.61	2	9.9	70	130	25	9.9	70	130
	Tetrachloroethene	ppbv	0.21	0.5	9.6	70	130	25	9.6	70	130
	Tetrahydrofuran	ppbv	0.58	2	10	70	130	25	10	70	130
	Toluene	ppbv	0.24	0.5	9.8	70	130	25	9.8	70	130
	trans-1,2-Dichloroethene	ppbv	0.38	1	9.8	70	130	25	9.8	70	130
	trans-1,3-dichloropropene	ppbv	0.31	1	9.1	70	130	25	9.1	70	130
	Trichloroethene	ppbv	0.35	1	9.6	70	130	25	9.6	70	130
	Trichlorofluoromethane	ppbv	0.31	1	9.6	70	130	25	9.6	70	130
	Vinyl acetate	ppbv	0.31	1	9.9	70	130	25	9.9	70	130
	Vinyl chloride	ppbv	0.41	1	9.4	70	130	25	9.4	70	130
	Xylenes, Total	ppbv	1.14	3	29.2	70	130	25	29.2	70	130
SUR	4-Bromofluorobenzene	ppbv	0	0.5	12.5	70	130	25	12.5	70	130

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MADEP APH

						CCV			DUP	ICV		
	&Analyte	Units	MDL	LOD	PQL	SPK	Low	High	RPD	SPK	Low	High
	C5-C8 Aliphatic	µg/m³	3.7	6	12	120	70	130	25	120	70	130
	C9-C12 Aliphatic	µg/m³	4.7	6	12	120	70	130	25	120	70	130
	C9-C10 Aromatic	µg/m³	1.9	5	8	80	70	130	25	80	70	130
	1,3-Butadiene	µg/m³	3.0	4.5	6.6	21.7	70	130	25	21.7	70	130
	tert-Butyl Methyl Ether	µg/m³	2.2	3.6	7.2	35.7	70	130	25	35.7	70	130
	Benzene	µg/m³	1.3	1.6	3.2	30.7	70	130	25	30.7	70	130
	Toluene	µg/m³	0.9	1.9	1.9	36.9	70	130	25	36.9	70	130
	Ethylbenzene	µg/m³	1.5	2.2	4.4	42.6	70	130	25	42.6	70	130
	m,p-Xylene	µg/m³	3.3	4.3	8.7	83.4	70	130	25	83.4	70	130
	o-Xylene	µg/m³	1.7	2.2	4.3	43.4	70	130	25	43.4	70	130
	Naphthalene	µg/m³	6.0	10.5	15.7	53.5	70	130	25	53.5	70	130
SUR	4-Bromofluorobenzene	µg/m³	0		3.6	89	70	130	25	89	70	130

Control Limits

Gulf Coast Analytical Laboratories

Method: SW-846 8260B

	LCS		
Analyte	**Name**	**LCL-UCL**	**Matrix**
630-20-6	1,1,1,2-Tetrachloroethane	77-122	S
71-55-6	1,1,1-Trichloroethane	70-130	S
79-34-5	1,1,2,2-Tetrachloroethane	66-129	S
79-00-5	1,1,2-Trichloroethane	74-120	S
75-34-3	1,1-Dichloroethane	71-126	S
75-35-4	1,1-Dichloroethene	68-129	S
563-58-6	1,1-Dichloropropene	70-138	S
87-61-6	1,2,3-Trichlorobenzene	69-130	S
96-18-4	1,2,3-Trichloropropane	63-132	S
120-82-1	1,2,4-Trichlorobenzene	64-135	S
95-63-6	1,2,4-Trimethylbenzene	75-130	S
96-12-8	1,2-Dibromo-3-chloropropane	60-123	S
106-93-4	1,2-Dibromoethane	74-122	S
95-50-1	1,2-Dichlorobenzene	76-125	S
107-06-2	1,2-Dichloroethane	68-126	S
78-87-5	1,2-Dichloropropane	72-129	S
108-67-8	1,3,5-Trimethylbenzene	74-136	S
541-73-1	1,3-Dichlorobenzene	77-127	S
142-28-9	1,3-Dichloropropane	77-121	S
106-46-7	1,4-Dichlorobenzene	74-123	S
544-10-5	1-Chlorohexane	68-136	S
594-20-7	2,2-Dichloropropane	74-129	S
78-93-3	2-Butanone	47-142	S
95-49-8	2-Chlorotoluene	75-132	S
591-78-6	2-Hexanone	47-137	S
106-43-4	4-Chlorotoluene	74-133	S
99-87-6	4-Isopropyltoluene	71-136	S
108-10-1	4-Methyl-2-pentanone	52-136	S
67-64-1	Acetone	38-152	S
107-02-8	Acrolein	34-158	S

107-13-1	Acrylonitrile	49-142	S
71-43-2	Benzene	73-128	S
108-86-1	Bromobenzene	73-124	S
74-97-5	Bromochloromethane	73-127	S
75-27-4	Bromodichloromethane	74-126	S
75-25-2	Bromoform	67-122	S
74-83-9	Bromomethane	48-139	S
75-15-0	Carbon disulfide	68-133	S
56-23-5	Carbon tetrachloride	71-133	S
108-90-7	Chlorobenzene	75-121	S
75-00-3	Chloroethane	57-144	S
67-66-3	Chloroform	74-124	S
74-87-3	Chloromethane	61-130	S
124-48-1	Dibromochloromethane	74-122	S
74-95-3	Dibromomethane	72-125	S
75-71-8	Dichlorodifluoromethane	59-138	S
100-41-4	Ethylbenzene	74-130	S
87-68-3	Hexachlorobutadiene	71-140	S
98-82-8	Isopropylbenzene (Cumene)	74-125	S
75-09-2	Methylene chloride	66-130	S
91-20-3	Naphthalene	54-132	S
100-42-5	Styrene	72-128	S
127-18-4	Tetrachloroethene	70-127	S
108-88-3	Toluene	74-121	S
79-01-6	Trichloroethene	78-127	S
75-69-4	Trichlorofluoromethane	64-141	S
108-05-4	Vinyl acetate	53-140	S
75-01-4	Vinyl chloride	67-131	S
1330-20-7	Xylene (total)	71-129	S
156-59-2	cis-1,2-Dichloroethene	72-130	S
10061-01-5	cis-1,3-Dichloropropene	72-129	S
136777-61-2	m,p-Xylene	72-128	S
104-51-8	n-Butylbenzene	68-144	S
103-65-1	n-Propylbenzene	73-137	S
95-47-6	o-Xylene	69-133	S
135-98-8	sec-Butylbenzene	72-141	S
1634-04-4	tert-Butyl methyl ether (MTBE)	69-126	S
98-06-6	tert-Butylbenzene	72-136	S
156-60-5	trans-1,2-Dichloroethene	67-134	S
10061-02-6	trans-1,3-Dichloropropene	72-126	S
17060-07-0	1,2-Dichloroethane-d4	62-125	Surrogate
460-00-4	4-Bromofluorobenzene	62-127	Surrogate

1868-53-7	Dibromofluoromethane	65-130	Surrogate
2037-26-5	Toluene-d8	71-132	Surrogate

Control Limits

Gulf Coast Analytical Laboratories

Method: SW-846 8260B

	LCSD		
Analyte	**Name**	**LCL-UCL**	**Matrix**
630-20-6	1,1,1,2-Tetrachloroethane	0-30	S
71-55-6	1,1,1-Trichloroethane	0-30	S
79-34-5	1,1,2,2-Tetrachloroethane	0-30	S
79-00-5	1,1,2-Trichloroethane	0-30	S
75-34-3	1,1-Dichloroethane	0-30	S
75-35-4	1,1-Dichloroethene	0-30	S
563-58-6	1,1-Dichloropropene	0-30	S
87-61-6	1,2,3-Trichlorobenzene	0-30	S
96-18-4	1,2,3-Trichloropropane	0-30	S
120-82-1	1,2,4-Trichlorobenzene	0-30	S
95-63-6	1,2,4-Trimethylbenzene	0-30	S
96-12-8	1,2-Dibromo-3-chloropropane	0-30	S
106-93-4	1,2-Dibromoethane	0-30	S
95-50-1	1,2-Dichlorobenzene	0-30	S
107-06-2	1,2-Dichloroethane	0-30	S
78-87-5	1,2-Dichloropropane	0-30	S
108-67-8	1,3,5-Trimethylbenzene	0-30	S
541-73-1	1,3-Dichlorobenzene	0-30	S
142-28-9	1,3-Dichloropropane	0-30	S
106-46-7	1,4-Dichlorobenzene	0-30	S
544-10-5	1-Chlorohexane	0-30	S
594-20-7	2,2-Dichloropropane	0-30	S
78-93-3	2-Butanone	0-30	S
95-49-8	2-Chlorotoluene	0-30	S
591-78-6	2-Hexanone	0-30	S
106-43-4	4-Chlorotoluene	0-30	S
99-87-6	4-Isopropyltoluene	0-30	S
108-10-1	4-Methyl-2-pentanone	0-30	S
67-64-1	Acetone	0-30	S
107-02-8	Acrolein	0-30	S

107-13-1	Acrylonitrile	0-30	S
71-43-2	Benzene	0-30	S
108-86-1	Bromobenzene	0-30	S
74-97-5	Bromochloromethane	0-30	S
75-27-4	Bromodichloromethane	0-30	S
75-25-2	Bromoform	0-30	S
74-83-9	Bromomethane	0-30	S
75-15-0	Carbon disulfide	0-30	S
56-23-5	Carbon tetrachloride	0-30	S
108-90-7	Chlorobenzene	0-30	S
75-00-3	Chloroethane	0-30	S
67-66-3	Chloroform	0-30	S
74-87-3	Chloromethane	0-30	S
124-48-1	Dibromochloromethane	0-30	S
74-95-3	Dibromomethane	0-30	S
75-71-8	Dichlorodifluoromethane	0-30	S
100-41-4	Ethylbenzene	0-30	S
87-68-3	Hexachlorobutadiene	0-30	S
98-82-8	Isopropylbenzene (Cumene)	0-30	S
75-09-2	Methylene chloride	0-30	S
91-20-3	Naphthalene	0-30	S
100-42-5	Styrene	0-30	S
127-18-4	Tetrachloroethene	0-30	S
108-88-3	Toluene	0-30	S
79-01-6	Trichloroethene	0-30	S
75-69-4	Trichlorofluoromethane	0-30	S
108-05-4	Vinyl acetate	0-30	S
75-01-4	Vinyl chloride	0-30	S
1330-20-7	Xylene (total)	0-30	S
156-59-2	cis-1,2-Dichloroethene	0-30	S
10061-01-5	cis-1,3-Dichloropropene	0-30	S
136777-61-2	m,p-Xylene	0-30	S
104-51-8	n-Butylbenzene	0-30	S
103-65-1	n-Propylbenzene	0-30	S
95-47-6	o-Xylene	0-30	S
135-98-8	sec-Butylbenzene	0-30	S
1634-04-4	tert-Butyl methyl ether (MTBE)	0-30	S
98-06-6	tert-Butylbenzene	0-30	S
156-60-5	trans-1,2-Dichloroethene	0-30	S
10061-02-6	trans-1,3-Dichloropropene	0-30	S

Control Limits

Gulf Coast Analytical Laboratories

Method: SW-846 8270

	LCS		
Analyte	**Name**	**LCL-UCL**	**Matrix**
95-94-3	1,2,4,5-Tetrachlorobenzene	60-120	S
120-82-1	1,2,4-Trichlorobenzene	46-120	S
95-50-1	1,2-Dichlorobenzene	44-120	S
122-66-7	1,2Diphenylhydrazine/Azobenzen	49-120	S
541-73-1	1,3-Dichlorobenzene	40-120	S
106-46-7	1,4-Dichlorobenzene	42-120	S
58-90-2	2,3,4,6-Tetrachlorophenol	60-120	S
95-95-4	2,4,5-Trichlorophenol	47-120	S
88-06-2	2,4,6-Trichlorophenol	46-120	S
120-83-2	2,4-Dichlorophenol	47-120	S
105-67-9	2,4-Dimethylphenol	47-120	S
51-28-5	2,4-Dinitrophenol	14-120	S
121-14-2	2,4-Dinitrotoluene	45-120	S
87-65-0	2,6-Dichlorophenol	60-120	S
606-20-2	2,6-Dinitrotoluene	47-120	S
91-58-7	2-Chloronaphthalene	52-120	S
95-57-8	2-Chlorophenol	48-120	S
91-57-6	2-Methylnaphthalene	43-120	S
88-74-4	2-Nitroaniline	44-120	S
88-75-5	2-Nitrophenol	49-120	S
91-94-1	3,3'-Dichlorobenzidine	35-120	S
99-09-2	3-Nitroaniline	29-120	S
534-52-1	4,6-Dinitro-2-methylphenol	29-120	S
101-55-3	4-Bromophenyl phenyl ether	51-125	S
59-50-7	4-Chloro-3-methylphenol	46-120	S
106-47-8	4-Chloroaniline	20-120	S
7005-72-3	4-Chlorophenyl phenyl ether	50-120	S
100-01-6	4-Nitroaniline	32-120	S
100-02-7	4-Nitrophenol	32-120	S
83-32-9	Acenaphthene	50-120	S

208-96-8	Acenaphthylene	53-120	S
62-53-3	Aniline	21-131	S
120-12-7	Anthracene	52-120	S
56-55-3	Benzo(a)anthracene	48-120	S
50-32-8	Benzo(a)pyrene	44-120	S
205-99-2	Benzo(b)fluoranthene	31-130	S
191-24-2	Benzo(g,h,i)perylene	29-134	S
207-08-9	Benzo(k)fluoranthene	36-122	S
111-91-1	Bis(2-Chloroethoxy)methane	51-120	S
111-44-4	Bis(2-Chloroethyl)ether	46-120	S
108-60-1	Bis(2-Chloroisopropyl)ether	46-120	S
117-81-7	Bis(2-Ethylhexyl)phthalate	46-129	S
85-68-7	Butyl benzyl phthalate	46-130	S
86-74-8	Carbazole	47-120	S
218-01-9	Chrysene	51-120	S
84-74-2	Di-n-butyl phthalate	50-120	S
117-84-0	Di-n-octyl phthalate	41-122	S
53-70-3	Dibenz(a,h)anthracene	27-129	S
132-64-9	Dibenzofuran	50-120	S
84-66-2	Diethyl phthalate	36-120	S
131-11-3	Dimethyl phthalate	50-120	S
206-44-0	Fluoranthene	39-120	S
86-73-7	Fluorene	48-120	S
118-74-1	Hexachlorobenzene	48-120	S
87-68-3	Hexachlorobutadiene	46-120	S
77-47-4	Hexachlorocyclopentadiene	23-121	S
67-72-1	Hexachloroethane	40-120	S
193-39-5	Indeno(1,2,3-cd)pyrene	43-132	S
78-59-1	Isophorone	49-120	S
91-20-3	Naphthalene	48-120	S
98-95-3	Nitrobenzene	45-120	S
608-93-5	Pentachlorobenzene	60-120	S
87-86-5	Pentachlorophenol	30-124	S
85-01-8	Phenanthrene	53-120	S
108-95-2	Phenol	42-120	S
129-00-0	Pyrene	38-136	S
110-86-1	Pyridine	11-120	S
1319-77-3MP	m,p-Cresol	46-120	S
621-64-7	n-Nitrosodi-n-propylamine	46-120	S
55-18-5	n-Nitrosodiethylamine	60-120	S
62-75-9	n-Nitrosodimethylamine	34-126	S
86-30-6	n-Nitrosodiphenylamine	54-125	S
95-48-7	o-Cresol	46-120	S

118-79-6	2,4,6-Tribromophenol	44-121	Surrogate
321-60-8	2-Fluorobiphenyl	47-127	Surrogate
367-12-4	2-Fluorophenol	51-119	Surrogate
4165-60-0	Nitrobenzene-d5	46-123	Surrogate
4165-62-2	Phenol-d5	43-123	Surrogate
1718-51-0	Terphenyl-d14	38-167	Surrogate

Control Limits

Gulf Coast Analytical Laboratories

Method: SW-846 8270

	LCSD		
Analyte	**Name**	**LCL-UCL**	**Matrix**
95-94-3	1,2,4,5-Tetrachlorobenzene	0-40	S
120-82-1	1,2,4-Trichlorobenzene	0-40	S
95-50-1	1,2-Dichlorobenzene	0-40	S
122-66-7	1,2Diphenylhydrazine/Azobenzen	0-40	S
541-73-1	1,3-Dichlorobenzene	0-40	S
106-46-7	1,4-Dichlorobenzene	0-40	S
58-90-2	2,3,4,6-Tetrachlorophenol	0-40	S
95-95-4	2,4,5-Trichlorophenol	0-40	S
88-06-2	2,4,6-Trichlorophenol	0-40	S
120-83-2	2,4-Dichlorophenol	0-40	S
105-67-9	2,4-Dimethylphenol	0-40	S
51-28-5	2,4-Dinitrophenol	0-40	S
121-14-2	2,4-Dinitrotoluene	0-40	S
87-65-0	2,6-Dichlorophenol	0-40	S
606-20-2	2,6-Dinitrotoluene	0-40	S
91-58-7	2-Chloronaphthalene	0-40	S
95-57-8	2-Chlorophenol	0-40	S
91-57-6	2-Methylnaphthalene	0-40	S
88-74-4	2-Nitroaniline	0-40	S
88-75-5	2-Nitrophenol	0-40	S
91-94-1	3,3'-Dichlorobenzidine	0-40	S
99-09-2	3-Nitroaniline	0-40	S
534-52-1	4,6-Dinitro-2-methylphenol	0-40	S
101-55-3	4-Bromophenyl phenyl ether	0-40	S
59-50-7	4-Chloro-3-methylphenol	0-40	S
106-47-8	4-Chloroaniline	0-40	S
7005-72-3	4-Chlorophenyl phenyl ether	0-40	S
100-01-6	4-Nitroaniline	0-40	S
100-02-7	4-Nitrophenol	0-40	S
83-32-9	Acenaphthene	0-40	S

208-96-8	Acenaphthylene	0-40	S
62-53-3	Aniline	0-40	S
120-12-7	Anthracene	0-40	S
56-55-3	Benzo(a)anthracene	0-40	S
50-32-8	Benzo(a)pyrene	0-40	S
205-99-2	Benzo(b)fluoranthene	0-40	S
191-24-2	Benzo(g,h,i)perylene	0-40	S
207-08-9	Benzo(k)fluoranthene	0-40	S
111-91-1	Bis(2-Chloroethoxy)methane	0-40	S
111-44-4	Bis(2-Chloroethyl)ether	0-40	S
108-60-1	Bis(2-Chloroisopropyl)ether	0-40	S
117-81-7	Bis(2-Ethylhexyl)phthalate	0-40	S
85-68-7	Butyl benzyl phthalate	0-40	S
86-74-8	Carbazole	0-40	S
218-01-9	Chrysene	0-40	S
84-74-2	Di-n-butyl phthalate	0-40	S
117-84-0	Di-n-octyl phthalate	0-40	S
53-70-3	Dibenz(a,h)anthracene	0-40	S
132-64-9	Dibenzofuran	0-40	S
84-66-2	Diethyl phthalate	0-40	S
131-11-3	Dimethyl phthalate	0-40	S
206-44-0	Fluoranthene	0-40	S
86-73-7	Fluorene	0-40	S
118-74-1	Hexachlorobenzene	0-40	S
87-68-3	Hexachlorobutadiene	0-40	S
77-47-4	Hexachlorocyclopentadiene	0-40	S
67-72-1	Hexachloroethane	0-40	S
193-39-5	Indeno(1,2,3-cd)pyrene	0-40	S
78-59-1	Isophorone	0-40	S
91-20-3	Naphthalene	0-40	S
98-95-3	Nitrobenzene	0-40	S
608-93-5	Pentachlorobenzene	0-40	S
87-86-5	Pentachlorophenol	0-40	S
85-01-8	Phenanthrene	0-40	S
108-95-2	Phenol	0-40	S
129-00-0	Pyrene	0-40	S
110-86-1	Pyridine	0-40	S
1319-77-3MP	m,p-Cresol	0-40	S
621-64-7	n-Nitrosodi-n-propylamine	0-40	S
55-18-5	n-Nitrosodiethylamine	0-40	S
62-75-9	n-Nitrosodimethylamine	0-40	S
86-30-6	n-Nitrosodiphenylamine	0-40	S
95-48-7	o-Cresol	0-40	S

Control Limits

Gulf Coast Analytical Laboratories

Method: Massachusetts EPH & VPH

LCS			
Test	**Name**	**LCL-UCL**	**Matrix**
Mass EPH	C9-C18 Aliphatic Hydrocarbons	40-140	S
Mass EPH	C19-C36 Aliphatic Hydrocarbons	40-140	S
Mass EPH	C11-C22 Aromatics Hydrocarbons	40-140	S
Mass EPH	1-Chlorooctadecane	40-140	EPH Surr
Mass EPH	o-Terphenyl	40-140	EPH Surr
Mass VPH	C5-C8 Aliphatic Hydrocarbons	60-140	S
Mass VPH	C9-C12 Aliphatic Hydrocarbons	60-140	S
Mass VPH	C9-C10 Aromatic Hydrocarbons	60-140	S
Mass VPH	2,5-Dibromotoluene	60-140	VPH Surr

Control Limits

Gulf Coast Analytical Laboratories

Method: Massachusetts
EPH & VPH

LCSD			
Test	**Name**	**LCL-UCL**	**Matrix**
Mass EPH	C9-C18 Aliphatic Hydrocarbons	0-40	S
Mass EPH	C19-C36 Aliphatic Hydrocarbons	0-40	S
Mass EPH	C11-C22 Aromatics Hydrocarbons	0-40	S
Mass VPH	C5-C8 Aliphatic Hydrocarbons	0-30	S
Mass VPH	C9-C12 Aliphatic Hydrocarbons	0-30	S
Mass VPH	C9-C10 Aromatic Hydrocarbons	0-30	S

Control Limits

Gulf Coast Analytical Laboratories

Method: SW-846 6010

	LCS		
Analyte	**Name**	**LCL-UCL**	**Matrix**
7439-92-1	Lead	80-120	S

Control Limits

Gulf Coast Analytical Laboratories

Method: SW-846 6010

		LCSD	
Analyte	**Name**	**LCL-UCL**	**Matrix**
7439-92-1	Lead	0-20	S