KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

Light Non-Aqueous Phase Liquid (LNAPL) Containment Interim Measure Work Plan
Part 1—Characterization Plan
Bulk Fuels Facility Spill
Solid Waste Management Units ST-106 and SS-111

July 2011

377 MSG/CEANR
2050 Wyoming Blvd. SE
Kirtland AFB, New Mexico 87117-5270

KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

LIGHT NON-AQUEOUS PHASE LIQUID (LNAPL) CONTAINMENT INTERIM MEASURE WORK PLAN PART 1—CHARACTERIZATION PLAN BULK FUELS FACILITY SPILL SOLID WASTE MANAGEMENT UNITS ST-106 AND SS-111

July 2011

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

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

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This Light Non-Aqueous Phase Liquid (LNAPL) Containment Interim Measure Work Plan, Part 1 – Characterization Plan, defines the activities and requirements for performing characterization of the site in order to support final design of the containment and capture of the non-aqueous phase liquid (NAPL) plume at Solid Waste Management Units ST-106 and SS-111 (collectively known as the Bulk Fuels Facility Spill) at Kirtland Air Force Base. The purpose of this Characterization Plan is to provide the rationale and scope of work to collect characterization data in support of the NAPL hydraulic containment system. The goal of the containment system is to gain hydraulic control of the NAPL plume and to maintain gradient that does not impact downgradient water rights, both for the current groundwater flow regime and for possible future groundwater regimes resulting from changes in the water supplying pumping. The scope of containment activities consists of the installation of groundwater extraction and injection wells, as well as a water treatment system. The characterization data collected as a result of this Characterization Plan will be used in the final design of the containment system, to be submitted as a Part 2 to the Containment Interim Measure Work Plan.

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COLONEL ROBERT L. MANESS
Commander

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KIRTLAND AIR FORCE BASE
377 ABW Public Affairs

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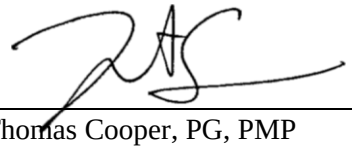
PREFACE

This Light Non-Aqueous Phase Liquid (LNAPL) Containment Interim Measure Work Plan, Part 1—Characterization Plan was prepared by Shaw Environmental and Infrastructure, Inc. (hereafter referred to as Shaw) for the U.S. Army Corps of Engineers (USACE), under Contract No. W912DY-10-D-0014, Delivery Order 0002. It pertains to interim measure activities associated with the Kirtland Air Force Base (AFB) Bulk Fuels Facility (BFF) Spill, Solid Waste Management Units (SWMUs) ST-106 and SS-111, located in Albuquerque, New Mexico. This Characterization Plan was prepared in accordance with 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* (Tetra Tech, 2004).

This Characterization Plan defines activities and requirements for characterizing the non-aqueous phase liquid (NAPL) plume at SWMUs ST-106 and SS-111 as part of phase-separated hydrocarbon remediation at the BFF Spill. The objective of the work in this plan is to collect characterization data on the NAPL and hydrogeologic data on the aquifer for use in final design. Data collected in this Work Plan will be used to design a NAPL containment system that will be presented in Part 2 of the Containment Interim Measure Work Plan.

This work was performed under the authority of the USACE, Contract No. W912DY-10-D-0014, Delivery Order 0002. All work was conducted from October 2010 through June 2011. 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 Characterization Plan was prepared by Ms. Diane Agnew and Dr. Gary Hecox.



Thomas Cooper, PG, PMP
Shaw Environmental & Infrastructure, Inc.
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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, 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

Attachment 3: December 10, 2010 Correspondence from the NMED HWB to Colonel Robert L. Maness, Base Commander, 377 ABW/CC and Mr. John Pike, Director, Environmental Management Section, 377 MSG/CEANR, Re: Bulk Fuels Facility Spill (SWMUs ST-106 and SS-111), Notice of Partial Approval with Modification and Notice of Disapproval, Interim Measures, Vadose Zone, and Groundwater Investigation Work Plans, HWB-KAFB-10-015, HWB-KAFB-10-016, HWB-KAFB-10-019

Attachment 4: May 31, 2011 Correspondence from the NMED HWB to Colonel Robert L. Maness, Base Commander, 377 ABW/CC and Mr. John Pike, Director, Environmental Management Section, 377 MSG/CEANR, Re: LNAPL Containment Interim Measure Work Plan, Bulk Fuels Facility Spill, Kirtland Air Force Base, HWB-KAFB-10-037

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ACRONYMS AND ABBREVIATIONS

3D	three-dimensional
ABCWUA	Albuquerque Bernalillo County Water Utility Authority
ADR	automated data review
AFB	Air Force Base
AFCEE	Air Force Center for Engineering and Environment
AmBe-241	americium-beryllium-241
ARCH	air-rotary casing hammer
AST	aboveground storage tank
ASTM	ASTM International
AVGAS	aviation gasoline
BFF	Bulk Fuels Facility
bgs	below ground surface
CFR	Code of Federal Regulations
cm	centimeter
COPC	contaminants of potential concern
DoD	U.S. Department of Defense
DTIC	Defense Technical Information Center
EDB	ethylene dibromide
EPA	U.S. Environmental Protection Agency
ERP	Environmental Restoration Program
ERPIMS	Environmental Resources Program Information Management System
FCR	Field Change Request
FFOR	Former Fuel Offloading Rack
GAC	granular activated carbon
GIS	geographical information system
gpm	gallons per minute
He-3	helium-3
HWB	Hazardous Waste Bureau
JP-4	jet propellant-4 fuel
JP-8	jet propellant-8 fuel
KAFB	Kirtland Air Force Base
LNAPL	light non-aqueous phase liquid
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mm	millimeter

ACRONYMS AND ABBREVIATIONS (concluded)

NAPL	non-aqueous phase liquid
NMED	New Mexico Environment Department
NTIS	National Technical Information Service
PG	Professional Geologist
PIANO	paraffins, isoparaffins, aromatics, naphthalene, and olefins
PMP	Project Management Professional
PPE	personal protective equipment
QAPjP	Quality Assurance Project Plan
QC	quality control
SOP	standard operating procedure
SSHP	Site Safety and Health Plan
SWMU	Solid Waste Management Unit
TPH	total petroleum hydrocarbons
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
USF	Santa Fe Group
V.A.	Veterans Administration

EXECUTIVE SUMMARY

This Light Non-Aqueous Phase Liquid (LNAPL) Containment Interim Measure Work Plan, Part 1 - Characterization Plan, together with the Groundwater Investigation Work Plan, the Vadose Zone Investigation Work Plan, and the Interim Measures Work Plan, were developed in response to April 2, 2010; August 6, 2010; February 21, 2011; and March 31, 2011 correspondence from the New Mexico Environment Department (NMED) Hazardous Waste Bureau to the Air Force. In the first two letters, the NMED Hazardous Waste Bureau required the Air Force to develop and submit work plans to address soil and groundwater contamination at the Bulk Fuels Facility Spill at Kirtland Air Force Base (AFB), New Mexico. The third letter required the Air Force to collect laboratory and field hydraulic data from the new wells. The fourth letter required the Air Force to split the original LNAPL Containment Interim Measure Work Plan into a Characterization Plan and Design Work Plan. The Design Work Plan will be designated Part 2 of the LNAPL Containment Interim Measure Work Plan.

As required by the March 31, 2011 NMED letter, the Characterization Plan is to be submitted to the NMED on February 1, 2012, and the Design Work Plan is due April 1, 2012.

This Characterization Plan defines activities and procedures for hydrogeologic characterization of the non-aqueous phase liquid (NAPL) plume at Solid Waste Management Units ST-106 and SS-111 as part of phase-separated hydrocarbon remediation at the Bulk Fuels Facility Spill. The results of this investigation will be used in the final design of the LNAPL containment system.

Five data gaps affecting NAPL containment system design and operations have been identified:
1) hydraulic conductivity of the aquifer; 2) groundwater quality in the immediate vicinity of the NAPL plume; 3) NAPL chemical and physical parameters; 4) NAPL migration soil parameters; and 5) quantitative definition of the three-dimensional hydrogeologic system for the final design.

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1. INTRODUCTION

1.1 Scope of Activities

This Light Non-Aqueous Phase Liquid (LNAPL) Containment Interim Measure Work Plan, Part 1 – Characterization Plan was prepared by Shaw Environmental & Infrastructure, Inc. (hereafter referred to as Shaw) for the U.S. Army Corps of Engineers (USACE), under Contract No. W912DY-10-D-0014, Delivery Order 0002. This Plan defines the activities and requirements related to performing containment and capture of the NAPL plume at Solid Waste Management Units (SWMUs) ST-106 and SS-111 at the Bulk Fuels Facility (BFF) Spill, Kirtland Air Force Base (AFB), as part of phase-separated hydrocarbon remediation. In the following discussions, the term non-aqueous phase liquid (NAPL) is used to describe the mixture of separate phase organic liquid that has been observed in the subsurface. Because this NAPL is less dense than water, it is sometimes referred to as LNAPL. In this discussion, the term NAPL is used for convenience. The objective of the containment system is hydraulic control of the NAPL plume. A secondary benefit of the containment system is to potentially isolate the source of the dissolved phase plume from the downgradient portion of the plume.

The objective of this Characterization Plan is to collect the characterization data needed to complete the final design of the LNAPL containment system. The five identified data gaps are: 1) hydraulic conductivity of the aquifer; 2) groundwater quality in the immediate vicinity of the NAPL plume; 3) NAPL chemical and physical parameters; 4) NAPL migration soil parameters; and 5) quantitative definition of the three-dimensional hydrogeologic framework for the final design. This Plan was prepared in accordance with regulatory correspondence from the New Mexico Environmental Department (NMED) Hazardous Waste Bureau (HWB) to the Air Force on April 2, 2010; August 6, 2010; February 21, 2011; and March 31, 2011 (Appendix A, Attachments 1 through 4).

1.2 Data Gaps

As part of the system design, existing data for the Kirtland AFB BFF were evaluated for usability. Several data gaps affecting the NAPL containment system design and operations were identified. The following five data gaps will be addressed to complete the final design of this NAPL containment system. Section 5 presents the data collection and analysis details for each of these data gaps.

1. Aquifer hydraulic parameters
2. NAPL plume groundwater quality
3. NAPL physical parameters
4. NAPL migration soil parameters
5. Three-dimensional (3D) hydrogeologic model

1.3 Relevant Requirements

On April 2, 1010, a letter was posted to Kirtland AFB, transferring regulatory authority from the NMED Ground Water Quality Bureau to the NMED HWB.

In a letter to Kirtland AFB dated April 2, 1010 (Appendix A, Attachment 1), the NMED HWB required immediate actions be taken to remediate and stop the migration of the NAPL plume since the NAPL plume could potentially endanger the groundwater users (including water supply wells). The NAPL plume has impacted the regional aquifer that is relied upon by the Albuquerque Bernalillo County Water Utility Authority (ABCWUA), Veterans Administration (V.A.), and Kirtland AFB for delivery of drinking water to its customers. The NAPL is acting as a source of dissolved-phase hazardous constituents upgradient of ABCWUA, V.A., and Kirtland AFB groundwater supply wells. As described in the NMED April 2, 2010 letter, Kirtland AFB will conduct a Corrective Measures Evaluation or Corrective Measures Implementation to mitigate endangerment of the regional aquifer. As part of the Corrective Measures Implementation plan (which will be submitted as a separate document at a later date), remedial alternatives will be developed that are appropriate to effectively arrest and remediate contamination in the vadose zone, the NAPL plume, and the dissolved-phase groundwater plume.

On August 6, 2010 (Appendix A, Attachment 2), the NMED determined that the draft work planning documents submitted in response to the April 2, 2010 letter were deficient and issued a Notice of Disapproval instructing Kirtland AFB to correct NMED-identified deficiencies.

A February 21, 2011 letter from the NMED requires the Air Force to collect laboratory and field hydraulic data from the new groundwater monitoring wells. The March 31, 2011 NMED letter requires the Air Force to split the original LNAPL Containment Interim Measure Work Plan into a Characterization Plan and Design Work Plan. The Design Work Plan will be designated Part 2 of the LNAPL Containment Interim Measure Work Plan.

1.4 Characterization Plan Organization

This Characterization Plan is organized as follows:

- Section 1, "Introduction"—Discusses the scope of activities, data gaps, and applicable requirements and regulatory criteria to be followed
- Section 2, "Project Management"—Addresses project management and personnel
- Section 3, "Background Information"—Describes the site and operational history
- Section 4, "Site Conditions"—Presents the environmental setting and previous investigations
- Section 5, "Data Gaps Technical Approach"—Details the technical activities to address the five data gaps
- Section 6, "Extraction Well Installation"—Describes the extraction well installation
- Section 7, "Field Operations Documentation"—Details the field documentation processes that will be followed
- Section 8, "Data Management Plan"—Contains the Data Management Plan
- Section 9, "Quality Assurance/Quality Control"—Presents the site-specific Quality Assurance Control Project Plan
- Section 10, "Project Schedule"—Outlines the project schedule

Tables and figures are provided in separate tabs following the body of the report.

Appendices to this work plan include the following:

- Appendix A, "2010 Regulatory Correspondence between the NMED HWB and the Air Force Regarding the Kirtland AFB, BFF Spill"—Contains regulatory correspondence from the NMED to the Air Force regarding requirements for further actions at the Kirtland AFB BFF Spill
- Appendix B, "Quality Assurance Project Plan"—Will contain the site-specific Quality Assurance Project Plan. This document is currently in review and will be submitted separately.
- Appendix C, "Waste Management Plan"—Presents the Waste Management Plan for the project
- Appendix D, "Field Forms"—Contains field forms that will be used for field documentation
- Appendix E, "Project Schedule"—Contains the project schedule

2. PROJECT MANAGEMENT

2.1 Project Scheduling and Reporting Requirements

Shaw is responsible for planning, scheduling, and performing the project activities and field work, as well as documenting and reporting project activities on a daily basis. Shaw is also responsible for compliance with the applicable quality control (QC) requirements, overall project safety, the safety and health of workers under its direction, and performance of field activities according to the work plan, regulatory requirements, and this contract. The project-specific Accident Prevention Plan, which contains the Site Safety and Health Plan (SSHP), was submitted under separate cover (Shaw, 2010a). The Quality Assurance Project Plan (QAPjP) will be included as Appendix B to this work plan; the QAPjP is currently in review and will be submitted under separate cover.

2.2 Project Organization and Resource Management

The organizational structure of the project team is shown on Figure 2-1.

Mr. Thomas Cooper is the Shaw Project Manager for all investigations and remedial work at SWMUs ST-106 and SS-111, collectively called the BFF Spill at Kirtland AFB, New Mexico. Mr. Cooper will have overall responsibility for safety and quality on all projects. He will manage and integrate team members and will oversee cost and schedule monitoring and control. All project activities will be coordinated through the USACE Project Manager, Mr. Walt Migdal. Mr. Migdal will have direct communication with the Kirtland AFB Chief of Environmental Restoration, Mr. Wayne Bitner, Jr.

The project team will include corporate, managerial, and technical positions. Personnel at the work site will vary in number, depending on the particular task being completed. According to the established chain of command, Shaw subcontractors will report to Shaw, and Shaw will report to the USACE Project Manager. Figure 2-1 and Table 2-1 specify Shaw personnel responsibilities and reporting lines.

Communication pathways are also detailed in the Project Management Plan, provided under separate cover (Shaw, 2010b). All Shaw personnel and Shaw subcontractors are required to have current hazardous waste training as defined by Title 29, Code of Federal Regulations, Section 1910.120. Shaw will directly supervise subcontractors performing field work at all times, and Shaw is responsible for the work performance of all subcontractors under its supervision.

Table 2-1 summarizes the roles and responsibilities, qualifications, and authorities of key project team members.

2.3 Project Coordination

Before the start of work, a field implementation kickoff meeting will be held at Kirtland AFB or at the NMED, as appropriate. Invitees may include representatives from the USACE, Kirtland AFB, Air Force Center for Engineering and Environment (AFCEE), the NMED, and contractors conducting the work. The meeting will outline roles and responsibilities of all participants; review scope, schedule, and procedures; and discuss Kirtland AFB base rules and security requirements. During the field implementation kickoff meeting, a list of critical contacts within the field team, USACE, Kirtland AFB, AFCEE, and NMED will be compiled. This contact list will be used should immediate input be needed in any decision process critically impacting field work.

During field investigation activities, Daily Quality Control Reports (DQCRs) will be completed by the field team managers and provided to the Project Manager and client designee(s) on a daily basis. These reports summarize field and QC activities that occurred during the day. In compliance with the QAPjP (Appendix B; to be submitted under separate cover), Field Change Request (FCR) forms (Appendix D) will be filled out if there are any significant changes from the scope of work. If the FCR represents a major change, such as moving a well or boring location more than 100 feet in a given direction, the USACE, , NMED, and Kirtland AFB will be notified, and the change will be approved prior to

commencement. If the FCR is minor and the resolution is clearly outlined in the data quality objectives, the FCR will be filed; the change will be made in the field; and USACE, Kirtland AFB, the Project Manager, and the NMED will be notified of the change. NMED approval will be required for changes to previously approved work plans.

Weekly conference calls may be held on an as-needed basis among the field team, USACE, Kirtland AFB, and the NMED to discuss progress of the field effort and upcoming field work, and to consider any problems or issues that require resolution. Minutes of the meeting will be kept by the field team manager and circulated to the participants.

With planning document approval, mobilization of field staff (management, technical, subcontractors), equipment (vehicles, computers, global positioning systems, etc.), and material (safety supplies, etc.) will begin as soon as practical based on the schedule and weather.

A staging area will be set up based on a prescribed location at Kirtland AFB. This area will contain an office trailer(s), laydown area, and work crew facilities; the staging area will be used for multiple phases of work for the Kirtland AFB BFF Spill project. An electrical subcontractor will be used for electricity hook-ups to the facilities, as needed.

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3. BACKGROUND INFORMATION

3.1 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 3-1). The approximate area of the base is 52,287 acres.

3.2 Operational History

The BFF Spill site is located in the northwestern portion of Kirtland AFB (Figure 3-1). 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 Air Force Base [KAFB]-1066) and a separate fuel-loading area where individual fuels trucks were filled. The truck-loading area appears to have been approximately 250 feet north of the tank area (Figure 3-2).

Subsequent aerial photographs indicate that construction of the facility and associated infrastructure took place from 1951 until 1953. The facility operated until it was removed from service in 1999, due to a below-grade line leakage along the off-loading rack (CH2M HILL, 2001). 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 were AVGAS, jet propellant-4 fuel (JP-4), and JP-8. The use of AVGAS and JP-4 at Kirtland AFB was phased out in 1975 and 1993, respectively. JP-8 was handled through the Former Fuel Offloading Rack (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 (aboveground storage tanks [ASTs] Tanks 2420 and 2422). The probable release points were investigated and are summarized in subsequent sections. Fuel transfer from the 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 ASTs (1.7 million gallons each). The site currently has one temporary JP-8 off-loading rack located in the southwest corner of the facility, west of the fuel-loading structure at Building 2404. This rack was placed into service following the piping failure at the FFOR (ST-106). A second small off-loading rack (Building 2401) is used for the delivery of diesel and unleaded gasoline motor vehicle fuels.

Fuel delivered to the temporary JP-8 off-loading 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 aboveground for approximately 750 feet and runs belowground for approximately 300 feet.

Figure 3-2 presents the infrastructure present at the eastern portion of the BFF source area.

4. SITE CONDITIONS

A detailed discussion of Kirtland AFB history, geology, and the known extent of contamination is presented below.

4.1 Geology

4.1.1 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 feet above mean sea level. These mountains are comprised of Precambrian metamorphic, igneous (primarily granite), and Paleozoic sedimentary rock (primarily marine carbonates). The western portion of the base (which includes 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 the eastern half of the base.

Kirtland AFB lies within the eastern portion of the Albuquerque structural basin, which 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 feet, though the thickness varies considerably because of the large amount of faulting in the basin (CH2M HILL, 2008).

Geologic materials of primary importance within the basin are the Santa Fe Group and the piedmont slope deposits. The Santa Fe Group 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 Santa Fe Group (USF) under the BFF is further broken down into two depositional facies called the USF-1 and USF-2 (Hawley et al., 1995). USF-1 is present from ground surface to approximately 86 feet below ground surface (bgs), then a transition occurs where USF-1 and USF-2 are interfingered to a depth of 144 feet bgs, under which USF-2 is present to a depth of greater than 500 feet (CH2M HILL, 2008).

4.1.2 Site-Specific Geology

The site geology is a typical fining-upward fluvial fan deposit with fine-grained silts and clays at the surface down to an elevation of approximately 5,100 feet (~200 feet bgs, Figure 4-1). Below a depth of approximately 200 feet, the amount of sand and gravel increases with sand being the predominant soil type with definite gravel lenses at various depths. The sand ranges in grain-size from fine-grained up to very coarse-grained. The gravel lenses are typically sandy gravel with some thinner less extensive lenses of silty and clayey gravel. Below the water table down to an elevation of approximately 4,700 feet (~600 feet bgs), sand is the dominant lithology with gravel and silty sand and silt lenses. In general, the gravel lenses below the water table are somewhat more laterally extensive than the gravel lenses above the water table–consistent with the overall fining-upward depositional sequence.

No obvious structure is apparent in the lithologic layers. The lithology layers are generally flat-lying as presented on Figure 4-1.

4.2 Hydrogeology

4.2.1 Regional Hydrogeology

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

Generally, the upper unit of the Santa Fe Group 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 feet per day to 50.0 feet per day because of 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 (Tetra Tech, 2004).

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 Santa Fe Group; 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 feet at a location 5 miles southwest of the airfield (Tetra Tech, 2004).

4.2.2 Site-Specific Hydrogeology

Locally to the BFF Spill site, the groundwater flow direction is approximately north-northeast with flow direction towards the Ridgecrest production wells. The groundwater gradient below the BFF varies from 0.0005 to 0.004 feet per feet (Shaw, 2011; Figure 4-2). A 4- to 6-foot increase in water levels has been observed at the BFF site since 2009, which is most likely due to the water conservation practices put into place by the ABCWUA to reduce groundwater withdrawals from the aquifer. This rise is expected to continue into the future and will be incorporated into the LNAPL system well design by adding 40 more feet of screen above the water table than was originally planned in the extraction well design.

The closest aquifer tests to the BFF were a series of aquifer tests conducted 4,000 feet southeast of the BFF at the ST-105 Nitrate Abatement site (Figure 4-3; MWH Americas, Inc., 2009). The slug test average hydraulic conductivity ranged from 0.3 feet/day up to 60 feet/day with an arithmetic mean of 18 feet/day and a standard deviation of 12 feet/day. The pumping test had usable drawdown in the pumping well KAFB-ST105-EX01 and the observation well KAFB-0508, which were 70 feet from the pumping wells. Two observation wells, which were 1,000 feet from the pumping well, had no usable drawdown results. The hydraulic conductivity from the pumping well was measured to be 130 feet/day and that from the observation well was 250 feet/day. The data from the observation well had a specific yield of 0.05 with a K_z/K_r ratio of 0.0007 (i.e., the horizontal hydraulic conductivity is ~1,500 times greater than the vertical hydraulic conductivity). The pumping well boring log indicates that approximately 35 feet of gravel was encountered near the bottom of the boring, whereas the surrounding wells completed just below the water table were primarily sand lithology. The difference between the slug and pumping test hydraulic conductivity results are attributed to these lithologic differences.

The hydrogeologic testing included in this work plan will be used to further refine the site-specific hydrogeology, including hydraulic conductivity, porosity, fraction of organic carbon, and specific yield. These data will be incorporated into the final hydrogeologic characterization and remediation system design.

4.3 Fate and Transport

Based on the analysis of current and existing organic compound and degradation data, it is apparent that microbial degradation is occurring and that it has a positive effect on the migration of organic compounds at the site. The ethylene dibromide (EDB) plume observed is approximately 2,400 feet downgradient from the edge of the NAPL plume (Shaw, 2011). Downgradient from the NAPL plume, benzene, one of the more mobile and soluble compounds in fuel-based NAPL, has migrated only half the distance of the total petroleum hydrocarbons (TPH) as gasoline range organics plume (Shaw, 2011). The other organic compounds are observed within the immediate vicinity of the NAPL plume that is the source of the dissolved plume compounds. Additional support for microbial degradation comes from the signature presented by the dissolved oxygen, oxidation/reduction potential, iron, and manganese data. (Shaw, 2011)

4.4 Nature and Extent of Contamination

4.4.1 Contaminant Sources

In November 1999, the following three known discharges occurred as a result of pressure testing of the lines that transfer fuel from the JP-8 off-loading rack (Building 2405) to the Pump House at the facility (Figure 3-2):

- Failure of one of the 14-inch-diameter belowground transfer pipelines during a hydrostatic pressure test
- Failure of a cam-lock coupling during pressure testing of the second belowground transfer pipeline
- 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 batch of 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, because of the presence of multiple types of fuel contamination on the water table and the size of the NAPL plume, it is likely that the primary pipeline had been in a state of failure for many years. The presence of NAPL 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, diesel, JP-4, and JP-8 (Tetra Tech, 2004).

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 (Tetra Tech, 2004). JP-4 is a mixture of aliphatic and aromatic hydrocarbons with a low flash point (0° Fahrenheit/-18° Celsius); 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. Ethylene dibromide 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 1990 serves as another potential marker.

4.5 Previous Investigations

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 off-loading 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),* (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)
- *Remediation and Site Investigation Report for the Bulk Fuels Facility, April 2009– September 2009* (CH2M HILL, 2009)

The conclusions of these reports are summarized below. In the reports, soil data collected during the BFF Spill investigations are compared to the NMED TPH Screening Guidelines to aid in defining the extent of contamination (NMED, 2009).

4.5.1 Stage 1 Abatement Plan Report

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

Site investigations conducted during 2000 also included soil characterization at depth, extending down to the water table at select locations. 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 off-loading rack. The maximum concentration detected in soil from

boring SB-25 was 81,000 parts per million of TPH in the sample from 105 feet 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 parts per million of TPH in the sample from 270 feet 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 had TPH concentrations greater than 100 milligrams per kilogram (mg/kg). Based on data from the additional borings, soil contaminated in excess of the NMED TPH Screening Guidelines (NMED, 2006) is limited to within approximately 310 feet of the surface; and within the area 65 feet south (SB-29A), 280 feet north (SB-34), 400 feet east (SB-32), and 175 feet west (SB-33) 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 feet bgs (CH2M HILL, 2001).

4.5.2 Stage 2 Abatement Plan Report

Four additional soil borings were advanced in 2003 as part of a pilot test for soil-vapor extraction. All four soil-vapor monitoring wells included both soil and vapor sampling capabilities and were completed to a depth of approximately 450 feet bgs. In addition to the anticipated intervals of petroleum-related contamination, two locations were found to have detections at the shallowest sampling depth of 60 feet bgs (CH2M HILL, 2006a).

4.5.3 Stage 1 Abatement Plan Report, East Side of the Kirtland AFB BFF

In 2005, a shallow soil investigation of potential source areas on the east side of the BFF 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 advancing direct-push borehole (SB-04) to 50 feet 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 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 feet bgs. The only area where the NMED TPH guideline (NMED, 2006) 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-foot bgs sample. None of the detections suggested the area was a contributor to the soil-vapor profile at the BFF Spill. (CH2M HILL, 2006b)

4.5.4 Semi-Annual Summary and Performance Report

In 2007, groundwater monitoring well KAFB-1066 was installed in the general vicinity of the east side of the BFF. 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 feet 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 the Semi-Annual Summary and Performance Reports (CH2M Hill, 2009). Soil sampling was conducted at 20-foot intervals during advancement of the KAFB-1066 borehole, from 20 to 480 feet bgs. 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 (less than 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 and 140 feet bgs in the borehole. While the individual fuel-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 (CH2M HILL, 2008).

4.5.5 Remediation and Site Investigation Report

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. Soil data are consistent with previous sampling results, and the effectiveness of the soil-vapor extraction system was indicated. NAPL was not detected in samples collected from any of the newly installed wells (CH2M HILL, 2009).

4.6 Identification of Potential Contaminants of 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 have 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 (COPCs) at the BFF Spill are constituents of refined petroleum products and include, but are not limited to, the following: benzene, toluene, ethylbenzene, xylenes, naphthalene, EDB, and lead.

Compound-specific groundwater maximum contaminant levels, developed for the protection of human health, are presented in New Mexico Administrative Code, Title 20 - Environmental Protection, Chapter 6, Water Quality, Part 2 - Ground and Surface Water Protection.

Maximum contaminant levels for the petroleum-related compounds are as follows:

- Benzene 0.01 milligrams/liter (mg/L)
- Toluene 0.75 mg/L
- Ethylbenzene 0.75 mg/L

- Total xylenes 0.62 mg/L
- 1, 2 dichloroethane 0.01 mg/L
- EDB 0.0001 mg/L

4.6.1 LNAPL Distribution

The NAPL plume extends approximately 2,600 feet long and is approximately 1,000 feet wide, trending along the groundwater flow direction (Figure 4-4). Based on existing historical data, the greatest thickness of NAPL was in the area to the east of the FFOR. NAPL thickness trends were consistent with vadose zone migration of bulk NAPL, and then followed the groundwater table toward the north and east. Because of rising water table (Section 4.2.2), in March 2011, NAPL was observed in three monitoring wells whereas in 2009, NAPL was observed in eight monitoring wells. The 2011 NAPL thickness in wells was less than 1 foot whereas in 2009, NAPL thickness up to almost 4 feet was observed. The liquid level data trends indicate that the majority of the NAPL is now trapped below the current water table at the 2009 depths.

4.6.2 Dissolved-Phase COPC Distribution

The distribution of dissolved-phase contaminants forms a halo around the NAPL plume. As expected, concentrations of dissolved COPCs are detected at high concentrations very close to the NAPL plume due to the dissolution of petroleum products into the groundwater, and lower concentrations are detected further from the NAPL plume. The dissolved-phase plume, as it is currently understood, extends approximately 4,500 feet along the axis of the plume, trending along the groundwater flow direction, and is approximately 1,200 feet wide. Ethylene dibromide 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. The currently known extent of the dissolved-phase plume is shown on Figure 4-1.

4.7 Potential Receptors

Potential receptors, identified for the NAPL and dissolved-phase contamination, include members of the City of Albuquerque, V.A. staff, and Kirtland AFB. The ABCWUA production wells are screened within the aquifer and provide drinking water to residents of the City of Albuquerque who rely on getting drinking water from the Santa Fe aquifer. Additionally, the V.A. uses a production well screened in the aquifer to provide water to staff and patients. Kirtland AFB has production wells screened in the aquifer that provide base staff and residents with drinking water. NAPL and dissolved-phase contamination have been detected in the drinking water aquifer, and there is the potential for downgradient water wells to be impacted if further migration should occur.

5. DATA GAPS TECHNICAL APPROACH

As part of the NMED comments on the original LNAPL Containment Interim Measure Work Plan, it was required that all of the characterization work be completed before the design work plan is developed in mid-2012. As part of this characterization work, five data gaps will be addressed using wells shown on Figure 5-1.:

1. **Aquifer Hydraulic Parameters**—This data gap will be addressed with laboratory hydrogeologic testing of soil samples during drilling, slug testing of groundwater monitoring wells, and installation and pumping tests on two extraction wells.

2. **NAPL Plume Groundwater Quality**—This data gap will be addressed by analyzing groundwater samples from below the NAPL-groundwater interface in groundwater monitoring wells. These samples will be collected as part of the quarterly groundwater monitoring program. These data will be used in the final design of the groundwater treatment system, including for carbon loading, metals removal, incrustation analysis, and biofouling management. The data also will be used in the microbial degradation analysis and modeling for long-term management of the dissolved-phase plume downgradient from the NAPL containment system.

3. **NAPL Physical Parameters**—This data gap will be addressed by collecting NAPL samples from wells with sufficient NAPL for sampling (approximately 6 inches or greater). These data will be used in the NAPL migration analysis, the design of the liquid treatment system, and in the microbial degradation analysis to define long-term groundwater compound source terms.

4. **NAPL Migration Soil Parameters**—This data gap will be addressed by collecting undisturbed soil samples from just below the water table during installation of monitoring wells. Eight soil samples representing various grain sizes will be analyzed for pore fluid saturation, grain size, and NAPL/water capillary curves, including calculation of van Genuchten parameters (van Genuchten, 1980) for use in NAPL migration analysis.

5. **Three-dimensional (3D) Hydrogeologic Model**—For containment system design and final remediation, it is necessary to develop a quantitative hydrogeologic model for use in design calculations.

5.1 Data Gap 1—Aquifer Hydraulic Parameters

Hydrogeologic properties of the aquifer below BFF will be determined using several field and laboratory methods including the following:

1. Laboratory tests on re-molded soil samples
2. Slug tests
3. Pumping tests

5.1.1 Hydraulic Property Laboratory Testing

Soil samples will be collected from the wells presented in Table 5-1 and on Figure 5-2 for laboratory testing of hydraulic properties shown in Table 5-2. The samples will be collected from the air-rotary casing hammer (ARCH) rig discharge cyclone using a bucket to preserve the fine-fraction. Samples will be collected from the approximate middle of the screen interval of the wells. Fifty-two samples will be tested for grain-size, and 34 samples will have laboratory hydraulic tests conducted.

5.1.2 Slug Tests

Slug tests will be performed on the wells presented in Table 5-1 and on Figure 5-3. It is planned that slug tests will be performed on 34 wells using either pneumatic (Butler et al, 2003) or solid pipe slugs. Solid slugs will be used in wells screened above the water table, and pneumatic slugs will be used on wells screened below the water table. Slug test data will be analyzed using the AQTESOLV™ or similar aquifer test software. If oscillatory slug test results are obtained from the pneumatic tests, they will be analyzed using methods similar to those described by Chen (2006).

A slug test is an aquifer test in which the water level in a well is "instantaneously" changed by using one of several methods. The water-level response is then monitored over a period of time in the well using a high-speed recording pressure transducer. Slug tests require rapidly recorded and accurate water-level data.

Slug tests will be performed in accordance with the procedure described below:

1. Equipment to be used will be inspected to ensure that it is in good working order.
2. Measuring and testing equipment will be calibrated and tested before use in accordance with manufacturer's specifications.
3. Before testing, fluid levels and the bottom of the well will be measured using an electric-sounding device, or a weighted steel tape, and recorded.

4. If the solid slug method is used, the following procedure will be followed:

   a) The wellhead will be visually inspected for damage or obstructions that could hinder transducer or slug insertion or removal.

   b) The height of the water column in the well will be calculated and used to determine the location of the transducer (Note: the maximum depth below the water surface is 23 feet for a 10-pounds-per-square-inch transducer).

   c) The pressure transducer will be lowered into the well and secured so that it will not move during the test.

   d) The location of the slug will be planned so that the height of the water column will totally immerse the slug but will also allow concurrent use of the pressure transducer. The slug will be lowered to just above the static water level.

   e) The recording frequency of the data logger will be set to record at logarithmically increasing intervals.

   f) The data logger and insertion of the slug will happen concurrently and as quickly as possible so the slug will be below the static water level. The slug will not be allowed to free-fall when lowering.

   g) The water-level decline will be monitored with the pressure transducer/data logger until the level has returned to approximately the pre-test level.

   h) The slug-in test may be terminated once the water level has returned sufficiently to the pre-test static level. Once the slug-in test is terminated, a physical water-level measurement will be taken using the electric tape. The measurement and time will be recorded. Work will proceed to the slug withdrawal ("slug-out") test.

   i) The slug test data will be reviewed and if appropriate, adjustments will be made to the procedure.

   j) Concurrently with starting the data logger, the slug will be raised as quickly as possible such that the rod is completely out of the water column and above the static water level.

   k) Water levels will be monitored as they rise with the pressure transducer/data logger.

   l) The slug-out test may be terminated once the water level has returned sufficiently close to the pre-test static level. The data will be reviewed in the field to help ensure the validity of the test.

   m) The slug-in and slug-out tests maybe repeated as necessary and as appropriate.

5. If the pneumatic slug method is used, the following procedure will be used:

   a) The well head equipment will be assembled on the well casing, and the top seal will be tightened.

   b) The transducer will be lowered to the determined depth below the water table. Normally, this will be 5 to 10 feet.

   c) The transducer cable will be secured on the well head using the split seal.

d) The air compressor will be attached to the air fitting on the well seal, and the well will be pressurized to the pre-determined slug pressure. Usually the test pressure will be 1 to 3 pound per square inch (2 to 6 feet of water).

e) The transducer will be monitored for stability. Once stability is achieved, the large air valve will be opened to induce the slug.

f) The water-level change will be monitored with the pressure transducer/data logger until the level has returned to approximately the pre-test level.

g) The slug test data will be reviewed and the test repeated, if appropriate. The oscillating slug test method will be used to analyze the slug test data.

6. After the tests are determined to be satisfactory, downhole equipment will be removed from the well, and the wellhead will be secured.

7. Downhole equipment will be decontaminated before moving to the next well.

5.1.3 Pumping Tests on KAFB-106157 and KAFB-106158

A series of pumping tests will be conducted once the two extraction wells, KAFB-106157 and KAFB-106158, are installed (see Section 6 for installation methods). One month prior to any pumping test, recording transducers will be installed in selected wells (Table 5-3) to determine water level fluctuations under non-pumping conditions. Weekly manual water levels will be measured in all monitoring wells for 1 month prior to the start of the pumping tests.

All pumping test-produced water will be routed through a temporary granular activated carbon (GAC) water treatment system for organics removal prior to discharge under a temporary discharge permit. Based on the anticipated pumping test flow rates and duration, approximately 1.5 million gallons of pumping-test water will be treated and discharged during the pumping tests.

A pumping test involves pumping water from a well at either a constant or variable discharge rate while monitoring the water-level changes (drawdown) in the pumped well and observation wells. The drawdown measured in response to the pumping is used to determine the transmissivity and storage coefficient of the aquifer. Water-level recovery also will be monitored after the pumping is discontinued.

5.1.3.1 Pumping Test Procedure

The general steps for the pumping tests are as follows:

1. Inspect the equipment to be used to ensure that it is in good working order.

2. Calibrate and/or test all measuring and testing equipment before use.

3. Decontaminate all downhole equipment.

4. Visually inspect the wellheads for damage or obstructions that could hinder the water-level recorder or pump insertion and removal.

5. Physically measure the liquid levels in the pumping and observation wells with electric tape and record them along with the date and time. Use 24-hour military time for all data collection. Use separate data sheets for each well.

6. Install the pump in the pumping well along with the pressure transducer and associated electrical or air supply lines. The transducer will be attached just above the top of the pump and secured at periodic intervals to the drop pipe or tubing as the assembly is lowered into the well. The transducer will be attached to the pump column at a level that 1) eliminates effects from the pump intake, 2) is below the anticipated water level during maximum drawdown, and 3) does not exceed the maximum transducer head limitations.

7. The position of the pump intake inside the well will be at minimum a few feet above the bottom of the well. Note the height of the water column from the static water level to the pump intake. During testing, the drawdown will not be so great as to cause the pump to cavitate. Record all information including the depth of the pump intake and pressure transducer.

8. Install the transducers in the observation wells. The transducers will be installed at a position inside each well that is below the anticipated water level during maximum drawdown, and that does not exceed the maximum head limitation.

9. Record the depths of the transducers below the water surface using the data logger.

10. Set the recording frequencies in the data loggers for the pumping test. Generally, an increasing logarithmic progression is used in the pumping well and nearby monitoring wells, and constant intervals are used in wells further from the pumping well. Set all transducers for a simultaneous recording start time immediately before the pump will be started.

11. Start the pump at the scheduled time and adjust the valve or flow regulator to maintain a constant rate of discharge. Record the pump start time and flow rate.

12. Continue to monitor water levels during pumping with the pressure transducers/data loggers, taking periodic manual water-level measurements in each of the wells with the electric tape. The water-level data will be evaluated during the test and, if necessary, the recording frequencies of the data loggers will be adjusted.

13. Observe and record the wellhead flow meter readings throughout the test on the same schedule as the manual water levels.

14. Near the end of the pumping period, re-set the data loggers to a simultaneous start for the recovery test.

15. Take a manual water-level measurement in each of the monitoring wells with the electric well tape, and record the measurements and times.

16. Shut down the pump at the scheduled stopping time. Record the time that the pump was shut down.

17. Continue to record the water-level recovery in the wells with the pressure transducers/data loggers until the water levels have recovered to within 90 percent of the level expected from the pre-test trends. Also, continue to take physical water-level measurements periodically during recovery. The recovery time will be approximately equal to the pumping time.

18. Once the recovery period is ended, take a physical water-level measurement in each observation well. Record the measurements and times.

19. Additional depth-to-water measurements may be physically taken following complete well recovery in order to monitor post-test trends in water levels.

20. Review data in the field to help ensure the validity of the test. Once the pump test is satisfactorily completed for the wells, remove and decontaminate all downhole equipment and secure the wellheads.

The above procedures may be modified based on field conditions and data observations.

5.1.3.2 KAFB-106157 Pumping Test

After the two extraction wells are installed and developed, a step-drawdown (variable rate) test will be performed on KAFB-106157 to determine the flow rate of the long-term test. The plan is to run steps of 50, 100 gallons per minute (gpm) for 1 to 2 hours, each followed by a 4- to 6-hour step of 150 gpm. The duration of each step will be determined in the field based on observed water-level response. Wells in the immediate vicinity of KAFB-106157 will be monitored for drawdown during the step test.

After evaluation of the step-drawdown data, a 72-hour (3 days) to 168-hour (7 days) constant rate pumping test will be performed using extraction well KAFB-106157 as the pumping well. Nearby monitoring wells will be used as observation wells during the pumping test. Both manual and recording transducer water-level data will be obtained. Figure 5-4 illustrates the location of KAFB-106157 pumping and monitoring wells that will be used as observation wells during the pumping test.

As part of the pumping test, Shaw will conduct a treatability test using GAC. This will consist of a two-bed system with the second bed designed as a guard bed for the primary bed so that all water discharged will be below regulatory concentrations for discharge per the temporary discharge permit. As part of the treatability test, influent and effluent samples will be collected according to the schedule in Table 5-4.

5.1.3.3 KAFB-106158 Pumping Test

After the completion of the KAFB-106157 pumping test, a 6- to8-hour step-drawdown test will be performed on KAFB-106158. This will be followed by a 24- to 72-hour constant rate pumping test. The monitoring wells shown in Table 5-3 and on Figure 5-3 will be used for this test, but the transducers installed in KAFB-106073 through KAFB-106075 will be moved to wells KAFB-106038 through KAFB-106040 or KAFB-106067 and KAFB-106068.

All discharge water will be treated using the temporary GAC treatment system, and treatability samples will be collected according to the schedule shown in Table 5-4.

5.1.3.4 Capture Zone Sensitivity Analysis

As required by the March 31, 2011 NMED letter, a sensitivity analysis of capture zone extent was conducted, and the results are presented on Figure 5-5. As shown on Plots A through C on Figure 5-5, if the extraction well pumping rates are increased in proportion to the increases in hydraulic conductivity, the capture zone extent stays constant. So in the final analysis, the capture zone extent is just a direct function of the drawdown in the extraction wells. As presented in Plot D on Figure 5-5, if the hydraulic conductivity is as high as 250 feet/day, two 100-gpm extraction wells will contain the NAPL area.

The mathematical reason for the relationship between the capture zone area and only the drawdown and hydraulic gradient is illustrated in the following equations. The Thiem equation (Todd, 1959) for steady-state flow to a well in a confined aquifer (the unconfined equation can also be used, but it is simpler to

understand the principle using the confined equation) can be inserted into the equation for capture zone width to show that capture zone is a function of drawdown in the well, radius of influence, and hydraulic gradient:

Equation 1. Thiem equation

$$Q = 2\pi Kb \frac{h_0 - h_w}{ln \frac{r_0}{r_w}}$$

and substituting the Thiem equation into the capture zone equation (Todd, 1959)

Equation 2. Width of capture zone

$$y = \pm \frac{Q}{2Kbi}$$

Equation 3. Capture zone equation with Thiem Equation substitutions

$$y = \pm \frac{2\pi Kb \frac{h_0 - h_w}{ln \frac{r_0}{r_w}}}{2Kbi}$$

$$y = \pm \frac{\pi \frac{h_0 - h_w}{ln \frac{r_0}{r_w}}}{i}$$

$$y = \pm \frac{\pi (h_0 - h_w)}{i * ln \frac{r_0}{r_w}}$$

where

Q = well pumping rate

K = hydraulic conductivity

b = aquifer thickness

h_0 = static water level in aquifer under non-pumping conditions

h_w = pumping water level in well

h_0 - h_w = drawdown in pumping well

r_0 = radius of influence of pumping well

r_w = effective hydraulic radius of pumping well

i = hydraulic gradient

y = width of capture zone

5.2 Data Gap 2—NAPL Plume Groundwater Quality

Water and NAPL samples will be collected from wells KAFB-1065, KAFB-1066, KAFB-1068, KAFB-1069, KAFB-10614, and KAFB-10610 (Figure 5-1). Groundwater samples will also be collected in these wells as part of the routine quarterly monitoring program. Field parameters, including temperature, pH, dissolved oxygen, oxidation/reduction potential, and ferrous iron will be measured during sampling. Laboratory samples will be analyzed for volatile and semivolatile organic compounds, TPH, jet fuel/gas/diesel, metals, and major cations and anions, including the degradation compounds ammonia, nitrate, and orthophosphate (Table 5-5). The project-specific QAPjP lists all analyses applicable to groundwater samples (Appendix B, to be submitted).

5.3 Data Gap 3—NAPL Physical Parameters

NAPL samples will be collected from wells with adequate LNAPL volume (minimum of 6 inches of NAPL thickness). NAPL samples will be collected using a point sampler or stainless-steel bailer. As applicable, NAPL will be decanted from the water into sample jars. Wells will not be purged before sampling.

NAPL samples will be analyzed for density, viscosity (at ambient groundwater temperature), interfacial tension (air/water, air/NAPL, and water/NAPL), flashpoint, American Petroleum Institute gravity, and organic compound PIANO analysis (paraffins [P], isoparaffins [I], aromatics [A], naphthalene [N], and olefins [O]), plus benzene, toluene, ethylbenzene, xylenes; 1,2 dichloroethane; and EDB (Table 5-5). The project-specific QAPjP lists all analyses applicable to the NAPL samples (Appendix B, to be submitted).

5.4 Data Gap 4—NAPL Migration Soil Parameters

The soil samples presented in Table 5-6 will be tested for grain-size, pore fluid saturation, air-water capillary curves, and NAPL/water capillary curves, including calculation of van Genuchten (1980) parameters for both the air/water and water/ NAPL curves for use in NAPL migration analysis. The cores were collected using acetate sleeves, and the field crew placed them on dry ice to preserve the pore fluids. Because only limited silt and clay cores were collected, it may be necessary to use literature values for the van Genuchten parameters for these lithologies.

5.5 Data Gap 5—3D Hydrogeologic Model

This geologic portion of this data gap will be addressed by developing a 3D lithologic model. This lithologic model will then be used in conjunction with the hydrogeologic test data from Data Gaps 1 and 4 to define the 3D hydrogeologic model for use in design. The hydrogeologic portion of this model will include horizontal and vertical hydraulic conductivity, permeability (for use in NAPL migration evaluations), porosity, pore fluid saturations, and fraction of organic carbon. To the extent possible, the hydraulic values will be associated with lithology in the hydrogeologic model.

5.5.1 3D Lithologic Model

Using the lithologic data from wells and borings, a 3D geologic model will be developed using RockWorks™ (RockWare, 2010). This model will use all available lithologic and geophysical log data from existing wells and borings, and the data from wells and borings installed during the ongoing

groundwater and vadose zone investigations. The model will be updated as additional geologic and geophysical data become available. This model will allow for ready analysis of geologic data, construction of scaled representations of site conditions (e.g., cross-sections), and the development of model layers for hydrogeologic modeling. RockWorks™ model results will be incorporated into the project geographical information system (GIS) for analysis and mapping.

5.5.2 3D Hydrogeologic Model

Based on the lithologic model, the 3D hydrogeologic conceptual model will be developed using the 3D lithologic model as the foundation. The hydrogeologic model will incorporate the results of all of the data collected for the data gap evaluations and ongoing monitoring data. The conceptual model will qualitatively assess NAPL migration, horizontal and vertical groundwater flow, and dissolved contaminant transport.

These qualitative findings will be incorporated into quantitative NAPL migration/remediation evaluations using one-dimensional (1D) or two-dimensional (2D) numerical models. The dissolved contaminant transport and remediation will be assessed with a 3D numerical flow and transport model. These quantitative model results will be incorporated into the determination of LNAPL containment system final flow rates. Major considerations in the design flow rate determination will be the anticipated water level rises over time and the associated future thickness of the LNAPL zone.

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6. EXTRACTION WELL INSTALLATION

Before the pumping tests and critical to the final design of the LNAPL containment system, the two extraction wells, KAFB-106157 and KAFB-106158, must be installed.

6.1 Permitting

Well construction permits for the two extraction wells will be obtained from the New Mexico Office of the State Engineer. A signed right-of-entry has been obtained for wells located off of the Kirtland AFB property. Additionally, a permit with the NMED Ground Water Quality Bureau will be obtained for the discharge of waste water associated with the proposed pumping tests.

6.2 Drilling Program

The drilling program will consist of a phased installation of two extraction wells using an ARCH drilling rig. The proposed well completion of the two extraction wells and one injection well are shown on Figures 6-1.

6.3 Requirements and Procedures

The procedures for well installation, development, and reporting are discussed in the following sections.

6.3.1 Borehole Clearance

The site will be marked for proposed drilling locations. Utility locates will be conducted at the well locations in advance of mobilization to begin drilling and well installation. Additionally, New Mexico One-Call (811) will be notified at least 48 hours prior to the start of work. Each boring will also be hand-augered for the first 5 feet bgs or until refusal by the hand augers.

6.3.2 Equipment Decontamination

Equipment and materials mobilized to the site will be free of foreign materials and maintained in a clean condition throughout work activities. Equipment and materials include, but are not limited to rods, bits, core samplers, and sampling equipment. Steps will be taken to clean equipment and tools before use, during sampling, and between well locations. Well installation activities will conform to New Mexico Office of the State Engineer well permit requirements, applicable codes, manufacturer's specifications, regulatory guidelines (e.g., Occupation Safety and Health Administration), and trade standards. Good housekeeping practices will be enforced to accommodate storm water best management practices on site. Drilling cuttings and liquids will be handled according to the Waste Management Plan (Appendix C).

6.3.3 Drilling

Drilling will begin after the drilling permits are obtained and the sites have been cleared for underground utilities. Each well boring will be advanced using the ARCH method. The ARCH method uses steel insulator casing advanced with a drill bit/rod to prevent borehole collapse. The well borings will be drilled using a 13¾-inch nominal drive casing down to a depth of approximately 200 feet bgs. The casing will be telescoped down to an 11⅝-inch outside diameter drive casing to total depth. The extraction well borings will be drilled to 50 feet below first-encountered groundwater, which is estimated to be 500 feet bgs.

6.3.4 Logging and Soil Sample Collection/Analysis

Each extraction and monitoring/observation well boring will be described on a boring log similar or equivalent to the form found in Appendix D, Form 1 and in accordance with ASTM International (ASTM) D5434-09 (*Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock*). The geologist will log the boring as it is being drilled by retrieving cuttings from the hopper and recording relevant data, as listed below, on either the appropriate boring log or in a bound field logbook. Boring log forms may be transcribed from a field logbook, but must be completed a weekly basis at a minimum on.

Soil cuttings will be collected and logged every 5 vertical feet from ground surface down to the total depth of the wells. Data that will be included in the logs, when applicable are described as follows:

- The identifying number and location of each boring will be recorded.
- Drilling logs and other scaled drawings will be drawn at a scale that is practical for the well depth. In addition, if sampling intervals are greater than 10 feet apart, the log can be represented with breaks in order to skip unlogged intervals. All measurements will be accurate to $^{1}/_{10}$ of a foot.
- Soil will be classified in accordance with the Unified Soil Classification System (USCS). These classifications will be applied in the field by the geologists and will be subject to revision based on laboratory tests and subsequent review by the Project Geologist.
- 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, the interval over which they occur, and the quantity losses, 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 cuttings that appear contaminated 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. 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 Soil

All classification data will be written directly onto the boring log. The method of deriving the classification will be described, or reference to this section or other manuals will be made. Handling of samples during soil classification will be coordinated with chemical sampling activities, if appropriate.

USCS Classification

Soil is 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) is classified as those which will pass through a No. 200 U.S. standard sieve (0.074 millimeter [mm]) and are of two types: silt "M" and clay "C." Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors only. Organic material "O" is 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" for well sorted, "W" for well graded/poorly sorted, "C" for clayey, "M" for silty, "L" for low plasticity, or "H" for 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 predominantly contains 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).

Soil Component

In nature, soil is comprised of particles of varying sizes and shapes and is 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 to 10 percent
Little	11 to 20 percent
Some	21 to 35 percent
Most	36 to 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.

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 Metric and English Equivalent Classification

Metric	English	Classification
>1 meter	> 3.3 ft	Very thick
30 cm to 1 meter	1.0 ft to 3.3 ft	Thick bedded
10 cm to 30 cm	4.0 in to 1.0 ft	Medium bedded
3 cm to 10 cm	1.0 in to 4 in	Thin bedded
1 cm to 3 cm	2/5 in to 1 in	Very thin bedded

Thickness Approximate Metric and English Equivalent Classification

Metric	English	Classification
3 mm to 1 cm	1/8 in to 2/5 in	Laminated
1 mm to 3 mm	1/32 in to 1/8 in	Thinly laminated
<1 mm	<1/32 in	Micro laminated

6.3.5 Pumping Well Construction

Two pumping test wells will be installed. Appropriate personal protective equipment (PPE) will be worn in accordance with the Accident Prevention Plan (Shaw, 2010a).

Wells will be constructed inside the temporary steel drive casing used to advance the borehole. The steel casing will be incrementally withdrawn as the well is constructed. The well assembly will be hung from a lifting bail during installation to maintain tension on the casing. Based on data collected from previous studies, the extraction wells are expected to have total depths of approximately 550 feet bgs. The top of the screens in each well will be at least 40 feet above the water table to accommodate future groundwater level rises.

Extraction well construction specifications, provided below and shown on Figure 6-1, may be modified if field conditions warrant. Extraction wells will consist of an 8-inch inner diameter (8⅝ outside diameter), carbon steel, Schedule 40, 0.322-inch wall (or approved equivalent) casing and an 8-inch inside diameter, double-strong, 304 stainless-steel, wire-wrapped well screen with 0.030-inch slots. The extraction wells will have approximately 100 feet of screen (Figure 6-1). Centralizers will be installed at the top, middle, and bottom of the screened zone within the sand-pack interval. Centralizers will be installed nominally every 40 feet on the blank casing above the screen and hammer locked in place at the casing joints.

Before setting the casing into the borehole, 6 inches of gravel-pack material will be placed at the bottom of the borehole. All well construction annular materials will be placed in the borehole, as described in the bullets below, through the temporary drive casing for installation of the sand pack, bentonite seal, and cement. The drive casing will be pulled from the borehole periodically during well construction.

- A sand pack comprised of clean, 10-20 graded silica sand will be placed around the well screen and blank casing so that the top of sand is at least 10 feet above the top of the screen. Sand gradation may be modified based on visual inspection of the formation materials obtained from core during drilling.
- A minimum 5 foot-thick seal of sodium bentonite-chips or pellets will be installed above the filter pack. The bentonite seal will be hydrated with 5 gallons of water after each bucket of pellets and allowed to stand for at least 2 hours before the annular grout seal is placed.
- The remaining annular space between the borehole and blank well casing will be filled with a cement grout with 6 percent bentonite mixed with 12-13 pounds of cement per gallon or approved alternative. The cement weight will be measured with a mud balance and recorded on the well construction log. The theoretical volume of grout required will be compared with the volume actually used. The depth of annular material will be measured with a sounding tape fitted with a stainless-steel weight.

The surface completion will include a 4-foot by 4-foot concrete pad, traffic bollards, and a reinforced steel-locking well cap. The surface seal will extend to a minimum of 12 inches around the perimeter of the pad and a minimum of 36 inches bgs.

Well construction diagrams will be completed for each installed well.

6.3.6 Well Development

Once constructed, the wells will be developed to improve hydraulic communication between the well and aquifer. The wells will be allowed to stabilize for at least 48 hours before they are developed to allow time for the cement to cure. Wells will be developed using a truck-mounted pump rig equipped with wire line swab/bailer equipment. The swab/bailer is moved up and down within the screened interval to create a strong back-and-forth flow of water between the bore and formation. The well is then bailed to remove soil particles until groundwater is nominally clear as measured with a sand content kit. Groundwater

temperature, pH, turbidity, alkalinity, and electrical conductivity are monitored during the development process.

The following procedure will be used to develop the wells:

1. Surge the well with a surge block lowered on a wire line. The surge block will be constructed using Teflon® or rubber disks sized to fit without interference with the well casing. Two disks will be placed on one steel rod approximately 3 to 4 feet apart.
2. Bail out accumulated soil from the well. A steel bailer approximately 10 feet long will be used. The bailer will be raised and lowered with the sand line on the pump rig.

This surging, bailing, and pumping process will be repeated until the well is developed. The well will be considered developed when the discharge water is visibly free of sediment/soil particles, as measured with a sand content kit, or when the field parameters have stabilized to within 10 percent of the previous measurement. Field parameters, including specific conductance, pH, temperature, and sand content, will be measured during development and recorded on a well development field sheet. Water pumped out of the well during development will be containerized, sampled, and staged for disposal pending sample results, as described in the Waste Management Plan (Appendix C).

6.4 Borehole Geophysical Data Collection

Geophysical logging will be performed in the cased hole after the total depth has been reached to refine the geologic data from the borehole. Before construction of the wells, geophysical measurements will be performed in each of the extraction and injection wells. Well borehole geophysics will consist of neutron, and gamma logging, and will be conducted on the two extraction wells described in this Characterization Plan. Induction logging will not be completed in the extraction and injection wells due to the interference of the steel casing.

6.4.1 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 neutron, and gamma (large crystal) logs. The objective of this effort is to characterize the subsurface conditions, particularly permeable zones, with a vertical accuracy of less than 1 foot.

The logs will be run from the bottom of the borehole (approximately 550 feet bgs) to ground surface through the drive or 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 and well construction reports.

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

A minimum of 100 feet of repeat log will be made after the initial logging effort, and the initial and repeat logs will be provided to the Site Supervisor in hardcopy form for review. After completion of the borehole, a paper copy of the strip logs will be provided to the Site Supervisor 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 will show results of neutron logging in raw count units, gamma logging in raw counts, and the results of each method plotted versus depth from the surface to total depth of the borehole. 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 in the boring log. Data will be provided in hard copy and in digital format. The log data will be post-processed to determine lithology.

Borehole logging will follow standard industry practices, such as those presented in the following guidelines:

- ASTM 5753-05(2010) (*Standard Guide for Planning and Conducting Borehole Geophysical Logging*)
- ASTM D6274-98(2004) (*Standard Guide for Conducting Borehole Geophysical Logging–Gamma*)
- ASTM D6727-01(2007) *(Standard Guide for Conducting Borehole Geophysical Logging–Neutron)*

6.4.2 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 the weathering products of potassium feldspar and mica.

The natural gamma probe uses 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 polyvinyl chloride-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 the neutron probe.

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. Naturally 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.

The 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. Additionally, the gamma instrumentation will be calibrated both before the logging of a borehole and afterwards. Calibration will be documented in the field and QC-checked daily.

6.4.3 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 recognize porous formations and lithology by identifying perched layers and by evaluating water saturation in vadose zones.

Note that neutron logging uses an active radioactive source.

The neutron measurement is a single function radiation probe that detects thermal neutrons using an 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, result in an exchange of energy. Thus, these neutrons are slowed down to thermal energies that 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 and certified, and will maintain the required licenses to handle nuclear source(s). Work will be completed in compliance with all federal and state requirements for the use of active-source tools.

6.4.4 Logging System and Requirements

6.4.4.1 Logging System

A Mount Sopris MGX digital logger, or equivalent, 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-foot depths.

6.4.4.2 Pre-Logging Requirements

Pre-logging activities include drilling and mobilizing 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 wire line 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 are 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 on site for all tools plus spares.
- All logging equipment will be properly decontaminated before arrival while on site, between wells, and before leaving the site. The equipment will be decontaminated according to Section 6.3.2 of this Characterization 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 polyvinyl chloride 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.

6.4.4.3 Logging Requirements

The basic borehole geophysical logging process consists of the following:

- After mobilization to the borehole and decontamination of the equipment, the logging contractor will connect the first tool to be run to the cable.
- The contractor will then check to ensure the equipment is functioning properly and conduct the "before" logging calibration check. The calibration results will be checked to ensure that they are within appropriate tolerances.
- The tool will be attached to the cable and then suspended over the borehole. (Note: sometimes the calibration will be conducted while the tool is suspended over the hole.) The contractor will check to ensure that all equipment is still functioning properly and then lower the logging tool into the borehole casing.
- While the tool is lowered to the bottom of the hole, a down-log will be generated.
- Once the tool is at the bottom of the hole, the down-log will be checked; the instruments will be appropriately adjusted, the scales will be set for proper response, and the logging speed will be adjusted, as necessary.

- The logging tool will then be run up the hole at the proper speed, and the up-log will be generated.
- Once the up-log is completed, the tool will be run back down the hole for a 100-foot interval, and a repeat log will be run for QC purposes.
- Field copies of the main and repeat logs will be generated. The repeat log will be checked for appropriate quality and repeatability.
- 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 will then be run. The calibration results will be checked to ensure they are appropriate tolerances.
- The tool will then be removed from the cable.
- If another tool is to be run, the process will be repeated. If not, then the logging unit and associated tools and equipment will be rigged down. Tools and equipment will be 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, will be performed. The time and results of the last shop calibration for each tool will be documented.
- Field calibrations will be run just before logging and recorded on the log tails or header.
- When logging tools are run in combination, all curves will 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 will 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, the run will be tied into the previous run, and the discrepancy will be noted on the log heading. When the tie-in is behind the casing, a gamma-ray log will be run to overlap the tie-in. The driller's reported casing depth will never be tied into.
- If logging tools are run in combination, care will be taken to ensure that all curves will be on the same depth. If sand or gravel is present at the base of the well, the driller will make sure that he/she 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 feet. 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 feet 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 to keep consistent, accurate records. Any and all problems (including tool malfunction and significant downtime) and associated corrective actions will be recorded on the appropriate form(s) according to the project work plans by the QC Geophysicist conducting oversight.

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 logging 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 the field logs (and final logs), all off-scale readings, drift adjustments, and first curve readings will be marked on the logs, and all curves will be 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.

A general procedure for the information recorded for a borehole geophysics survey will include recording all information necessary to correctly interpret the log, including the following:

- 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 aboveground level
- Depth of the bottom of the casing(s)
- Total depth drilled

6.4.4.4 Post-Logging Requirements

A predetermined number of final log prints will be provided upon completion of 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. Data will be provided in both hard copy and digital ASCII data format.

6.4.5 Borehole Geophysical Equipment Decontamination

All downhole logging equipment and materials will require decontamination before use, between each borehole, and before demobilization. All equipment will be cleaned before mobilization, and equipment will be thoroughly decontaminated between boreholes. Cleaning and decontamination will be carried out per the Kirtland AFB basewide standard operating procedures (SOPs) for field investigations and as discussed in Section 6.3.2.

6.5 Reporting

All submittals will be complete, legible, and of such quality that additional reproduction of the information may be performed.

6.5.1 Daily Field Reports

Field record of the operation of site activities, including boreholes logged and support activities such as equipment decontamination and calibration will be made available to the Site Supervisor at the completion of each day's work. At 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 equipment on site and its location (borehole or equipment decontamination location.)
- Any problems encountered, including standby time recorded

6.5.2 Final Report

Three copies of the paper strip logs and report, and digital (Microsoft® Word [text], Adobe®PDF [figures], ASCII [logging data]) copies on CD will be provided. Each log title block will include, at 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.

6.5.3 Technical Review

All borehole geophysical logging plans, scopes of work, field procedures, field QC 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 in the Kirtland AFB SOPs and the project work plans
- 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.

7. FIELD OPERATIONS DOCUMENTATION

7.1 Field Records

Records of field analytical or monitoring measurements will be recorded on pre-printed, prepared forms. Field documentation will consist of soil boring logs, soil classification logs, the Field Activity Daily Log, analytical request/chain-of-custody forms, and test equipment and calibration logs, as applicable (Appendix D). Soil sampling locations will be surveyed and documented. Measurements for organic vapors using the photoionization detector, depths to groundwater, discharge volumes and rates, and groundwater quality measurement will be taken and recorded.

7.2 Sample Documentation

Use of sample documentation, including sample numbers, labels, and chain-of-custody records, will follow the procedures and forms described in the project-specific QAPjP Worksheet #27 (Appendix B, to be submitted).

7.3 Sample Numbering System

Each sample will be assigned a unique field identification nomenclature specific for the Kirtland AFB BFF. The sample numbering system used for samples collected will follow the nomenclature outlined in the project-specific QAPjP (Appendix B, to be submitted).

7.4 Sample Labels

Sample labels will be affixed to each sample container. Complete collection information, sample type, matrix, time, date, field number, analysis requested, and the sampler's name will be recorded with indelible ink.

7.5 Chain-of-Custody Records

Chain-of-custody documentation will be completed in the field to document sample collection, possession, and chain of custody. A sample is considered to be in a person's custody while either under physical possession or safely secured in a controlled access location. Sample custody can be transferred by signature relinquishment and acceptance. Shipping company waybills or bills of lading are considered part of the custody record between the time of collection and receipt at the analytical laboratory. Chain-of-custody records will accompany the sample shipment until receipt at the contractor laboratory.

7.6 Sample Packaging and Shipping Requirements

Soil and groundwater samples will be packaged and shipped as non-hazardous environmental samples. This section summarizes the process of packaging and shipping samples.

Sample containers will be sealed and packed into plastic bags. Samples will be placed into a cooler for shipping. If applicable, absorbent material may be placed in the bottom of the cooler as well in order to contain any spillage from sample breakage, meltwater, or condensation. Bubble wrap, bubble bags, or pre-cut foam blocks will serve as cushioning material in each cooler. If used, the ice will be double-bagged in plastic bags to contain meltwater and packed with the samples to provide adequate cooling until receipt at the laboratory. Chain-of-custody documents will be sealed in waterproof bags and included in the shipping cooler, which will be sealed and secured before being relinquished to the transport company. Samples will be packed and shipped overnight to the analytical laboratory by air express carrier as soon as possible after collection so as to not exceed the sample holding times.

Custody seals will be placed at two separate locations on the shipping cooler to provide evidence that the lid has not been opened before receipt by the laboratory. Custody seal information will be completed in indelible ink; the information on the custody seal will include the date and full signature of the person responsible for sealing the samples and cooler.

Field personnel are responsible for contacting and coordinating with an overnight express air carrier (e.g., FedEx or United Parcel Service) to arrange for sample shipment. Soil samples for chemical analysis will be shipped to a contractor laboratory for processing and analysis. The laboratory will maintain a Department of Defense (DoD) Environmental Laboratory Accreditation Program certification. The analytical laboratory will be selected before mobilization.

The shipping cooler and its contents will be inspected and inventoried upon receipt at the analytical laboratory. The temperature and condition of the samples will be documented upon receipt. The analytical laboratory will contact field personnel immediately if there are any discrepancies in the shipment documentation. The laboratory will provide sample receipt documentation with its analytical report.

7.7 Investigation-Derived Waste

All investigation-derived waste 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 wells will be containerized in roll-off containers at the drilling location. Composite soil samples will be collected from each roll-off container for waste disposal characterization. Water produced from well development and sampling will be containerized and characterized for waste disposal. All PPE (e.g., sampling gloves) will be handled according to the Waste Management Plan in Appendix C.

7.8 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 will be used by field personnel responsible for cleaning sampling or other equipment in the field. This section was developed for use by field personnel who are responsible for cleaning sampling or other equipment in the field.

Specification for Decontamination Materials

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

7.8.1 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 may be used for storing the specified cleaning materials:

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

7.8.2 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 decontamination of heavy machinery, such as backhoes, excavators, etc.

- Wash the external surfaces of equipment with high-pressure; hot water; and Liquinox®, 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.

This decontamination procedure will be performed before equipment is used and between each well or other sampling locations.

7.8.3 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 proven to be free of volatile organic compounds and metals.
- 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 of as required by the project-specific Waste Management Plan (Appendix C). Personnel directly involved in equipment decontamination will wear appropriate 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.

7.8.4 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 so as 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 for being splashed and re-contaminated.
- Water collected on the pad will be containerized and disposed of as per the Waste Management Plan (Appendix C). Small amounts of water may be left to evaporate.

7.9 Personal Protective Equipment

Personnel directly involved in equipment decontamination will wear appropriate PPE as specified in the SSHP. Appropriate PPE will be selected based on the level of contamination present or suspected at a site. Care will be taken to ensure that the selected PPE will protect 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 the following standards:
  - ASTM D5088-02(2008) (*Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Site*) requirements
  - ASTM D5608-10 (*Standard Practices for Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites*) as applicable.

Analytical data validation will be conducted in accordance with the approved project-specific QAPjP (Appendix B, to be submitted).

8. 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 Environmental Laboratory Accreditation Program accreditation for all appropriate analytical methods (DoD, 2009). All generated analytical data will be uploaded into the Environmental Restoration Information System quarterly.

8.1 U.S. Environmental Protection Agency Level III Data Review

Analytical data generated in support of the Kirtland BFF project will undergo a U.S. Environmental Protection Agency (EPA) Level III data review by a Project Chemist. An automated data review (ADR) software developed by Laboratory Data Consultants, Inc. 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 the interim measure field sampling activities. The data review will be performed using the QC criteria specified the following documents:

- The project-specific QAPjP (Appendix B, to be submitted)
- *DoD Quality Systems Manual for Environmental Laboratories, Version 4.1* (DoD, 2009)
- *Test Methods for Evaluating Solids Waste, Physical/Chemical Methods, SW846* (EPA, 2007 and updates)
- *Guidance for Evaluating Performance-Based Chemical Data, Engineer Manual (EM) 200-1-10* (USACE, 2005)
- *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review* (EPA, 2008b)
- *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review* (EPA, 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/laboratory control sample duplicate recoveries
- Matrix spike/matrix spike duplicate recoveries
- Relative percent difference for duplicate samples
- Initial calibrations
- Continuing calibrations
- Trip and field blank data (water samples for volatiles only)
- Field duplicate samples

Note that due to laboratory information system limitations, laboratories may not be able to provide initial and continuing calibration results in Staged Electronic Data Deliverables. 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 Oracle-based Environmental Information Management System 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 QAPjP (Appendix B, to be submitted) and applicable *Base-Wide Plans for Investigation Under the Environmental Restoration Program, 2004 Update*, (Tetra Tech). 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's Environmental Information Management System and will be linked with validated analytical results to generate output files that will be used to populate Environmental Restoration Program Tools and to generate Environmental Resources Program Information Management System (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. ERPIMS submittals will be deemed complete upon receipt of the insertion letter from the Air Force.

Site characterization data will be mapped using a 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 North American Datum 83. The GIS effort will involve preparation, analysis, processing, and interpretation of data-acquired geophysical surveys. The GIS coordinator will register and process all survey and field data such that it can easily be incorporated into the Kirtland AFB and Army Mapper database. Contractor 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 Shaw's 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.

9. QUALITY ASSURANCE/QUALITY CONTROL

A comprehensive QAPjP document was developed for the Kirtland AFB BFF Spill project and will be implemented in support of sampling and analysis activities. The project-specific QAPjP is currently in review and will be submitted separately as Appendix B.

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10. PROJECT SCHEDULE

A detailed project schedule has been provided as Appendix E of this Characterization Plan. The project schedule in Appendix E includes details for the LNAPL containment system characterization, design, construction, and startup.

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FIGURES

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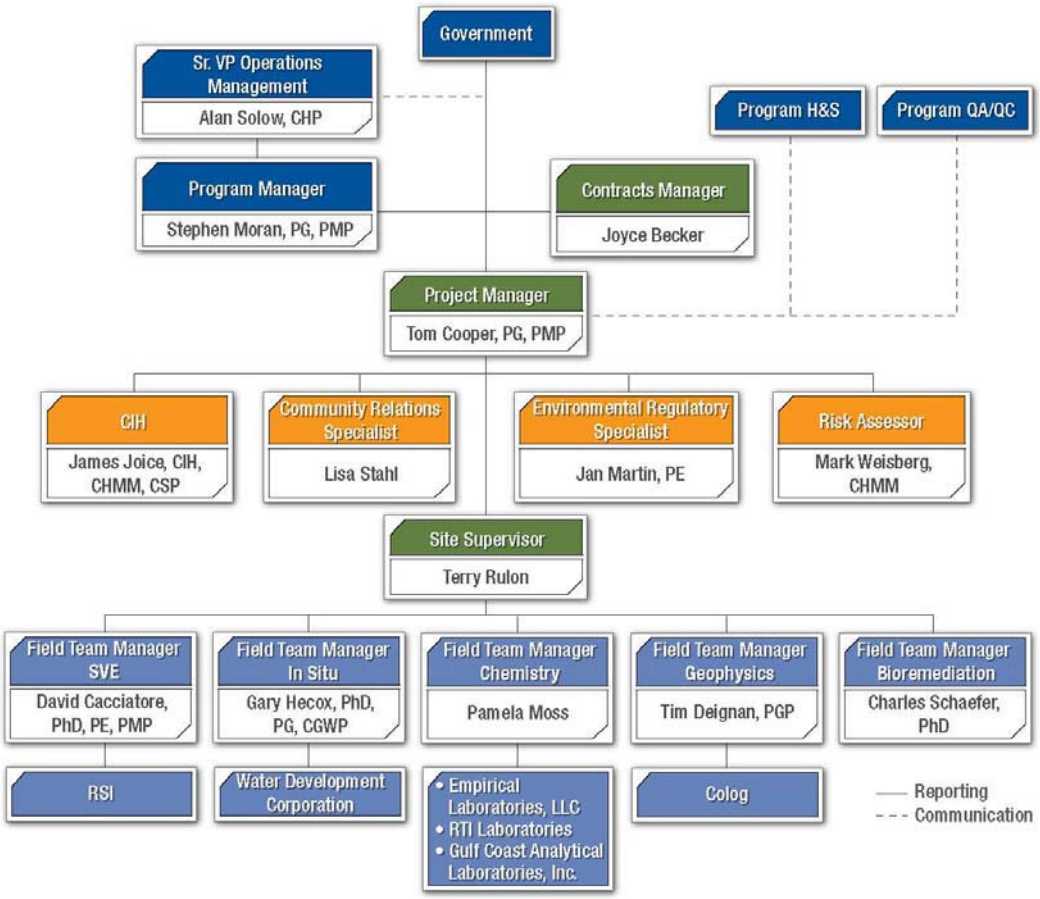
Figure 2-1. Project Organization



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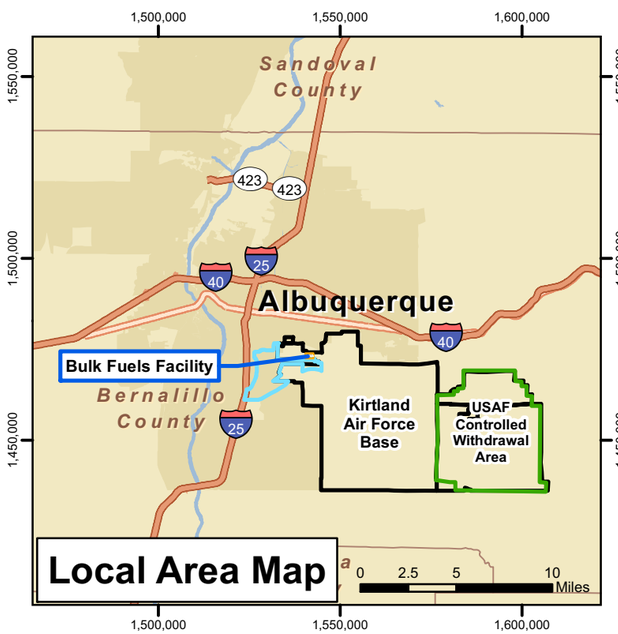

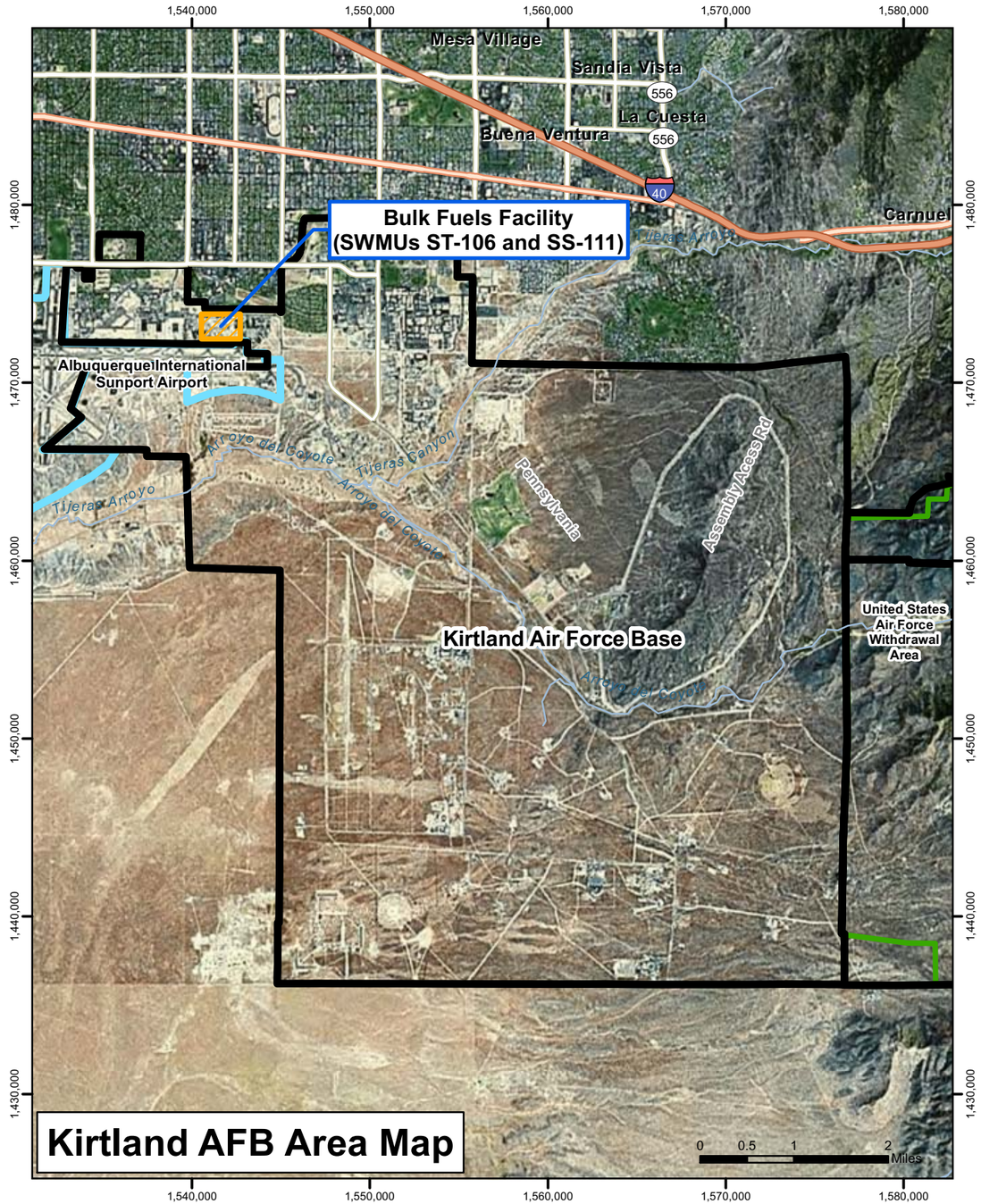

Legend

- Major Highways
- Highways
- Major Roads
- Rivers
- Bulk Fuels Facility (SWMUs ST-106 and SS-111)
- Installation Location
- Kirtland Air Force Base Installation Boundary
- Albuquerque International Sunport Airport
- United States Air Force Withdrawal Area
- Urban Areas
- Counties
- States

N

Revision Date: 06/06/11

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

LNAPL CONTAINMENT INTERIM MEASURE
WORK PLAN PART 1 - CHARACTERIZATION PLAN
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-1

SITE LOCATION MAP

H:\Kirtland_AFB\GIS_Documents\Project_Maps\2001AB_Site_Plans\LNAPL_Work_Plan\WP_Figures\KAFB_019_loc_map.mxd 06/06/11

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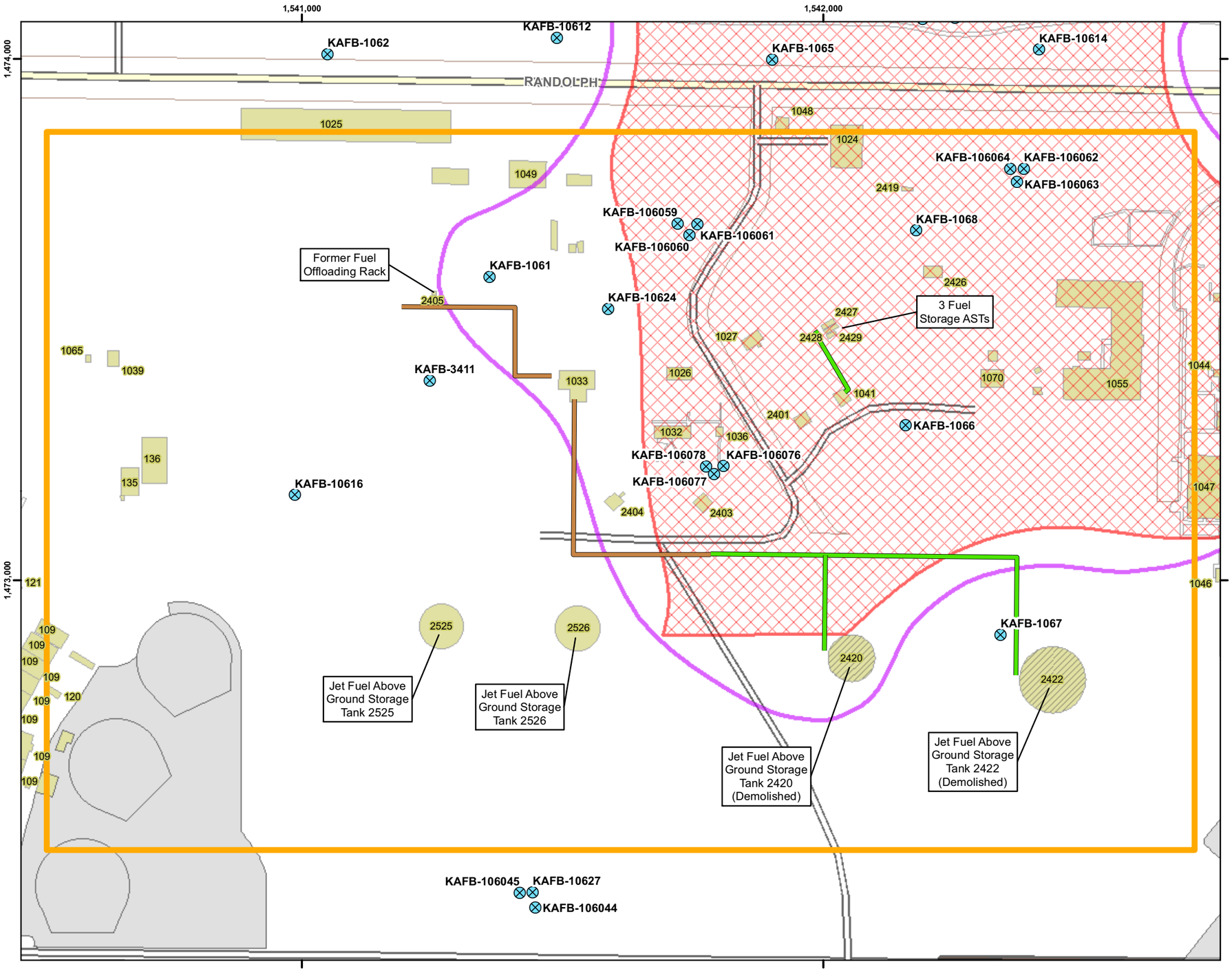
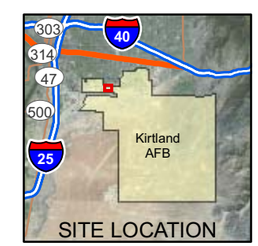


Legend

- Monitor Well
- Aboveground Fuel Transfer Lines
- Underground Fuel Transfer Lines
- Bulk Fuels Facility (SWMUs ST-106 and SS-111)
- Historical Area of Observed NAPL (July 2009)
- Dissolved Plume Extent (March 2011)
- Installation Boundary



Revision Date: 06/20/11

N

0 50 100 200

Feet

1 inch = 200 feet

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

LNAPL CONTAINMENT INTERIM MEASURE
WORK PLAN PART 1 - CHARACTERIZATION PLAN
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-2

SOURCE AREA AND INFRASTRUCTURE

H:\Kirtland_AFB\GIS_Documents\Project_Maps\2001AB_Site_Plans\LNAPL_Work_Plan\WP_Figures\KAFB_020_Source_Area_Infrastructure.mxd 06/20/11

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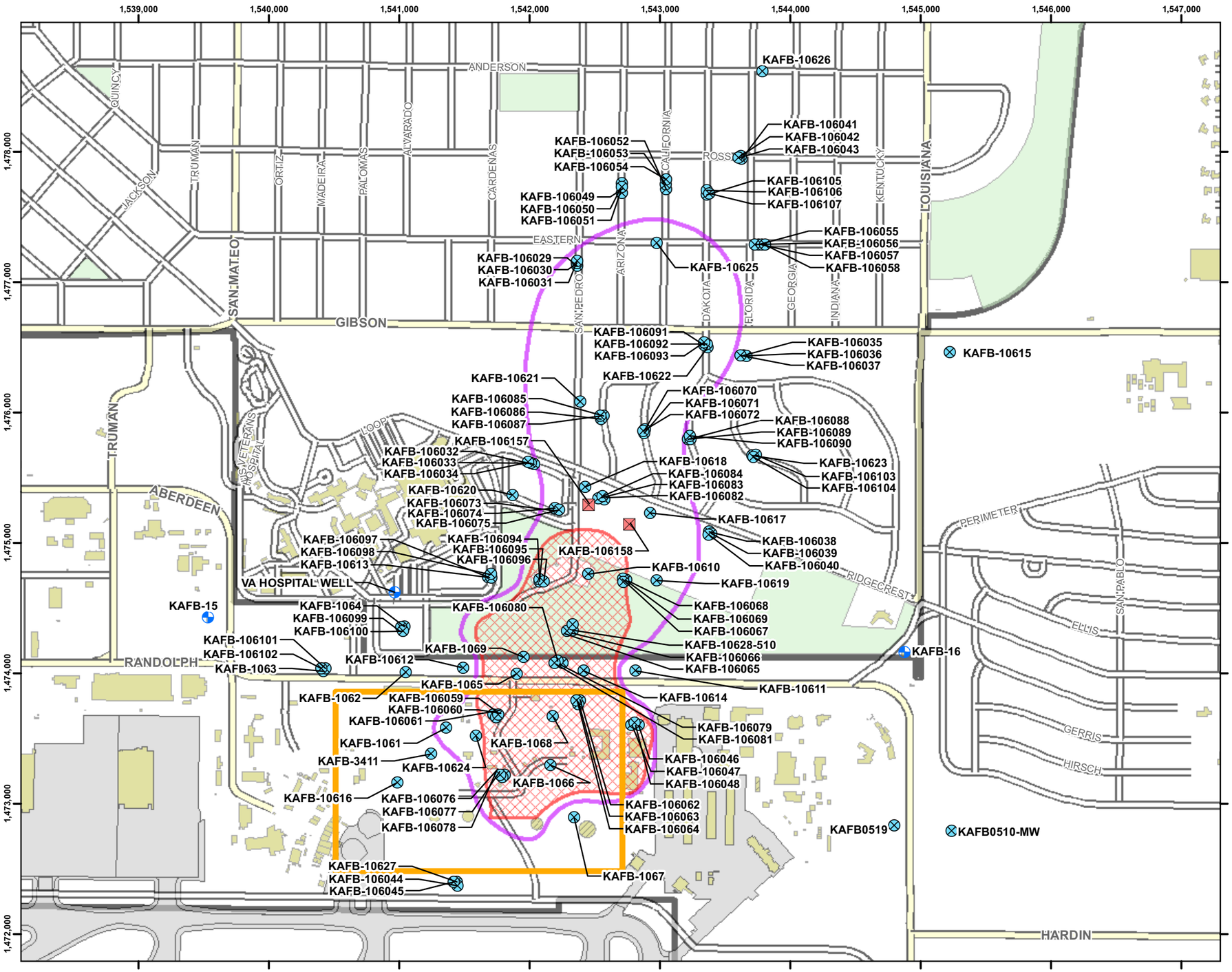
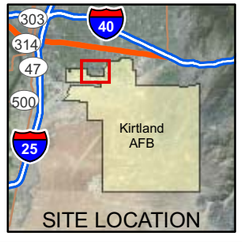


Legend

- Pumping Test Well
- Monitor Well
- Water Supply Well
- Bulk Fuels Facility (SWMUs ST-106 and SS-111)
- Historical Area of Observed NAPL (July 2009)
- Dissolved Plume Extent (March 2011)
- Installation Boundary

Note: Proposed and active monitoring wells are shown.



Revision Date: 06/20/11

N

0 400 800 1,600

Feet

1 inch = 800 feet

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

LNAPL CONTAINMENT INTERIM MEASURE
WORK PLAN PART 1 - CHARACTERIZATION PLAN
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 4-1

APPROXIMATE LNAPL PLUME EXTENT AND SITE DETAIL FOR BULK FUELS FACILITY

H:\Kirtland_AFB\GIS_Documents\Project_Maps\2001AB_Site_Plans\LNAPL_Work_Plan\WP_Figures\KAFB_021_LNAPL_Plume_Extent.mxd 06/20/11

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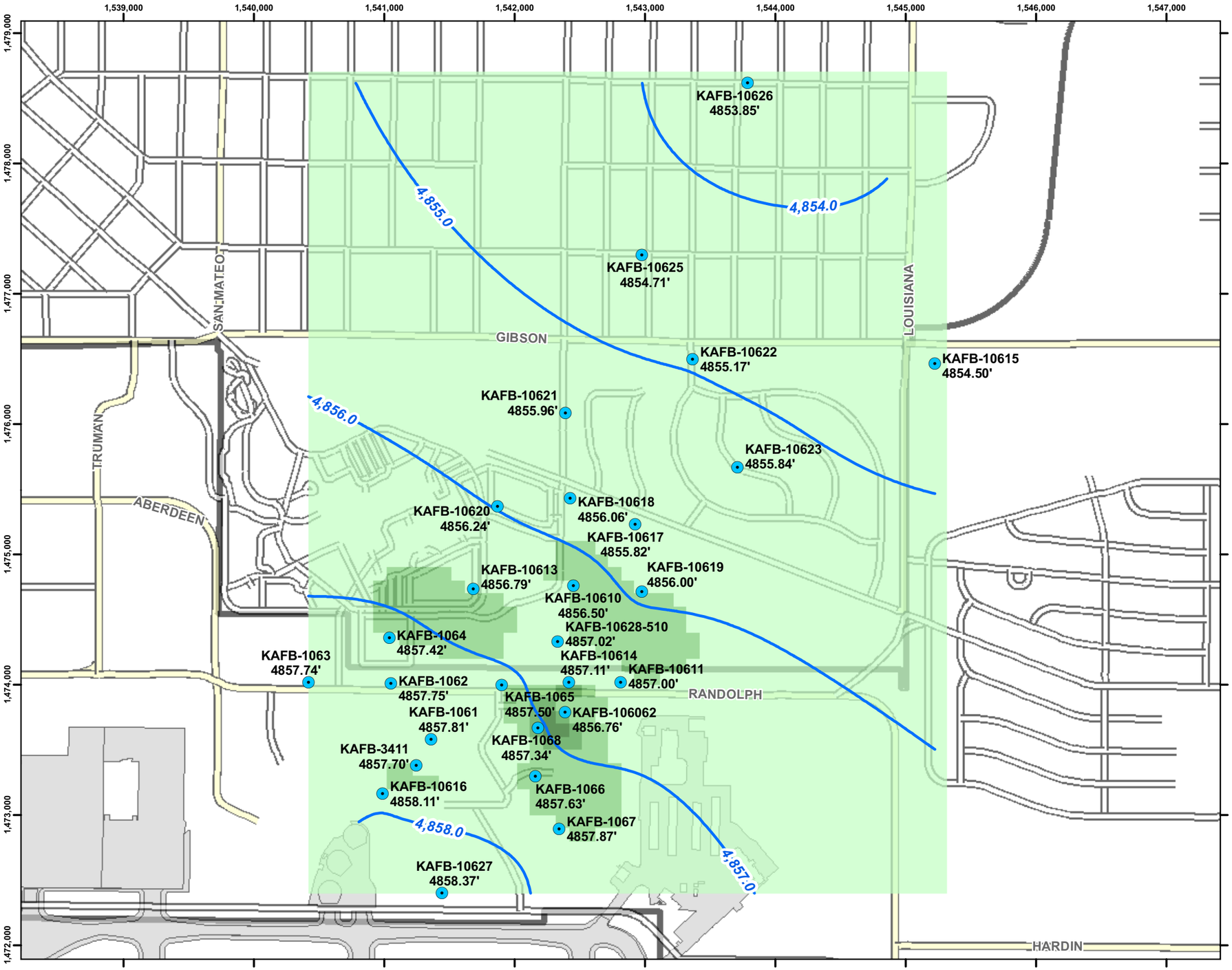


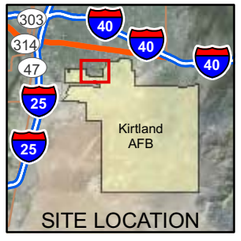
Legend

- Monitor Well With March 2011 Groundwater Elevation
- Groundwater Level Contour (ft msl)

Groundwater Gradient

- 0.00009 - 0.001 ft/ft
- 0.001 - 0.002 ft/ft
- 0.002 - 0.003 ft/ft
- 0.003 - 0.004 ft/ft
- Interstate
- Major Road
- Road
- Runway
- Installation Boundary

Note: Groundwater level contours were interpolated using ordinary kriging with a range of 6100 ft using a spherical variogram and a nugget of zero. This map represents the horizontal gradient.



Revision Date: 06/13/11

N

0 400 800 1,600

Feet

1 inch = 800 feet

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

LNAPL CONTAINMENT INTERIM MEASURE
WORK PLAN PART 1 - CHARACTERIZATION PLAN
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 4-2

GROUNDWATER GRADIENT
MARCH 2011

H:\Kirtland_AFB\GIS_Documents\Project_Maps\2001AB_Site_Plans\LNAPL_Work_Plan\WP_Figures\KAFB_029_gw_gradient.mxd 06/13/11

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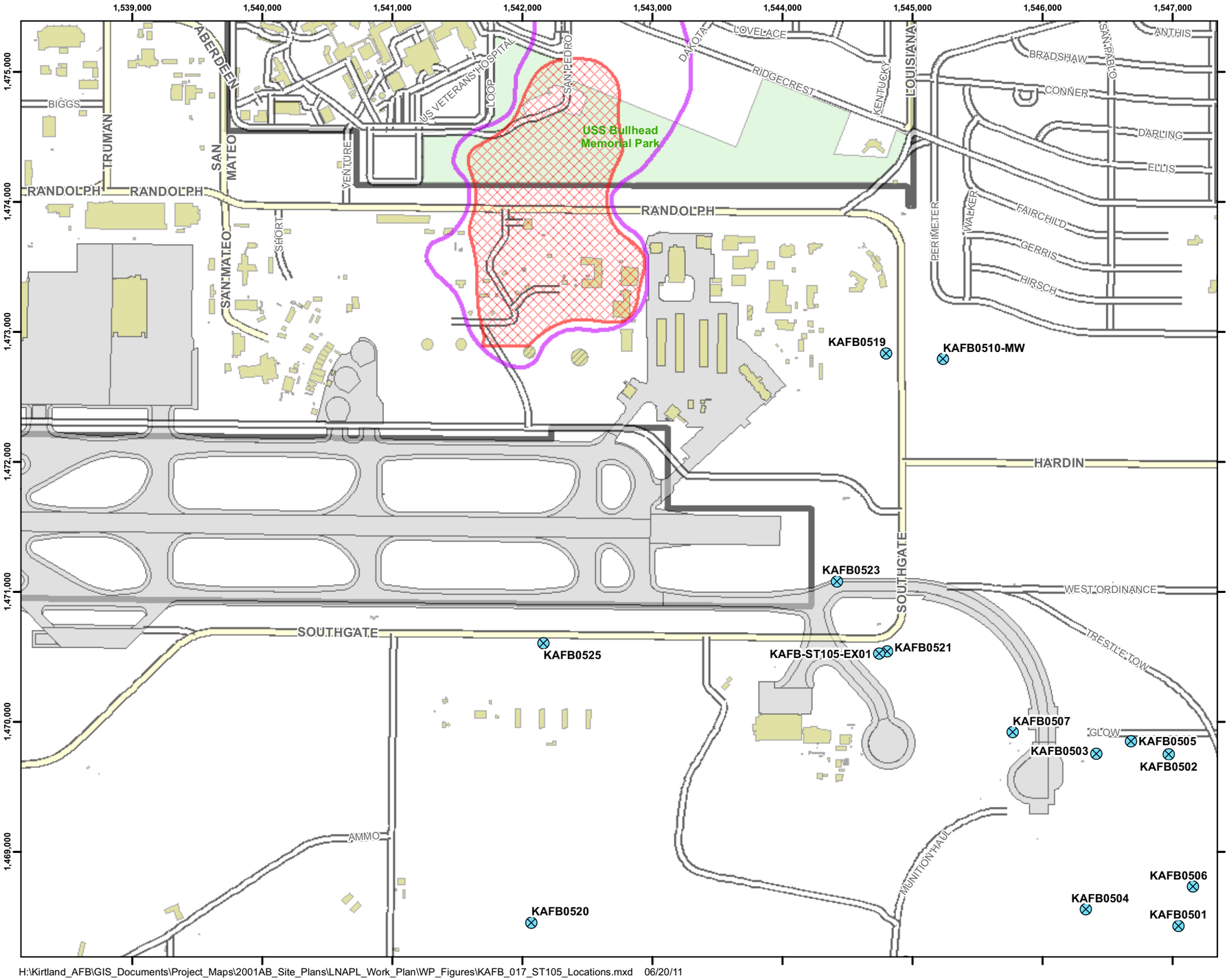
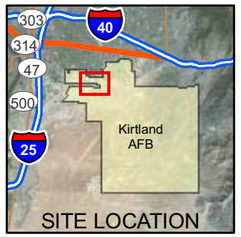


Legend

- Monitor Well
- Historical Area of Observed NAPL (July 2009)
- Dissolved Plume Extent (March 2011)
- Installation Boundary



N

Revision Date: 06/20/11

0 400 800 1,600

Feet

1 inch = 800 feet

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

LNAPL CONTAINMENT INTERIM MEASURE
WORK PLAN PART 1 - CHARACTERIZATION PLAN
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 4-3

LOCATION OF ST-105 WELLS AND BFF PLUME

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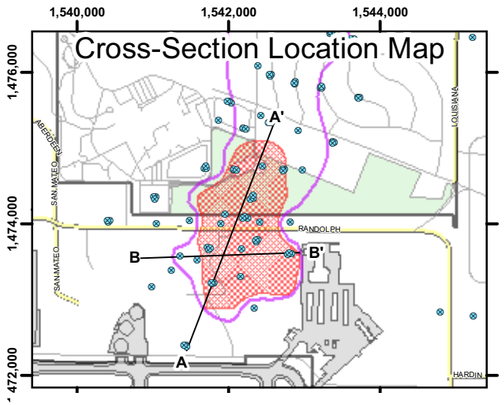
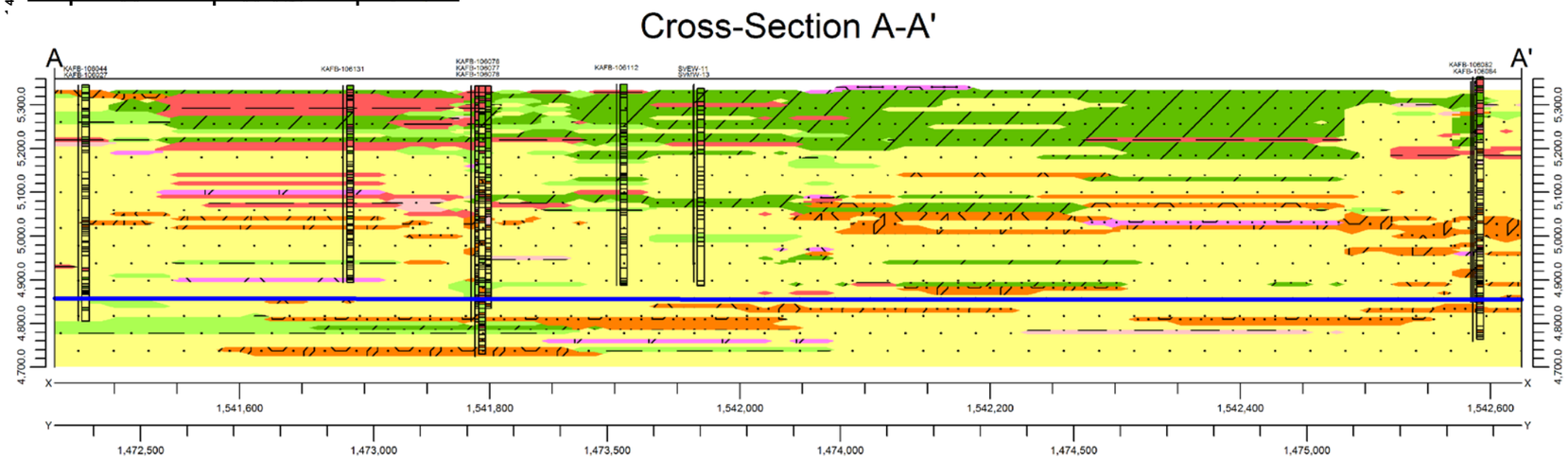
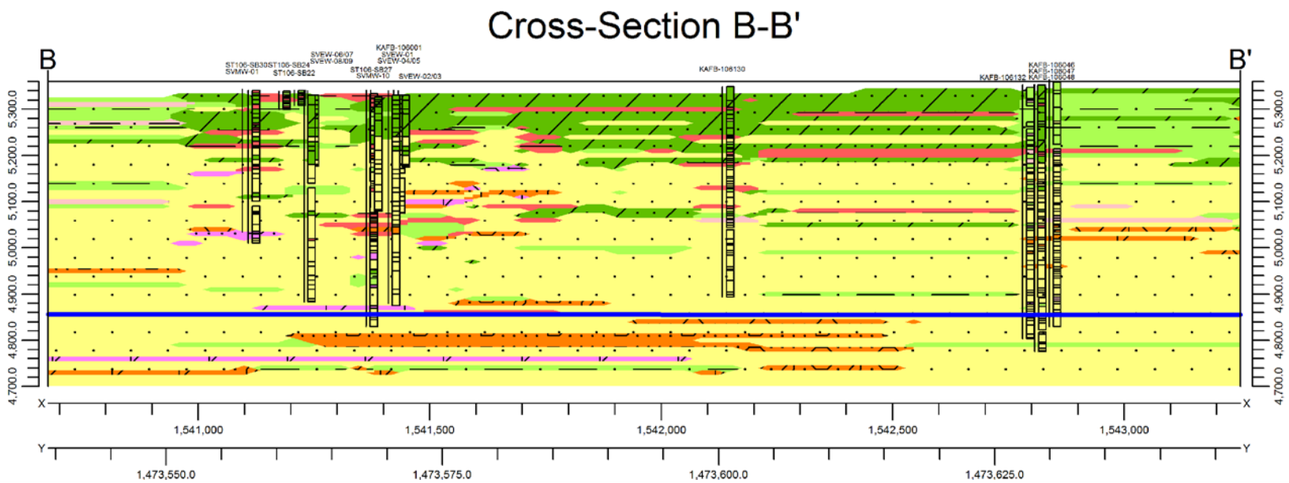




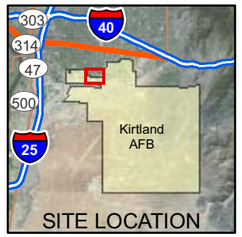


Legend

- Monitor Well
- Cross-Section Line
- Historical Area of Observed NAPL (July 2009)
- Dissolved Plume Extent (March 2011)
- Installation Boundary

Lithology

- Clay
- Clayey sand
- Gravel
- Sand
- Silt
- Silty Gravel
- Silty Sand
- Undefined



Revision Date: 06/13/11

N

0 400800 1,600

Feet

1 inch = 2,000 feet

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

LNAPL CONTAINMENT INTERIM MEASURE
WORK PLAN PART 1 - CHARACTERIZATION PLAN
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 4-4

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

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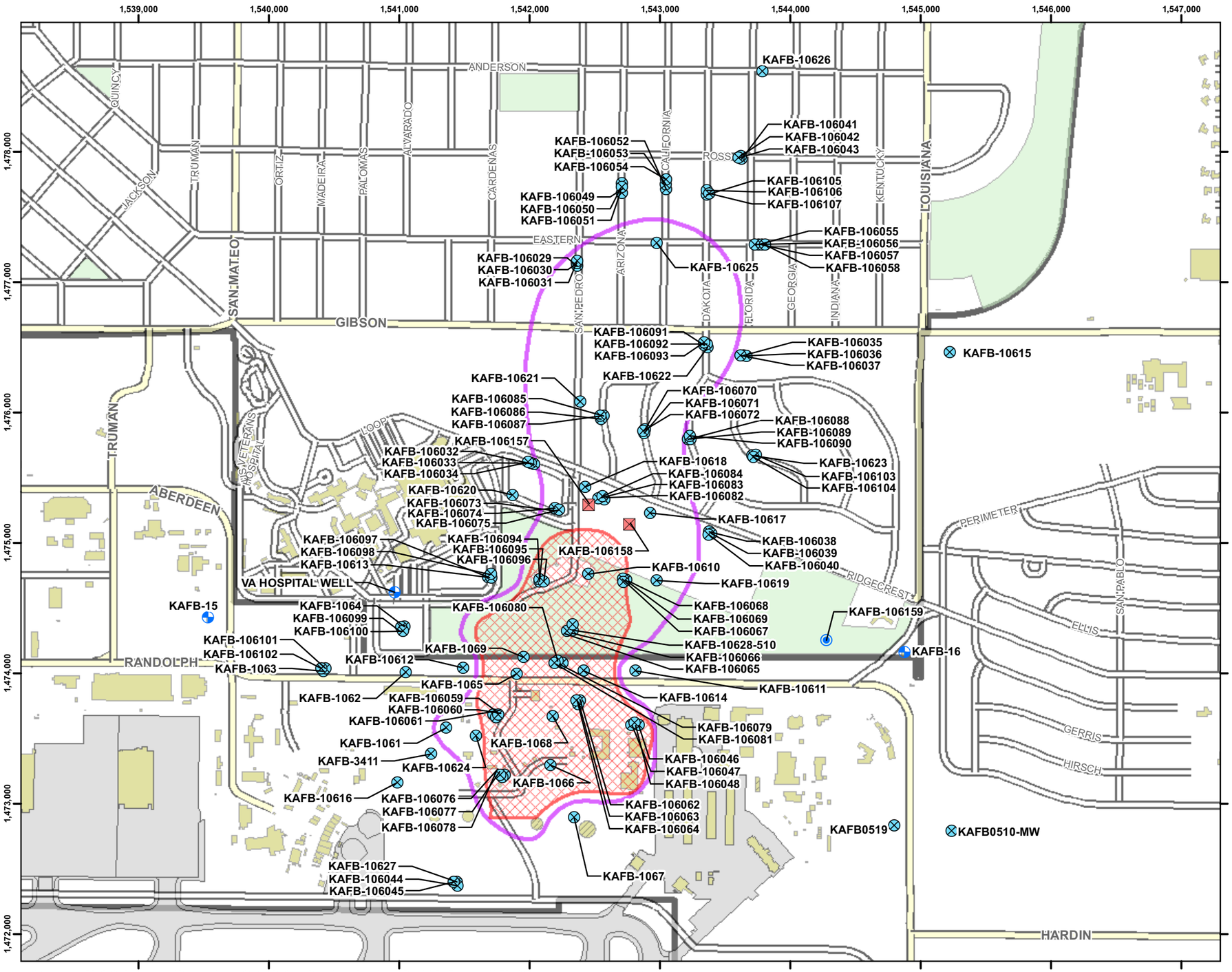
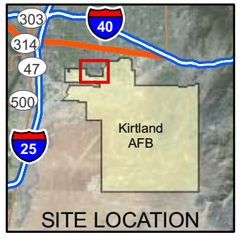


Legend

- Injection Well
- Pumping Test Well
- Monitor Well
- Water Supply Well
- Historical Area of Observed NAPL (July 2009)
- Dissolved Plume Extent (March 2011)
- Installation Boundary

Note: Proposed and active monitoring wells are shown.



Revision Date: 06/20/11

N

0 400 800 1,600

Feet

1 inch = 800 feet

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

LNAPL CONTAINMENT INTERIM MEASURE
WORK PLAN PART 1 - CHARACTERIZATION PLAN
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 5-1

INVESTIGATION WELL LOCATIONS

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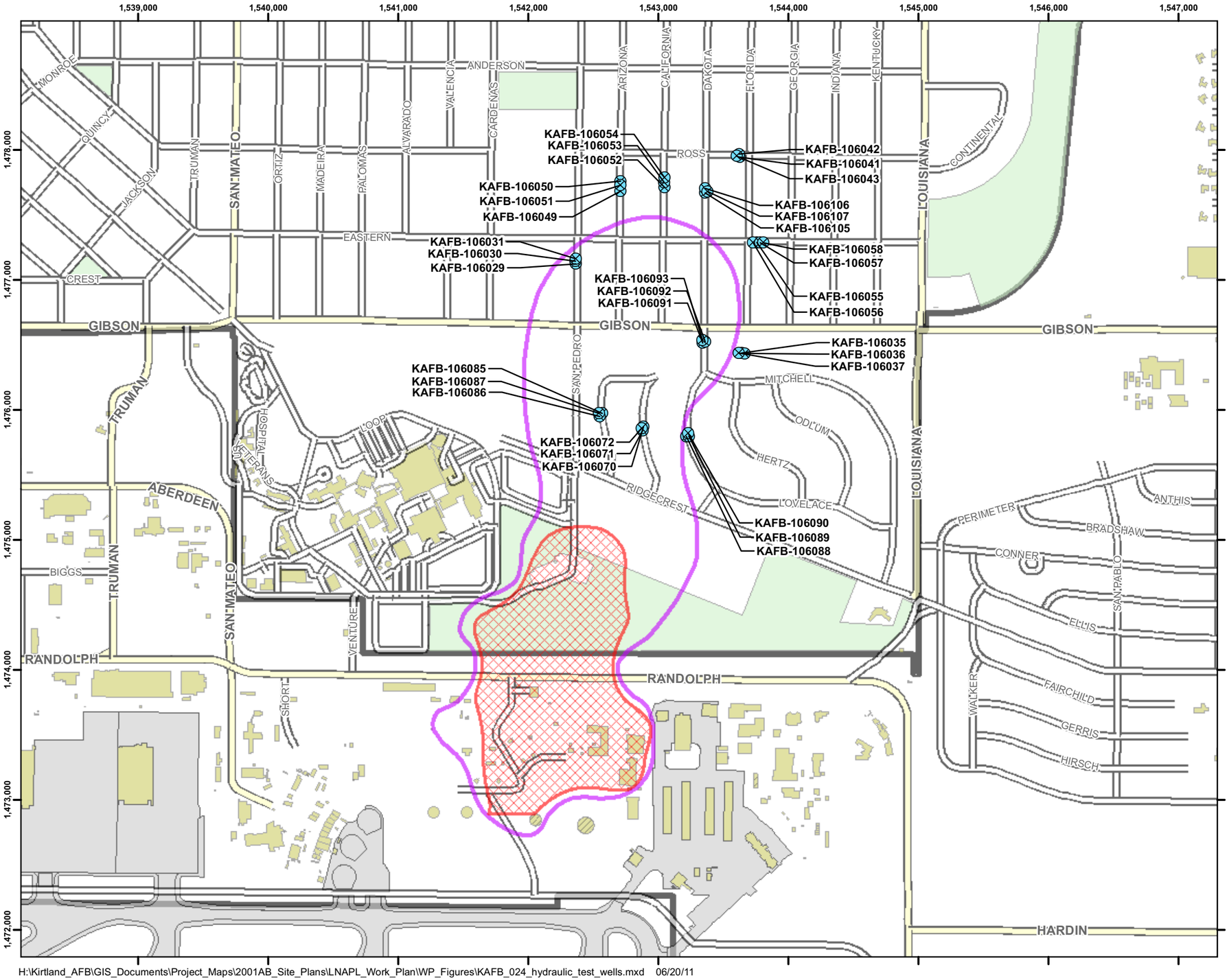
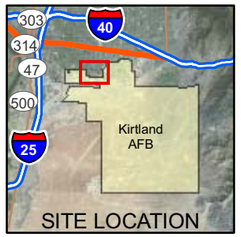


Legend

- Monitor Well
- Historical Area of Observed NAPL (July 2009)
- Dissolved Plume Extent
- Installation Boundary



Revision Date: 06/20/11

N

0 400 800 1,600

Feet

1 inch = 800 feet

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

LNAPL CONTAINMENT INTERIM MEASURE
WORK PLAN PART 1 - CHARACTERIZATION PLAN
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 5-2

LABORATORY HYDRAULIC TEST WELLS

H:\Kirtland_AFB\GIS_Documents\Project_Maps\2001AB_Site_Plans\LNAPL_Work_Plan\WP_Figures\KAFB_024_hydraulic_test_wells.mxd 06/20/11

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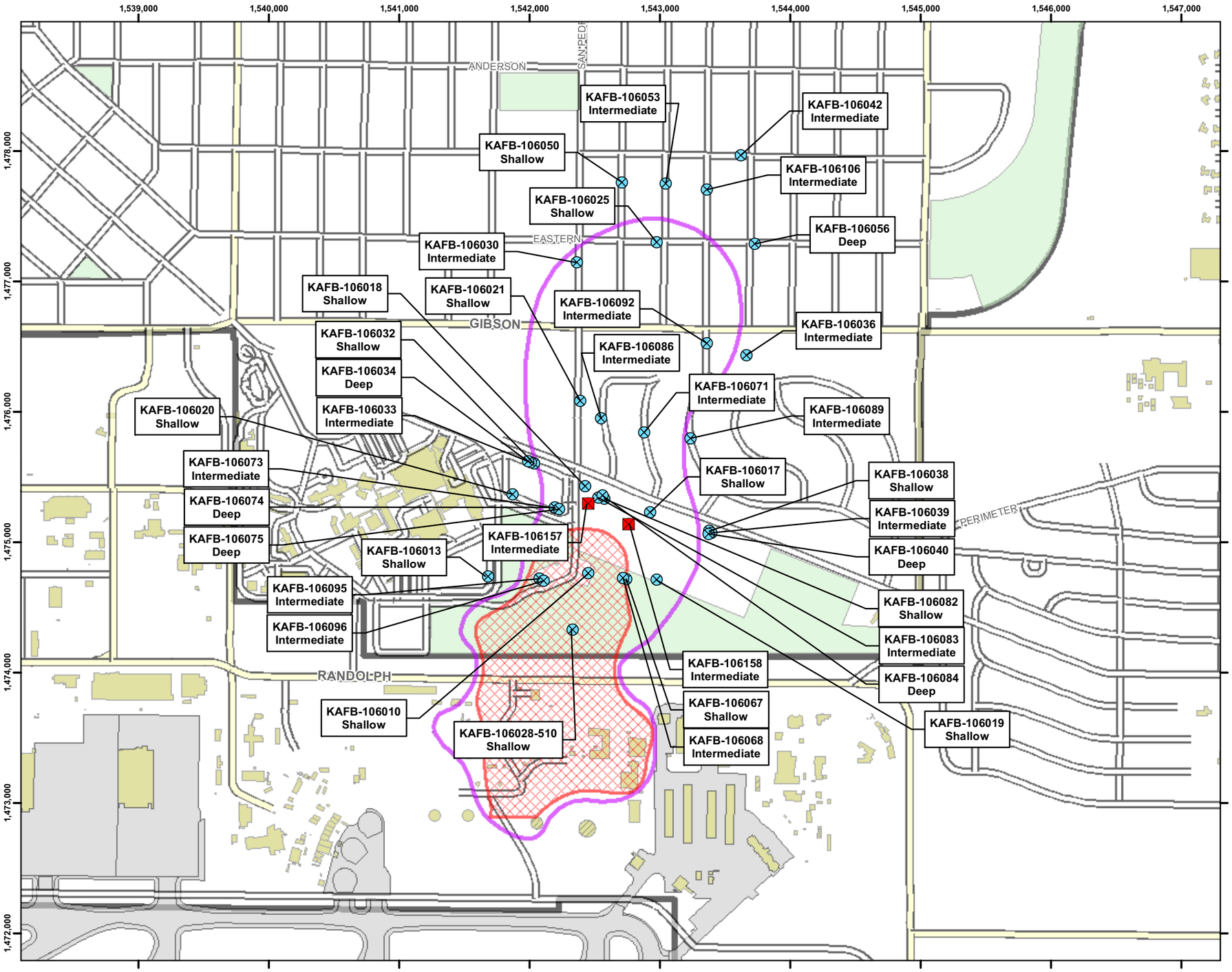
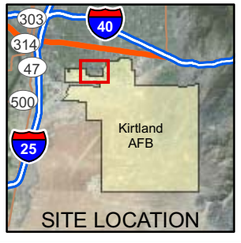


Legend

- Pumping Test Well
- Monitor Well
- Historical Area of Observed NAPL (July 2009)
- Dissolved Plume Extent
- Installation Boundary

Note: Shallow wells are 0 - 30 feet below the January 2011 water table. Intermediate wells are 30 - 60 feet below the January 2011 water table. Deep wells are 60 - 100 feet below the January 2011 water table.



Revision Date: 06/20/11

N

0 400 800 1,600

Feet

1 inch = 800 feet

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

LNAPL CONTAINMENT INTERIM MEASURE
WORK PLAN PART 1 - CHARACTERIZATION PLAN
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 5-3

SLUG TEST LOCATIONS

H:\Kirtland_AFB\GIS_Documents\Project_Maps\2001AB_Site_Plans\LNAPL_Work_Plan\WP_Figures\KAFB_022_slug_test_wells.mxd 06/20/11

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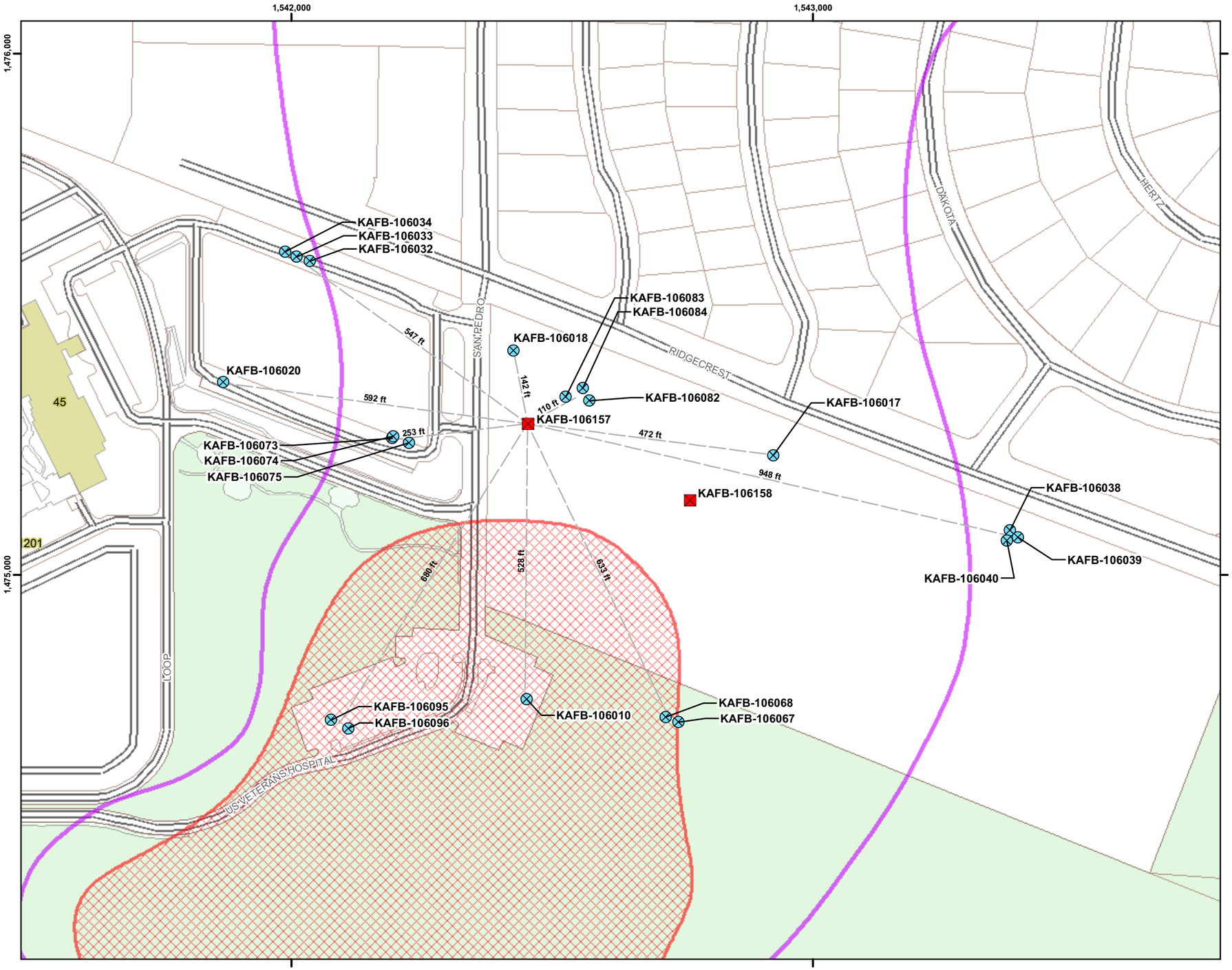
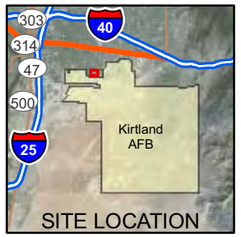


Legend

- Monitor Well
- Pumping Test Well
- Distance Line
- Historical Area of Observed NAPL (July 2009)
- Dissolved Plume Extent (March 2011)
- Installation Boundary

Distance lines represent horizontal distance from the approximate center of each well cluster or observation well to pump test well KAFB-106157.



Revision Date: 06/13/11

N

0 100 200 400

Feet

1 inch = 200 feet

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

LNAPL CONTAINMENT INTERIM MEASURE
WORK PLAN PART 1 - CHARACTERIZATION PLAN
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 5-4

PUMP TEST LOCATIONS

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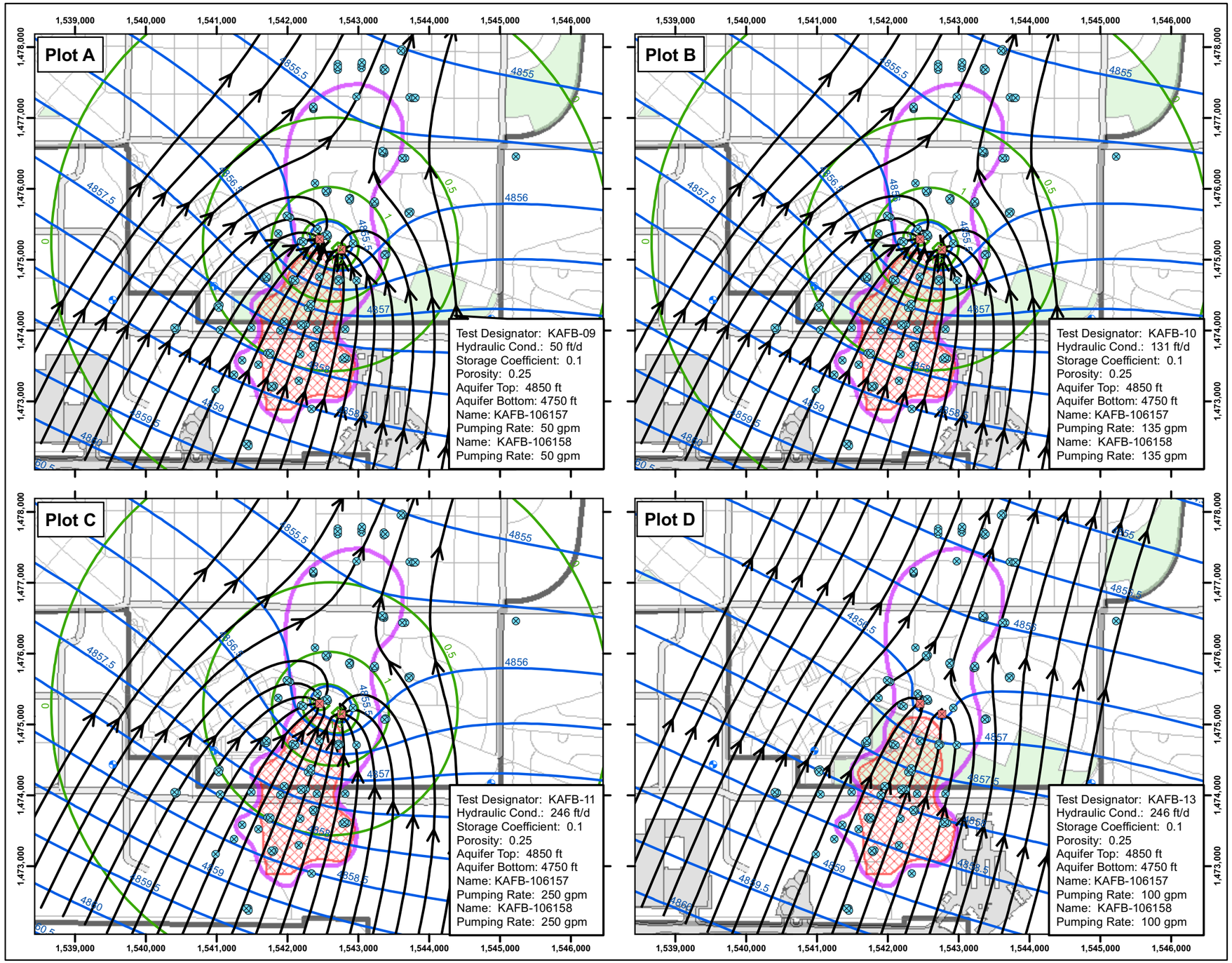
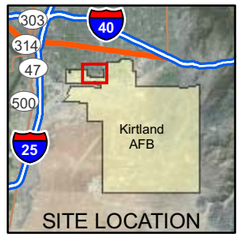


Legend

- Pumping Test Well
- Monitor Well
- Water Supply Well
- Drawdown (ft)
- Groundwater Elev. (ft)
- Particle Track
- Historical Area of Observed NAPL (July 2009)
- Dissolved Plume Extent (March 2011)
- Interstate
- Major Road
- Road
- Installation Boundary

Note: For simulations NAPL-09, NAPL-10, and NAPL-11, the extraction well pumping rates were adjusted to maintain same capture zone extent to account for increased hydraulic conductivity.



Revision Date: 06/13/11

N

0 750 1,500 3,000

Feet

1 inch = 1,500 feet

Projection : NAD83 State Plane New Mexico Central FIPS3002 Feet

LNAPL CONTAINMENT INTERIM MEASURE
WORK PLAN PART 1 - CHARACTERIZATION PLAN
BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 5-5

SENSITIVITY ANALYSIS
CAPTURE ZONES AND FLOW RATES

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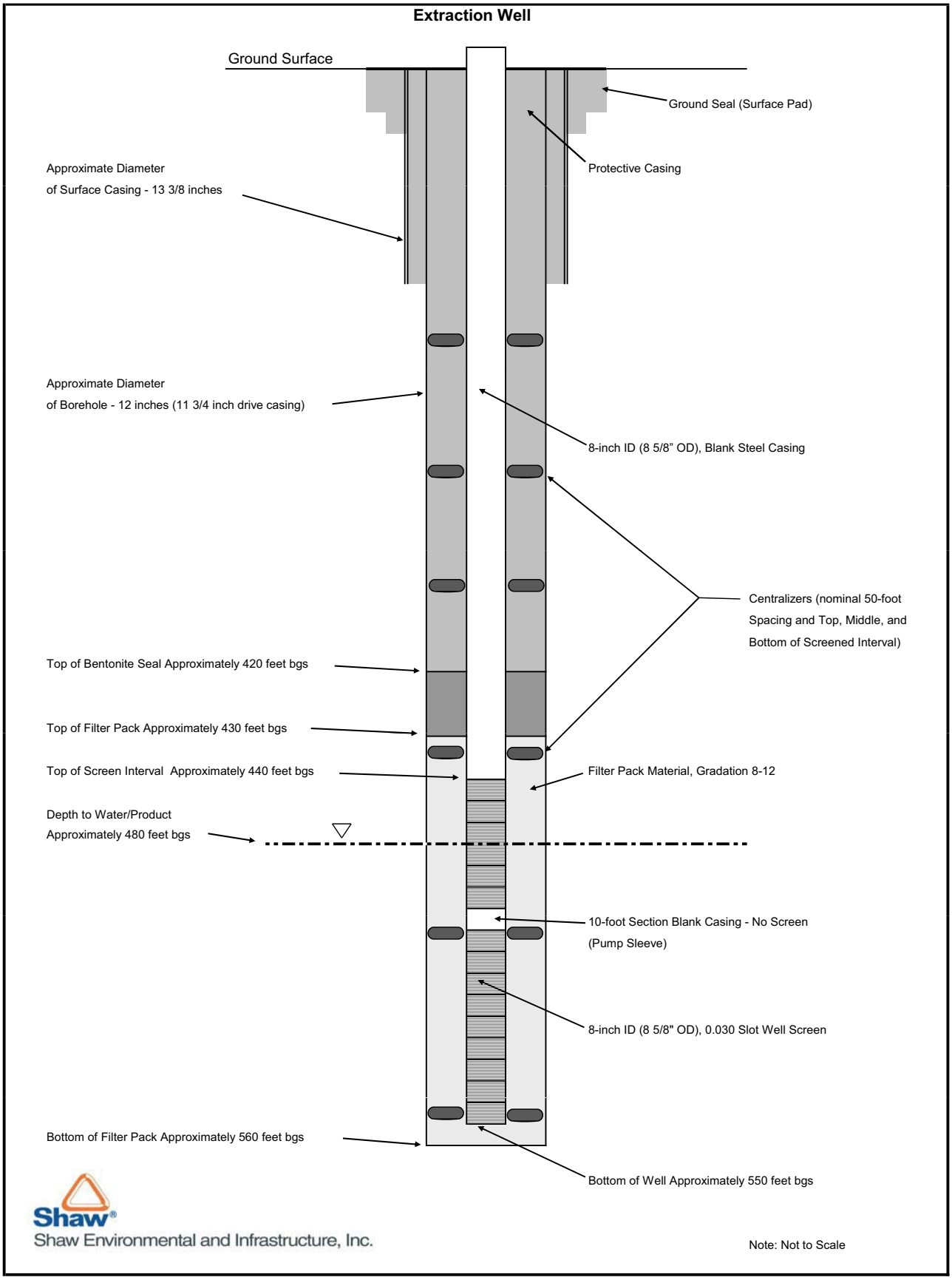

Figure 6-1. Extraction Well Construction

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TABLES

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Table 2-1. 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 justifies 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 balances project resources • Schedules use of equipment • Manages sampling of environmental media and investigation-derived waste (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 2-1. 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 soil vapor extraction/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 Resource Conservation and Recovery Act (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 2-1. 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, New Jersey and Knoxville, Tennessee. 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 2-1. 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 data quality objective s that will meet the project-specific performance standards • Determines appropriateness of sampling procedures, analytical methods, and laboratory quality systems • Approves the final Quality Assurance Project Plan • 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 2-1. 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 2-1. 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 off-site 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 2-1. Project Team Roles and Responsibilities (Concluded)

Position	Qualifications	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 Quality Assurance Project Plan and DoD Quality Systems Manual • Provides analytical data in electronic Adobe® 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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Table 5-1. Hydraulic Test Well Summary

Well	NMED Location	Screen Interval	Aquifer Depth Interval	Grain-size Analysis	Lab Tests[1]	Slug Test	Gamma Log	Neutron Log
KAFB-10610	Existing	483-508	Shallow			X	X	X
KAFB-10613	Existing	486.5-511.5	Shallow			X	X	X
KAFB-10617	Existing	482-507	Shallow			X	X	X
KAFB-10618	Existing	476-501	Shallow			X	X	X
KAFB-10619	Existing	493-518	Shallow			X	X	X
KAFB-10620	Existing	482-507	Shallow			X	X	X
KAFB-10621	Existing	458-483	Shallow			X	X	X
KAFB-10625	Existing	465-490	Shallow			X	X	X
KAFB-10628-510	Existing	488-513	Shallow			X	X	X
KAFB-106029	GWM-01-1	-		X	X		X	X
KAFB-106030	GWM-01-2	-		X	X	X	X	X
KAFB-106031	GWM-01-3	-		X	X		X	X
KAFB-106032	GWM-02-1	-		X		X	X	X
KAFB-106033	GWM-02-2	-		X		X	X	X
KAFB-106034	GWM-02-3	-		X		X	X	X
KAFB-106035	GWM-03-1	-		X	X		X	X
KAFB-106036	GWM-03-2	-		X	X	X	X	X
KAFB-106037	GWM-03-3	-		X	X		X	X
KAFB-106038	GWM-04-1	-		X		X	X	X
KAFB-106039	GWM-04-2	-		X		X	X	X
KAFB-106040	GWM-4	-		X		X	X	X
KAFB-106041	GWM-05-1	-		X	X		X	X
KAFB-106042	GWM-05-2	-		X	X	X	X	X
KAFB-106043	GWM-05-3	-		X	X		X	X
KAFB-106049	GWM-08-1	-		X	X		X	X
KAFB-106050	GWM-08-2	475-489	Shallow	X	X	X	X	X
KAFB-106051	GWM-08-3	502-515	Deep	X	X		X	X
KAFB-106052	GWM-09-1	-		X	X		X	X
KAFB-106053	GWM-09-2	-		X	X	X	X	X
KAFB-106054	GWM-09-3	-		X	X		X	X
KAFB-106055	GWM-10-1	-		X	X		X	X
KAFB-106056	GWM-10-2	-		X	X	X	X	X
KAFB-106057	GWM-10-3	-		X	X		X	X
KAFB-106058	GWM-10-4	-		X	X		X	X

Table 5-1. Hydraulic Test Well Summary (concluded)

Well	NMED Location	Screen Interval	Aquifer Depth Interval	Grain-size Analysis	Lab Tests[1]	Slug Test	Gamma Log	Neutron Log
KAFB-106067	GWM-14-1	-	Shallow	X		X	X	X
KAFB-106068	GWM-14-2	580-595	Intermediate	X		X	X	X
KAFB-106070	GWM-15-1			X	X		X	X
KAFB-106071	GWM-15-2	548-563	Deep	X	X	X	X	X
KAFB-106072	GWM-15-3	475-495	Intermediate	X	X		X	X
KAFB-106073	GWM-16-1	500-514	Intermediate	X		X	X	X
KAFB-106074	GWM-16-2	570-584	Deep	X		X	X	X
KAFB-106075	GWM-16-3	480-500	Shallow	X		X	X	X
KAFB-106082	GWM-19-1	472-492	Shallow	X		X	X	X
KAFB-106083	GWM-19-2	495-510	Intermediate	X		X	X	X
KAFB-106084	GWM-19	566-581	Deep	X		X	X	X
KAFB-106085	GWM-20-1			X	X		X	X
KAFB-106086	GWM-20-2			X	X	X	X	X
KAFB-106087	GWM-20-3			X	X		X	X
KAFB-106088	GWM-21-1			X	X		X	X
KAFB-106089	GWM-21-2			X	X	X	X	X
KAFB-106090	GWM-21-3			X	X		X	X
KAFB-106091	GWM-22-1			X	X		X	X
KAFB-106092	GWM-22-2			X	X	X	X	X
KAFB-106093	GWM-22-3			X	X		X	X
KAFB-106095	GWM-23-2			X		X	X	X
KAFB-106096	GWM-23-3			X		X	X	X
KAFB-106105	GWM-28-1			X	X		X	X
KAFB-106106	GWM-28-2			X	X	X	X	X
KAFB-106107	GWM-28-3			X	X		X	X
KAFB-106157	Extraction well	495-550	Intermediate	X		X	X	X
KAFB-106158	Extraction well	495-550	Intermediate	X		X	X	X
		Totals		52	34	38	61	61

1. Hydraulic conductivity, effective porosity, fraction of organic carbon on bucket samples from screen interval.
2. Blank monitor well screen interval and aquifer depth interval mean well has not yet been installed.

Table 5-2. Hydraulic Testing Laboratory Summary

Parameters	Method Reference	No. Samples	Comments
Grain-size analysis using laser method	ASTM D4464M	52	Clay to coarse sand grain-size
Hydraulic conductivity	API RP40/EPA 9100	34	Permeability and hydraulic conductivity
Porosity	Mod. ASTM D425	34	Total and effective porosity
Fraction of organic carbon	Walkley-Black	34	
Laboratory tests will be conducted on re-molded bucket samples collected from the drill rig cyclone.			

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Table 5-3. Pump Test Well Summary

Well	NMED Location	Screen Interval[1]	Pumping Test Use
KAFB-106157	LNAPL Extraction	495-550	Pumping well (transducer)
KAFB-106158	LNAPL Extraction	495-550	Pumping well (transducer)
KAFB-10610	Existing	483-508	Obs. Well (transducer)
KAFB-10617	Existing	482-507	Obs. Well (transducer)
KAFB-10618	Existing	476-501	Obs. Well (transducer)
KAFB-10620	Existing	482-507	Obs. Well (manual)
KAFB-106032	GWM-02-1	-	Obs. Well (manual)
KAFB-106033	GWM-02-2	-	Obs. Well (manual)
KAFB-106034	GWM-02-3	-	Obs. Well (manual)
KAFB-106038	GWM-04-1	-	Obs. Well (manual)
KAFB-106039	GWM-04-2	-	Obs. Well (manual)
KAFB-106040	GWM-4	-	Obs. Well (manual)
KAFB-106067	GWM-14-1	-	Obs. Well (manual)
KAFB-106068	GWM-14-2	580-595	Obs. Well (manual)
KAFB-106073	GWM-16-1	500-514	Obs. Well (transducer)
KAFB-106074	GWM-16-2	570-584	Obs. Well (transducer)
KAFB-106075	GWM-16-3	480-500	Obs. Well (transducer)
KAFB-106082	GWM-19-1	472-492	Obs. Well (transducer)
KAFB-106083	GWM-19-2	495-510	Obs. Well (transducer)
KAFB-106084	GWM-19	566-581	Obs. Well (transducer)
KAFB-106095	GWM-23-2	-	Obs. Well (manual)
KAFB-106096	GWM-23-3	-	Obs. Well (manual)

1. Blank monitor well screen interval and aquifer depth interval mean well has not yet been installed.

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Table 5-4. Treatability Analytical Test Schedule

	Sample Location			Analysis					
Sample Location	**Influent**	**Effluent 1**	**Effluent 2**	**Field Parameters**	**TPH Analysis**	**VOC Analysis**	**SVOC Analysis**	**Major Cation/Anions**	**Degradation Parameters**
Day 1 Sample	X			Daily all locations	X	X	X	X	X
Daily Sample		X	X	Daily all locations		X			
Final Day Sample	X	X	X	Daily all locations	X	X	X	X (Influent only)	X (Influent only)

Major cations--Ca, Mg, Na, K
Major anions--HCO3, SO4, Cl
Degradation parameters--NO3, ammonia, iron, manganese
Field parameters--pH, specific conductance, dissolved oxygen, ORP, ferrous iron
Daily VOC samples will be analyzed at local lab with 24-hour turn-around.

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Table 5-5. NAPL and Groundwater Laboratory Analyses

		Location ID					
		KAFB-1065	KAFB-1066	KAFB-1068	KAFB-1069	KAFB-10610	KAFB-10614
		Media					
Parameter	**Method**	**NAPL**	**NAPL**	**NAPL**	**NAPL**	**NAPL**	**NAPL**
NAPL cleaning	Lab specific	X	X	X	X	X	X
Density	ASTM D1481	X	X	X	X	X	X
Viscosity	ASTM D445	X	X	X	X	X	X
Interfacial tension	ASTM D970	X	X	X	X	X	X
Flashpoint	ASTM D93	X	X	X	X	X	X
API gravity	ASTM D287	X	X	X	X	X	X
PIANO + BTEX + EDC and EDB	Proprietary	X	X	X	X	X	X
		Water	**Water**	**Water**	**Water**	**Water**	**Water**
Volatiles	EPA 8260C	X	X	X	X	X	X
Semivolatiles	EPA 8270D						
TPH	Lab specific	X	X	X	X	X	X
Metals and cations	EPA 6010C	X	X	X	X	X	X
Anions	EPA 300.0	X	X	X	X	X	X
Hydrocarbon degrading bacteria	Proprietary	X	X	X	X	X	X

BTEX denotes benzene, toluene, ethylbenzene, and xylene.
EDB denotes ethylene dibromide.
EDC denotes1, 2 dichloroethane.
PIANO denotesparaffin, isoparaffins, aromatics, naphthalene, and olefins.
Locations may be modified depending on presence or absence of NAPL.

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Table 5-6. NAPL Migration Soil Test Summary

CORE ID	Depth feet	Core Recovery feet	Field Lithology	Slab and Core Photo	Pore Fluid Saturation Package	Grain Size Analyses	Air/Water Drainage Capillarity Pkg.	LNAPL/Water Drainage Capillarity Pkg.	Test Interval
				Lab Method					
				--	API RP40	ASTM D 4464 (laser)	ASTM D6836, API RP40	ASTM D6836, API RP40	
KAFB-106059-GEO2	304-306	1.95	GW	X	X	X	X	X	304.3-305.5 sandy gravel
KAFB-106060-GEO1	486-489	2.90	SW	X	X	X	X	X	486-487 sand
KAFB-106063-GEO1	489-490.5	1.90	SW	X	X	X	X	X	489.5-490.5 sand
KAFB-106063-GEO2	335-336	1.00	SW	X	X	X	X	X	335-336 sand
KAFB-106078-GEO1	486-489	2.95	SW/GW	X	X	X	X	X	488-489 sand
KAFB-106078-SAND	489-491	1.83	SW	X	X	X	X	X	489-490 sand
KAFB-106080-GEO2	427-428	1.00	SM	X	X	X	X	X	427-428 silty sand
KAFB-106081-GEO1	489-492	2.65	SP	X	--	X	--	--	489-490.5 grain size only
KAFB-106081-GEO2	450-452	1.90	ML	X	X	X	X	X	451-452 silt
			Totals	9	9	9	9	9	

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APPENDIX A

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

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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

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AR Doc # 3451

NEW MEXICO ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau

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April 2, 2010

APR 19 2010

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Mr. John Pike
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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
B. Olson, Chief, NMED GWQB
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

APR 19 2010

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

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

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NEW MEXICO ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau

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RON CURRY
Secretary

SARAH COTTRELL
Deputy Secretary

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

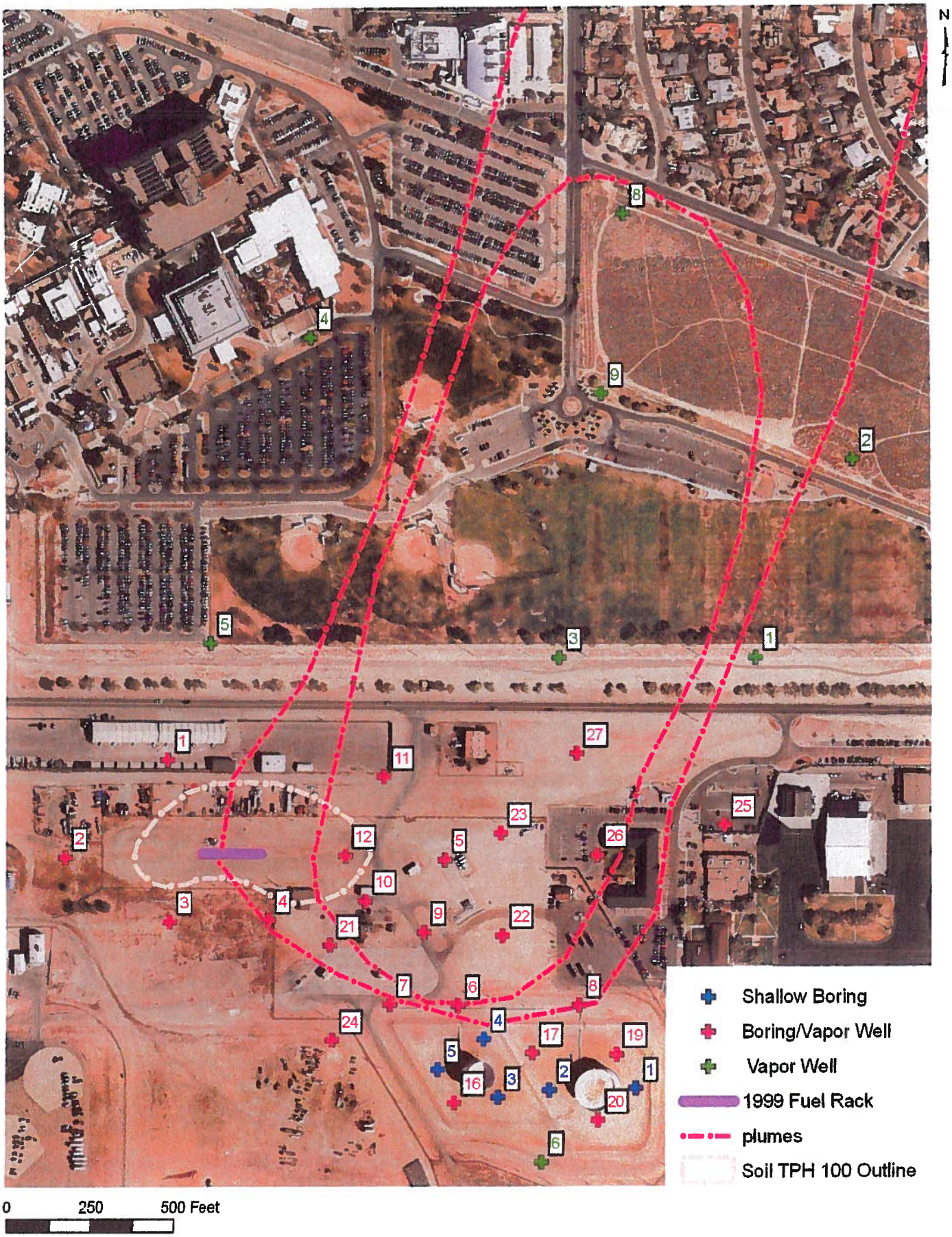

Figure 1. Soil Boring and
Soil-Vapor Monitoring Well Locations

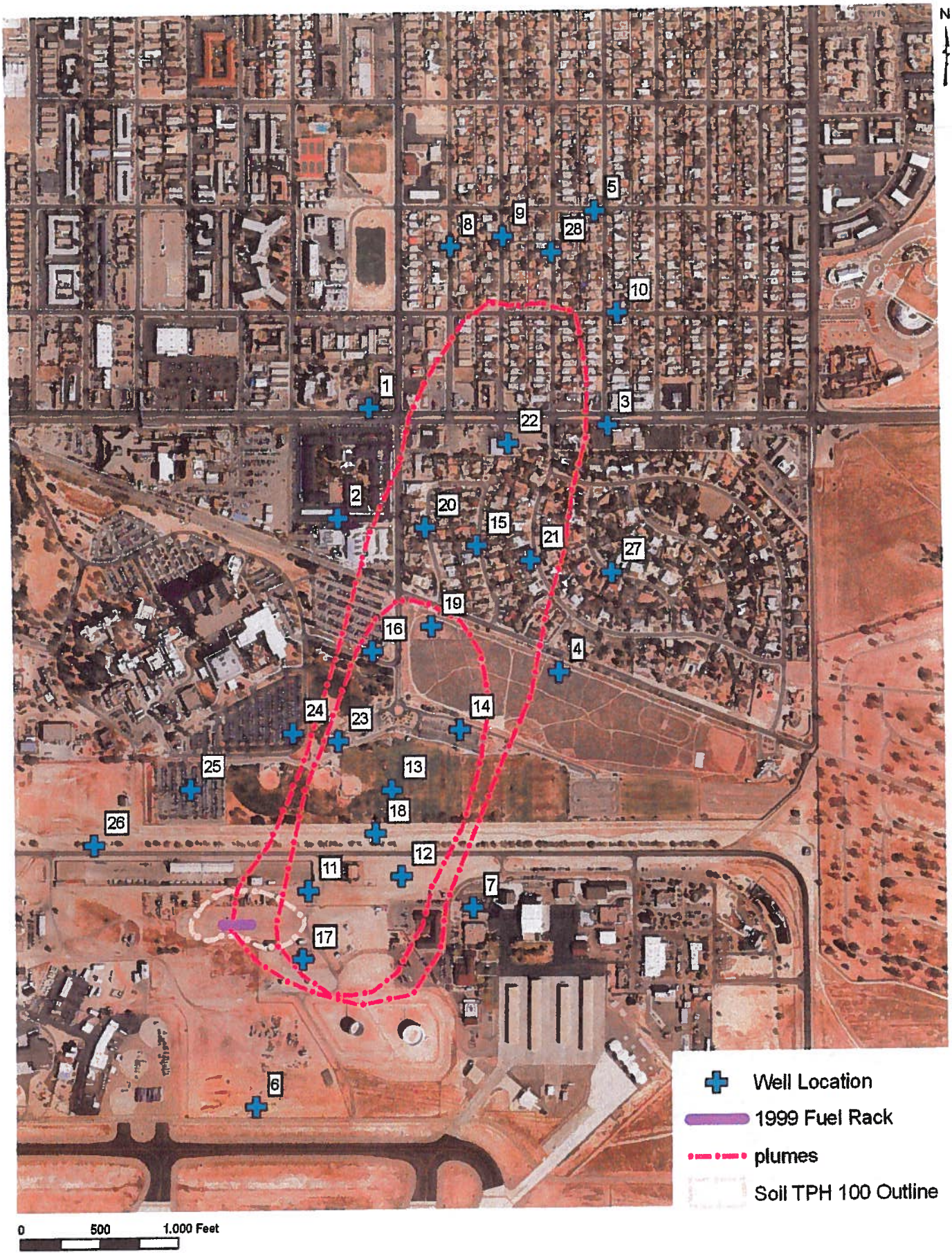

Figure 2. Groundwater Monitoring Well Locations

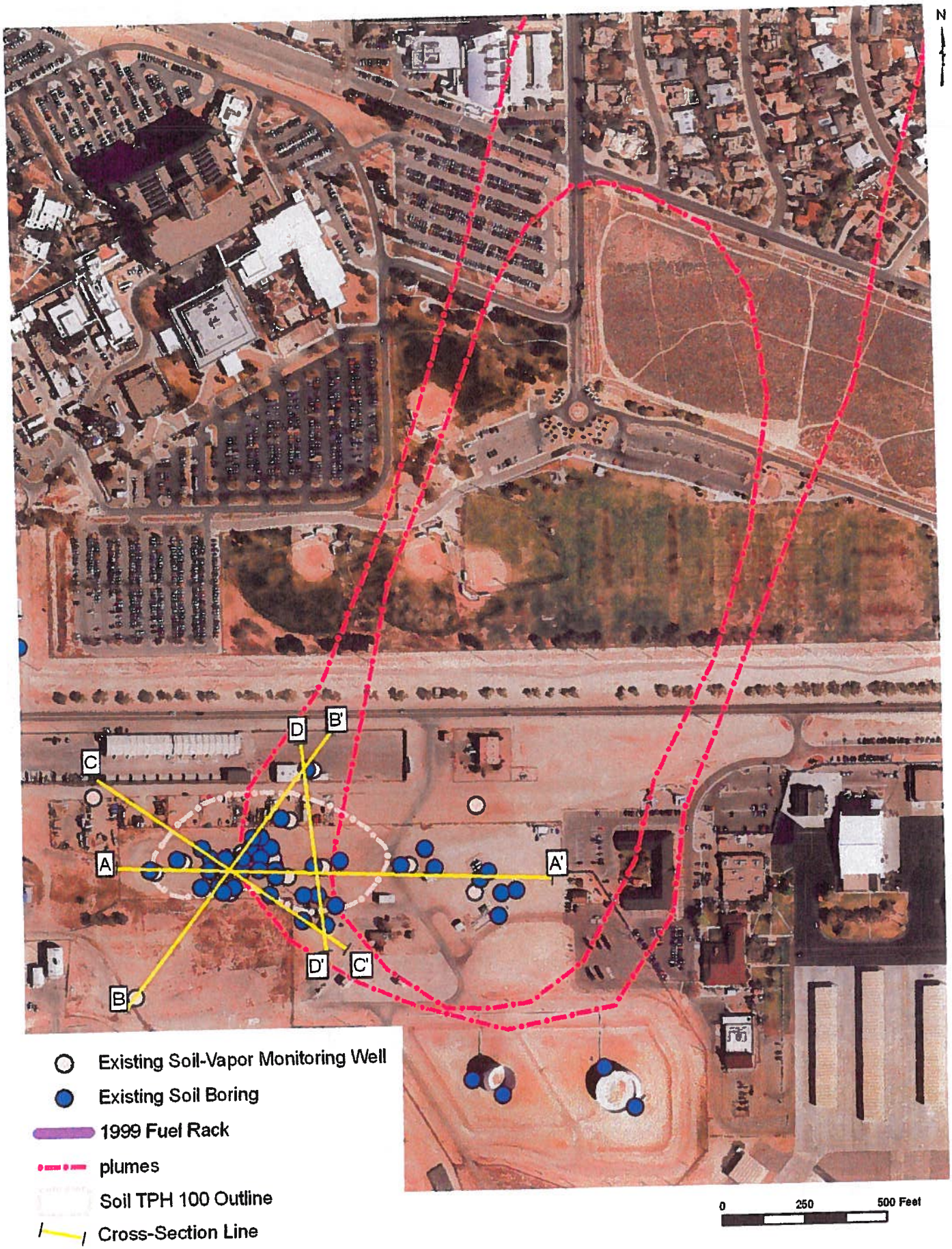

Figure 3 Existing Soil Boring, Soil-Vapor Monitoring Well and Cross-Section Locations

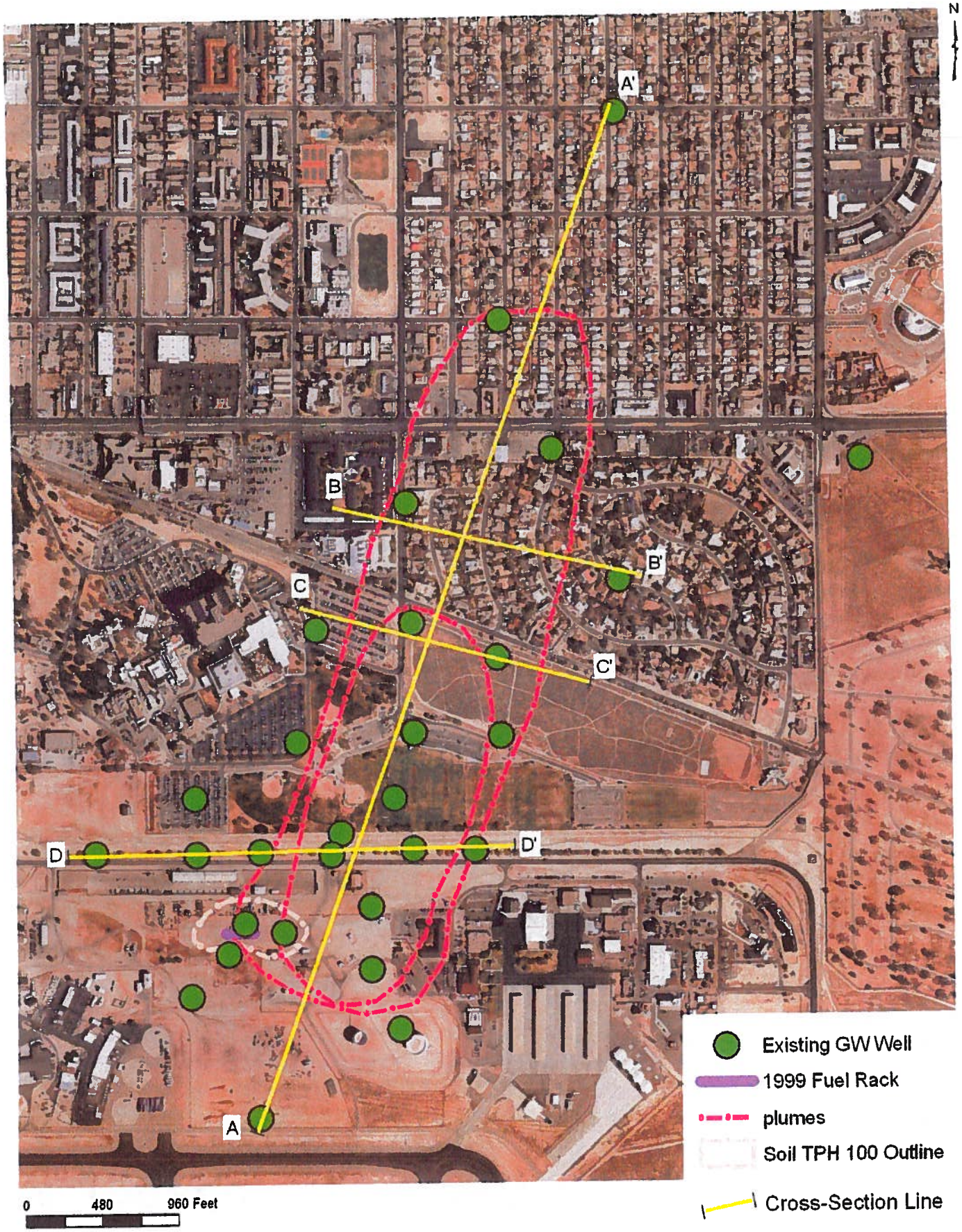

Figure 4. Existing Well and Cross-Section Locations

ATTACHMENT 3

December 10, 2010 Correspondence from the NMED HWB to Colonel Robert L. Maness, Base Commander, 377 ABW/CC and Mr. John Pike, Director, Environmental Management Section, 377 MSG/CEANR

Re: Bulk Fuels Facility Spill (SWMUs ST-106 and SS-111), Notice of Partial Approval with Modification and Notice of Disapproval, Interim Measures, Vadose Zone, and Groundwater Investigation Work Plans, HWB-KAFB-10-015, HWB-KAFB-10-016, HWB-KAFB-10-019

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NEW MEXICO ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau

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BILL RICHARDSON
Governor

DIANE DENISH
Lieutenant Governor

RON CURRY
Secretary

SARAH COTTRELL
Deputy Secretary

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

December 10, 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)
NOTICE OF PARTIAL APPROVAL WITH MODIFICATIONS AND NOTICE OF DISAPPROVAL
INTERIM MEASURES, VADOSE ZONE, AND GROUNDWATER INVESTIGATION WORK PLANS, NOVEMBER 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 New Mexico Environment Department (NMED) has reviewed the revised Interim Measures, Vadose Zone, and Groundwater Investigation Work Plans, concerning the Kirtland Air Force Base (KAFB) Bulk Fuels Facility Spill, Solid Waste Management Units (SWMUs) ST-106 and SS-111. The revised plans were submitted November 4, 2010, in response to the NMED's Notice of Disapproval (NOD) issued August 6, 2010.

NMED finds the plans to be deficient, and provides the following comments. However, NMED must also ensure that commencement of the vadose zone and groundwater investigations and interim measures not be further delayed. NMED is therefore partially approving with modifications the Work Plans in accordance with Permit Part 1.38 of the Permittee's Hazardous Waste Operating Permit (Permit), issued July 15, 2010. Those aspects of the Work Plans that are approved with modifications are addressed in Part 1 of this letter. Under Part 1 of this letter, the Permittee must conduct certain activities to

begin the investigation of the vadose zone and groundwater at the Bulk Fuels Facility immediately, and to conduct interim measures at the former Fuel Offloading Rack, prior to approval of the remainder of the Work Plans. These activities are to be conducted as described in this letter, and without delay. The work to be conducted under Part 1 must also be included in the revised Work Plans even if the Permittee believes that such work has been completed when it submits the revised Work Plans for approval. NMED reserves the right to require the Permittee to correct work completed under Part 1 that does not meet the corrective action requirements of Permit Part 6 or the modifications specified in this letter for such work.

Part 2 of this letter concerns those aspects of the Work Plans that are disapproved. The Permittee is further directed, in Part 2 of this letter, to make additional revisions to the three Work Plans, which are necessary before NMED can approve the plans.

PART 1
PARTIAL APPROVAL WITH MODIFICATIONS

The Permittee must begin immediate investigation of the vadose zone and groundwater in accordance with the corrective action requirements of Permit Part 6, and with the modifications to the three Work Plans that are specified in this letter. The Permittee shall also complete the removal of the former Fuel Offloading Rack and the excavation of contaminated soil exceeding NMED Soil Screening Levels (SSLs).

A. Installation of New Groundwater Monitoring Wells

NMED approves the well installations as described in the revised Groundwater Investigation Work Plan submitted November 4, 2010 with the following modifications. The Permittee shall therefore immediately commence installation of the 78 groundwater monitoring wells provided for in Section 5.2.4 of the revised Groundwater Investigation Work Plan. The installation of the wells shall be completed by **April 28, 2011** (Appendix B of the Groundwater Investigation Work Plan).

Because steel well screens and casing would render most of the geophysical logs useless the Permittee must use polyvinyl chloride (PVC) screens and casing for the deep wells. The Permittee may substitute PVC screens and casing for the intermediate-depth wells, and may use PVC screens and casing for wells screened across the water table at locations where LNAPL is not present.

Section 5.2.4.1 of the Groundwater Investigation Work Plan, *Monitoring Well Installation Procedures*, item #6 states that three PVC centralizers would be used in well construction, one installed directly above and one below the well screen and one installed at the midpoint of the well. In lieu of a centralizer installed at the midpoint, the Permittees shall install PVC centralizers approximately every 100 feet between the top of screen and the ground surface.

The borehole of each well shall be logged in accordance with Permit Part 6.5.15 by a registered professional geologist.

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.

Each of the new wells shall be developed pursuant to Permit Part 6.5.17.10.6. Pursuant to Permit Part 6.5.17.3, initial groundwater samples shall be obtained from newly-installed monitoring wells within 30 days after completion of well development. Groundwater sampling and reporting requirements shall be conducted as directed in NMED's letter of June 4, 2010, and as specified in Permit Part 6.5.17.5.

B. Development of Existing Wells

In NMED's letter of April 2, 2010, the Permittee was directed to develop all existing wells located within the LNAPL plume, and to make such wells available to sample groundwater below the floating LNAPL so that concentrations of dissolved-phase contaminants can be assessed in this area. This work was to be completed by July 6, 2010. The Permittee failed to complete this work. Furthermore, the revised Groundwater Investigation Work Plan does not contain any provisions for developing the existing wells within the LNAPL plume.

NMED is again directing the Permittee to develop all existing wells located within the LNAPL plume, and to make such wells available to sample groundwater. Well development shall be conducted in accordance with Permit Part 6.5.17.10.6. The work must be completed no later than **February 15, 2011**.

C. Geophysical Logging of Existing Wells

In the August 6, 2010, NOD, the Permittee was directed to conduct borehole geophysical logging (medium and deep induction, gamma, and neutron) at all existing groundwater monitoring wells, and to submit copies of the geophysical logs to the NMED by October 6, 2010. The Permittee failed to complete this work on time, but provides for the geophysical logging of existing wells in the revised Groundwater Investigation Work Plan.

NMED approves the Permittee's proposal to conduct borehole geophysical logging (medium and deep induction, gamma, and neutron) at all existing groundwater monitoring wells. Copies of the logs must be submitted to the NMED by no later than **February 15, 2011**.

D. Completion of Soil Borings

NMED approves the projects in Sections D and E of this letter as described in the revised Vadose Zone Investigation Work Plan submitted November 4, 2010 with the following modifications The Permittee shall immediately complete the 35 deep and 5 shallow soil borings provided for in Section 5.2.10 of the revised Vadose Zone Investigation Work Plan. The work shall be completed by **February 11, 2011**(Appendix B of the Vadose Zone Investigation Work Plan). Each deep boring at each location shall be drilled from the surface to the water table.

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. The soil samples shall be analyzed for TPH, VOCs, SVOCs, and lead.

Soil samples from 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.

Each soil boring shall be logged in accordance with Permit Part 6.5.15 by a registered professional geologist.

E. Installation of New Soil-Gas Monitoring Wells

The Permittee shall immediately install the 35 soil-gas monitoring wells provided for in Section 5.2.11 of the revised Vadose Zone Investigation Work Plan submitted November 4, 2010. The well installations shall be completed by **February 11, 2011** (Appendix B of the Vadose Zone Investigation Work Plan).

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.

The borehole of each well shall be logged in accordance with Permit Part 6.5.15 by a professional geologist.

Vapor sampling and reporting requirements shall be conducted as directed in NMED's letter of June 4, 2010.

F. Geophysical Logging of New Groundwater and Soil-Vapor Wells

NMED approves the Permittee's proposal to conduct borehole geophysical logging (medium and deep induction, gamma, and neutron) at all new groundwater and soil-vapor monitoring wells. Copies of the logs must be submitted to the NMED by no later than **June 1, 2011**.

G. Interim Measures at Former Fuel Offloading Rack

The NOD issued August 6, 2010, specified that the Permittee begin removal of the remaining components of the former Fuel Offloading Rack and excavation of contaminated soil exceeding NMED SSLs to 20 feet (SSLs shall be those based on residential land use) by October 6, 2010. The Permittee was also instructed that laboratory analysis of soil samples shall be conducted to determine the concentrations of hazardous constituents for the purpose of defining the final extent of excavation, for risk assessment, and for waste determination. NMED approves the Permittee's proposal for sample analysis, with the following modification: Soil samples shall be analyzed in the laboratory for TPH, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and lead, and collected on all sides and the bottom of the excavation at a spacing not to exceed 25 feet. Additionally, the excavation of soil and removal of the former Fuel Offloading Rack shall be completed by October 6, 2011, and a report on completion of the work submitted to the NMED by January 15, 2012.

NMED approves the Permittee's soil sampling plan except as modified below. Section 4.5.2 of the Interim Measures Work Plan, *FFOR Soil Investigation and Sampling*, indicates that the direct-push technology (DPT) samples are to be collected at the former Fuel Offloading Rack (FFOR) and along the remaining aboveground and underground piping on 25-ft centers. The Permittee does not adequately describe the locations of the samples nor are the locations individually depicted on Figure 4-2. No additional sampling is proposed for the known three locations of pipeline leaks, which occurred approximately 18 ft, 150 ft, and 200 ft from the west end of FFOR.

For underground piping from Building 1033 (Pump House) to its terminus at the west end of the FFOR, the Permittee shall instead collect soil samples on 10-ft centers along a line oriented directly over what was once the centerline of the now-excavated pipeline (hereafter referred to as the former pipe centerline). Soil samples shall also be collected at locations spaced no further than 10 ft apart along two lines oriented parallel to the former pipe centerline, with the two lines situated no further than 5 ft from and on opposite sides of the former pipe centerline. Sampling shall also be conducted directly beneath each of the three known leak locations.

At each of the three known leak locations, sampling shall be increased by collecting soil samples at 5 ft by 5 ft grid nodes.

At each sampling location, soil samples shall be collected at depths of 0, 5, 10, 15, and 20 feet.

If lead, VOCs, or SVOCs are detected in soil at concentrations exceeding the NMED SSLs at a given location, the soil at the location shall be excavated, removed from the site, and properly disposed of. The Permittee shall also increase the sampling grid at the location by using the same method as directed above for sampling the three known leak locations, and collect and analyze the additional samples. Expansion of sampling and the collection and analysis of additional samples shall continue until all soil containing VOCs, SVOCs, or lead at concentrations exceeding the NMED SSLs have been excavated.

Section 4.5.2.1, Bullet 4, of the Work Plan states "The field Geologist will collect samples for laboratory analysis that appear to contain the greatest degree of contamination based on visual observation and headspace VOC screening...", suggesting that not all samples will be submitted to the laboratory for analysis. Because headspace analysis will not detect lead and may not detect SVOCs, all soil samples must be submitted to the laboratory for analysis.

Confirmation samples are samples collected to verify that all contaminated soil with concentrations of hazardous constituents exceeding the NMED SSLs has been excavated and removed. In Section 4.5.3.6, *Confirmation Sampling*, the Interim Measures Work Plan indicates that confirmation samples will not be collected from the sidewalls of the excavation. In contrast, the Interim Measures Work Plan in Section 4.5.1 indicates that sidewalls will be sampled for confirmation.

Confirmation samples must be collected from the bottom and sides of all excavations at intervals not to exceed 25 feet. This includes any areas excavated to depths of 20 ft. The Permittee can collect sidewall conformation samples ahead of, behind, or through shoring via portholes cut through the shoring.

Excavation of contaminated soil at the former Fuel Offloading Rack must be completed by **October 6, 2011**.

H. Piping From Building 1033 to Tanks

NMED approves the Permittee's soil sampling plan, except as modified below. The Permittee must excavate to a depth of up to 20 feet any contaminated soil exceeding NMED SSLs that occurs along the piping from Building 1033 to the jet-fuel fuel storage tanks. In lieu of what the Permittee proposed, for the underground and aboveground piping from Building 1033 to the jet-fuel storage tanks, the Permittee shall collect soil samples at locations spaced no further than 20 ft apart along two lines oriented parallel to the pipe centerline, with the two lines situated no further than 5 ft from and on opposite sides of the pipeline. Soil samples shall be collected at depths of 0, 5, 10, 15, and 20 feet and shall be analyzed in the laboratory for TPH, VOCs, SVOCs, and lead.

If lead, VOCs, or SVOCs are detected in soil at concentrations exceeding the NMED SSLs at a given location, the soil at the location shall be excavated and removed from the site for proper disposal. The Permittee shall also increase sampling at the location by using the same method as directed above for sampling the three known leak locations at the former Fuel Offloading Rack, and collect and analyze the additional samples. Expansion of the sampling and the collection and analysis of additional samples shall continue until all soil containing VOCs, SVOCs, or lead at concentrations exceeding the NMED SSLs are excavated and removed from the site for disposal.

Section 4.5.2.1, Bullet 4, of the Work Plan states "The field Geologist will collect samples for laboratory analysis that appear to contain the greatest degree of contamination based on visual

observation and headspace VOC screening...", suggesting that not all samples will be submitted to the laboratory for analysis. Because headspace analysis will not detect lead and may not detect SVOCs, all soil samples shall be submitted to the laboratory for analysis.

Confirmation samples must be collected from the bottom and sides of all excavations at intervals not to exceed 25 feet. This includes any areas excavated to depths of 20 ft. The Permittee can collect sidewall conformation samples ahead of, behind, or through shoring via portholes cut through the shoring.

Sampling along the pipeline from Building 1033 to the storage tanks shall be completed by **March 7, 2011**.

I. Soil-Vapor Extraction

In the August 6, 2010, NOD, the Permittee was directed to install and operate additional SVE units, or prepare for SVE operations at the following 16 locations: existing groundwater monitoring wells KAFB-3411, KAFB-10614, KAFB-10624, KAFB-10617, KAFB-10618, and KAFB-10610, at soil boring/soil-vapor monitoring well locations # 4, 5, 9, 10, 11, 12, and 21 listed in Table 1 of the NOD, and soil-vapor monitoring well locations #3, 8 and 9 on Table 2 of the NOD. The Permittee did not accomplish this work, and did not propose any alterative work for NMED to consider. Furthermore, the Permittee has not done anything in the past four months to accelerate the reduction of the soil-vapor mass in the vadose zone at the Bulk Fuels Facility.

Nevertheless, NMED has reconsidered its earlier position to expand the number of SVE Units. Instead of expanding the number of operating SVE Units, the Permittee is directed to prepare the locations of existing groundwater monitoring wells KAFB-3411, KAFB-10614, KAFB-10624, KAFB-10617, KAFB-10618, and KAFB-10610 for conducting SVE by no later than **February 15, 2011**. The Permittee is also directed to prepare an SVE Optimization Plan for the four existing SVE Units, with the concept that the four SVE units will be moved periodically between the six aforementioned locations and the four locations where SVE is currently conducted to maximize the removal of contaminants (by mass) via vapor extraction. Furthermore, the Permittee must propose in the SVE Optimization Plan alternative technologies for the removal and treatment of soil-vapor contamination that do not rely on the use of internal combustion engines. The SVE Optimization Plan must be submitted to NMED by **March 31, 2011**.

J. Special Tests under Interim Measures Work Plan

NMED approves the ROI, hydrocarbon baildown, and Pneulog tests. The Permittee shall conduct the Radius of Influence, the Hydrocarbon Baildown, and PneuLog tests by **April 6, 2011**; **March 2, 2011;** and **December 21, 2011**, respectively.

K. Collection of LNAPL Sample

The Permittee shall collect a sample of LNAPL from one of the groundwater monitoring wells within the LNAPL plume and provide the sample to the Scientific Laboratory Division (SLD) of the New Mexico Department of Health by no later than **March 31, 2011**. The Permittee shall notify the NMED in writing of the delivery of the LNAPL sample to the SLD no later than **1 business day** following delivery of the sample.

The Permittee is directed to conduct all activities required in Part 1 of this letter in accordance with the terms described in each section of this letter and to resubmit the Work Plans with the required revisions along with the changes required by Part 2 of this letter. Any portion of a Work Plan that was not specifically approved and modified as described above is disapproved and must be corrected as described in Part 2.

PART 2
PORTIONS OF WORK PLANS THAT ARE DISAPPROVED

A. Deficiencies Common to All Three Plans

1. Part 1, A.7 of the NOD issued on August 6, 2010, required that the Permittee list the data gaps that apply to each of the three plans, as appropriate for the topic of a plan. The Permittee was also instructed to revise the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans to include a description of at least the data gaps identified by the NMED and point specifically to where in each of the documents the data gaps are addressed.

This deficiency was not corrected in any of the revised Work Plans submitted on November 4, 2010. The NMED is directing the Permittee again to 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 the data gaps are addressed in each of the documents.

2. Part 1, A.9 of the NOD issued on August 6, 2010, required that the Permittee include 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 in each of the plans. However, none of the revised Work Plans contains a site conceptual model. Instead, the issue was addressed under the Work Plans by stating that a model will be provided later by the Permittee.

The NMED is directing the Permittee again to revise the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans to include 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 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 invites the Permittee to meet to discuss NMED's expectations with respect to the conceptual model and graphic representation of data.

3. Part 1, A.10 of the NOD issued on August 6, 2010, required that the Permittee meet Section E of the NMED's letter of April 2, 2010, which directed that investigation plans are to 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, and clearly show which borings/wells contributed data towards construction of the maps and cross-sections and which did not. Additionally, 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 were also to be included in the plans. For soil-gas monitoring wells, tables and graphs were also to be included providing trends of TPH concentration versus time for the depths below ground surface of 25, 50, 150, 250, 350, and 450 feet.

The required maps, cross-sections, tables, and graphs were not included in the Work Plans submitted November 4, 2010. Revise the Work Plans accordingly.

4. Appendix E, Uniform *Federal Policy-Quality Assurance Project Plan* – This plan is incorporated into the Vadose Zone Investigation, Groundwater Investigation, and Interim Measures Work Plans. The plan, as written, appears to be a combination of many types of plans, such as project management, training, data validation, quality assurance, and sampling and analysis plans. Additionally, much of the information presented appears to be overly burdensome and not particularly useful in the present format. For example, a tabulated listing of field quality control samples to be collected for every quarter/year is unnecessary as the types and frequencies of such samples are not likely to change every quarter or even every year. Listings of quality control targets (in particular, limits for laboratory control samples) from three different entities are also not useful – instead only those that will actually be used for this particular project should be listed.

The Permittee must revise Appendix E into multiple appendices to separate the various types of plans (e.g. project management, training, data validation, quality assurance, and sampling and analysis). The various listings of laboratory analytes per media (QAPP Worksheet # 18a-c), field quality control samples (QAPP Worksheet # 20a-c), quality control targets (Appendix A of Appendix E) should be revised to simplify the information presented and contain only the necessary information to support the Bulk Fuels Facility Spill project. Some tables, such as QAPP Worksheets # 3, 4, 9, 16, 24c, 25, 28a-d, do not provide useful information to the NMED and should be deleted.

NMED is expecting a Quality Assurance (QA) Plan that contains specific quality assurance and quality control activities for the Bulk Fuels Facility Spill project. The QA plan is to integrate all technical and quality aspects of the project to ensure that the necessary type and quality of data are obtained to adequately characterize the release, the contaminated media, and for conducting and verifying clean up. NMED invites the Permittee to meet and discuss NMED's expectation

with respect to what should be in the QA Plan, as well as project management, training, data validation, and sampling and analysis plans.

B. Groundwater Investigation Work Plan

1. The Permittee must describe in the first paragraph of Section 5.2.5 what geophysical logging has been previously conducted at existing wells.

2. The last paragraph on page 5-19, Section 5.2.5.1, states "The logs will be run from the groundwater table (approximately 500 ft bgs) to ground surface through the well casing." Correct the text to read "The logs will be run from the bottom of the well to the ground surface." Also, change all references to "groundwater table" in the Groundwater Investigation Work Plan to the correct term "water table".

3. The first sentence on page 5-20, Section 5.2.5.1, references a proposed seismic survey. Discuss the survey, or remove the reference to the seismic survey if such a survey will not be conducted.

4. Section 5.2.5.2, *Induction Logging*, on page 5-22, 3rd paragraph, 1st sentence states: "The borehole induction system can be used in boreholes that range from 2 to 8 inches diameter without significant borehole effects." Because the Permittee is proposing to drill boreholes with diameters of 9-5/8 and 11-3/4 inches, indicate whether the borehole induction system can be used properly in boreholes with diameters greater than 8 inches, or modify the plan to indicate that another, more appropriate tool will be used to log the boreholes.

5. Section 5.2.5.2, *Induction Logging*, page 5-22, the last sentence of the 3rd paragraph states; "The maximum depth of measurement for the most induction logging systems is 650 ft (200) meters)." Explain what this sentence means, as wells many thousands of feet deep are logged using induction logging. If the sentence is incorrect, correct the sentence or delete it from the Work Plan.

6. The last paragraph and bullets in Section 5.2.5.2, *Induction Logging*, discusses general procedures for all geophysical logging. This discussion needs to be moved to a more general section, such as Section 5.2.5 *Logging Requirements*. Also:

   a. Add total depth from the logger to the list of bullets.

   b. Add the same information to the list of bullets that is to be recorded in the first bullet of Section 5.2.3.2 of the Vadose Zone Investigation Work Plan (e.g., logging tool serial number, sensitivity range setting).

   c. The Permittee must include the measured deviation between the "zero point" of the tool at ground level at the start of the logging run and after completing the logging run.

7. Describe in Section 5.2.5.1 of the Work Plan if tools are to be run centralized, decentralized, or free in casing and describe where that information will be recorded.

8. Section 5.2.6.1, Logging System, p.5-25, last sentence, states "The logging system will be equipped with.... cable long enough to log 600-ft.depths." Because some of the groundwater monitoring wells may be 610-620 ft deep, the logging system must be capable of logging the full depth of all wells, even those in excess of 600 ft depth.

9. Table 4-1, Data Quality Objectives Summary Table, in the 3rd and 4th column in row 4, *Define the Study Boundary* states "Study boundaries are indicated on Figure 2-1". Many wells are outside the study boundary shown on the figure. Correct the statement or the figure as appropriate.

Revise Table 4-1 in accordance with the directives in this letter, or delete the table. Although the Permittee may use the EPA's DQO process to plan work, NMED prefers that Table 4-1 and Section 4 be deleted from the Work Plan, as they add little additional useful information. Items in the table should be included in the text of the Work Plan with additional details and as modified in accordance with the directives of this letter.

10. Table 4-1, Data Quality Objectives Summary Table, in the 3rd and 4th column in row 6, *Specify Limits on Decision Errors* states "Borehole geophysics measurements obtained is less than 1 ft." Explain what this sentence means, especially in light of the second sentence in Section 5.2.5.2 on page 5-22, which states "The intercoil spacing resolves conductivity layers 20 inches thick." See comment # 9 above about the deletion of Table 4-1 and Section 4.

11. Section 5.2.7, *Borehole Geophysics Equipment Decontamination* – Revise the Work Plan to indicate clearly that both the cable and probe will be decontaminated.

12. The 2nd paragraph, last sentence of the *Preface* states "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)."

Revise the Work Plan to include a detailed description of what is to be included in the Part II Work Plan. NMED notes further that the inclusion of a "report" in a work plan is unusual and generally inappropriate. Information derived from newly completed work is normally submitted as a stand alone report, not as a section of a work plan.

Furthermore, the schedule in Appendix B lists the Part II Work Plans as being submitted by August 6, 2011. Because the contents of the Phase II plans are unknown to the NMED, the NMED can not agree to this submittal due date.

13. There are few details of reporting in the Work Plan, and most of those are aimed at the geophysical logging. Revise the Work Plan to include details for reporting on well installation, monitoring, and sampling results.

14. Section 3.5.3, *Identification of Contaminants of Potential Concern*, page 3-10 lists WQCC water quality standards from 20.6.2 NMAC. The cleanup levels for groundwater shall be the New Mexico Water Quality Control Commission (WQCC) water quality standards (20.6.2.3103 and 20.6.2.4103 NMAC) and the drinking water maximum contaminant levels (MCLs) adopted by EPA under the Federal Safe Drinking Water Act (42 U.S.C. §§ 300f to 300j-26). If both a WQCC standard and a MCL have been established for a contaminant, then the most stringent of the two levels shall be the cleanup level for that contaminant.

If a WQCC standard or MCL has not been established for a contaminant, the EPA Regional Screening Level (RSL) (EPA, 2009) for tap water shall be used as the cleanup level. If a RSL for tap water does not exist for a contaminant, and toxicological information is available, the Permittee shall propose a cleanup level based on a residential scenario, a total target human health excess cancer risk level of 10^{-5} and for non-carcinogenic contaminants a HQ of one (1.0). Revise the Work Plan accordingly.

See Permit Section 6.2.3.1.

15. Section 3.5.4, *Light Non-Aqueous Phase Liquid Distribution*, contains a list of wells where LNAPL has been detected. Add well KAFB-10628 to the list.

16. Section 5.2.3.1, page 5-6, 3rd bullet, discusses a scale of 1 inch =10 feet for drilling logs for wells shallower than 200 feet, but does not address a scale for wells greater than 200 feet. Because all wells are likely to be greater than 200 feet deep, identify the scale to be used.

17. Section 5.2.4, Groundwater Monitoring Wells, page 5-14, 2nd paragraph, last sentence states "A schematic showing a well construction detail is included in Appendix D, Forms 4, 5, 6, and 7." None of the four forms seems to fit the proposed construction details with a single cased, telescoped borehole, as shown on Figure 5-1. Revise the Work Plan to include appropriate well-construction field forms.

18. Section 5.2.4.3, *Well Development*, 2nd bullet discusses stabilization of groundwater field parameters during well development. Water stability indicators must be as described in the Permit, not as listed in this section, or as listed in Appendix D. Form 8, *Well Development Record and Water Quality Field Data Sheet (Continued 5 of 6).*

19. Appendix D. Form 8, *Well Development Record and Water Quality Field Data Sheet (Continued 5 of 6)* lists conversion factors to determine the volume of well water to be purged for development and sampling based upon the height of the water column in the well. A distinction is made between a dedicated and non-dedicated system. NMED does not recognize such a

distinction and requires that all well development meet Permit Part 6.5.17.10.6 and that well purging be conducted as directed in NMED's letter of June 4, 2010, and Permit Part 6.5.17.4.

20. Appendix C, *Waste Management Plan*, Table 2 implies that the preferred method of disposal of non-hazardous waste water, a form of investigation-derived waste (IDW), is to discharge it to the ground surface. NMED encourages the Permittee to dispose such non-hazardous waste water into the City of Albuquerque's Publically-Owned Treatment Works (POTW) sewer system. Furthermore, all such water must be containerized and tested prior to disposal in accordance with 20.4.1.300 NMAC incorporating 40 CFR § 262.11. Waste water from one well can not be commingled with that from any other well or wells unless demonstrated not to be a hazardous waste.

21. The Permittee shall address the following concerning Appendix E, *Uniform Federal Policy-Quality Assurance Project Plan.*

a) Appendix E is shown as "(Pending Review)". This suggests that Appendix E is a draft document. Revise the Work Plan to contain only finished products, ready for NMED review.

b) Appendix E, page 77, Section 17.2, first paragraph, correct "April 2009" to the appropriate date.

c) Appendix E, page 77, Section 17.2 must clearly state quarterly groundwater monitoring will occur until a change is approved by NMED.

d) Describe what risk evaluation the Permittee is expecting to do and why.

e) List the data quality objectives that the QAPP must address.

f) Describe the Quality Assurance for geophysical logging.

g) Appendix E, Section 17.5 (and elsewhere) – Samples must be analyzed at an EPA-certified laboratory. Also, the Permittee must indicate whether the referenced Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) laboratory is EPA-certified. Revise the Work Plan accordingly.

h) Appendix E, Section 17.8, *Investigation-Derived Waste* –This section needs to clearly state that no IDW water from individual wells will be comingled before appropriate testing.

i) Appendix E, Section 17.9.4 states that no trip blanks will be collected for soil samples for VOC analysis. Revise the Work Plan to indicate that trip blanks are required for soil samples that are to be analyzed for VOCs.

j) Appendix E, Section 17.9 must include percent frequency of field quality control samples in each subsection. The sampling frequency must be as described in Permit 6.5.17.6.

k) Appendix E, Section 17.9.5, states field (ambient) blanks will be collected for groundwater only. Revise the Work Plan to include field blanks for soil sampling.

l) Appendix E mainly addresses sampling only for laboratory and field analyses. Other field activities, such as surveying and geophysical logging need to be addressed.

m) Appendix E, Section 17.2.2, *MNA Groundwater Monitoring*, states "30 groundwater monitoring wells will be installed for the monitored natural attenuation (MNA) investigation effort." Specify which wells these are and the purpose of this monitoring given that NMED has not made any decision concerning MNA as a remedy. Additionally, Section 11.2 of Appendix E, indicates that there are 35 wells to be included in the study. Specify which number of wells is correct.

22. Revise the Work Plan to provide for the collection and maintenance of representative soil samples encountered during well installations and to indicate that said samples will be made available for NMED inspection upon request by the NMED. Additionally, Section 11.2 of Appendix E indicates that there are 35 wells to be included in the study. Specify which number of wells is correct.

23. Revise the Work Plan to specify the frequency that soil samples will be tested for grain size via sieve analysis. Indicate the specific sieve screen sizes that will be utilized for the testing.

24. Table 6-2 lists only two soil samples each to be collected for grain size, residual LNAPL saturation, Water/LNAPL Drainage Capillary Pressure and Water LNAPL Relative Permeability and only one LNAPL sample each for testing for viscosity, fluid density and surface and interfacial tension. Revise the Work Plan to describe why these few numbers of samples are sufficient for the range of conditions at the site. Also, clarify in the table if the column titled "No. of Field Samples" is correct, and if the column "Total No. of Samples to Laboratory" is correct.

25. Saturated hydraulic conductivity and porosity are important variables in groundwater flow considerations. Specify field or laboratory tests that will be conducted to arrive at a range of site specific values. Revise the Work Plan to indicate how values for saturated hydraulic conductivity and porosity will be assessed.

C. Vadose Zone Investigation Work Plan

1. Geophysics – Revise the Vadose Zone Investigation Work Plan in accordance with the above Comments 1-8 and 10-11 concerning Groundwater Investigation Work Plan.

2. Geophysical logging is proposed in soil-gas wells with 2-inch casing. Confirm that all tools fit in 2-inch casing, given the neutron probe is described as being 60 mm in diameter (2.36 inches, see page 5-24 of the Groundwater Investigation Work Plan, first paragraph, last sentence) or make an appropriate change in tool size or casing size.

3. For the soil vapor wells, describe where the 2-inch casing will be located in the borehole (e.g., in the center, closer to one side), and if so, how geophysical logging conducted in the 2-inch casing could be affected by the other soil-vapor monitoring points attached to 0.75-inch diameter casing in the same nested borehole.

4. The Work Plan does not include a detailed discussion of soil-vapor sampling. Revise the Vadose Zone Investigation Work Plan to include a section describing soil-vapor sampling in detail, with discussion of sampling methods, analytical methods, sampling frequency, laboratory and field quality control, handling, shipping and packaging, and reporting of results.

5. Section 5.2, top line on page 5-3 references Table 4 of the August 6, 2010, NOD for number, location, and depths of soil borings/soil-vapor wells. The table number is incorrect. The correct reference is Tables 1, 2 and 3.

6. Table 5-2 of the Work Plan does not show an exact correspondence to the August 6 letter. However, NMED will accept the locations as described in Table 5-2.

7. Section 5.2.10, *Soil Borings/Drilling*, page 5-18, last sentence, 1st paragraph, mentions "10 ¾" O.D. casing whereas Figure 5-2 shows "11 ¾" casing. Correct, as appropriate, the figure or the text.

8. Section 5.2.10, *Soil Borings/Drilling*, page 5-18, last sentence, 1st paragraph, mentions telescoping to a smaller diameter borehole at 200 feet, while Figure 5-2 shows telescoping to a smaller diameter borehole at 150 feet. Correct, as appropriate, the figure or the text.

9. Revise the Work Plan to add total depth from the logger to the first bullet of Section 5.2.3.2.

10. In the bullets of Section 5.2.3.2, define what "Assemble the downhole logging tool" means as a type of information recorded, or remove the bullet.

11. Section 6.1, *Soil Sampling*, Revise the Work Plan to indicate that additional samples will be collected and analyzed, beyond those obtained at the planned sampling intervals, if field evidence suggests contamination may be present as required in Permit Part 6.5.11.

12. Describe what will be submitted in Part 2 Vadose Zone Investigation Work Plan, indicate when the information will it be submitted, and explain why any of the information that was required by November 8, 2010, was not included in Part 1.

13. Appendix E, Section 17.3, *Pre-remedy Quarterly Monitoring Program – Soil Vapor*, discusses soil-vapor monitoring. Describe the risk evaluation the Permittee is proposing to conduct and the purpose of the evaluation. Revise the Work Plan to state that soil-gas

monitoring will be conducted quarterly until a change in frequency or termination of soil-gas monitoring is approved by the NMED.

14. Table 5-2 – Correct the date of the "August 8" letter to "August 6" in the title and last column heading.

15. Table 5-2 – Correct the locations listed in the last column under Shallow Borings. The same location is given for the five separate borings. Revise the Work Plan to correct the location numbers.

16. There are few details of reporting in the Work Plan, and most of those are aimed at the geophysical logging. Revise the Work Plan to include details for reporting on well installation, monitoring, and sampling results.

17. Section 5.2.11, Soil Vapor Monitoring Wells, p.5-27, 1st paragraph, discusses movement of the monitoring point by up to 20 feet if the point lies in a fine-grained layer. This is acceptable for the four deepest points (150, 250, 350, 450) but not for the two shallow points (25, 50). Movement of up to +/-5 feet for the shallow points will be acceptable. Screen depths can only be changed if the adjustment sets the screen in a more permeable geologic unit.

18. Section 5.2.11, Soil Vapor Monitoring Wells, p.5-27, 1st paragraph, states "If a large deviation is required, the NMED will be notified in writing of the deviation." All deviations must have prior written approval from NMED.

D. Interim Measures Work Plan

1. Section 2. 4.5.3.2, Waste Profiling – The Work Plan states that soil will be characterized in place by sampling waste, but is unclear how sample locations will be selected and at what frequency that samples will be collected. Revise the Work Plan accordingly.

2. Section 4.6.11, Radius of Influence (ROI) Testing – The Work Plan does not indicate which existing wells will be used for the testing. Revise the Work Plan to list the wells to be used in the ROI tests.

3. Section 4.6.2.4 states that soil-gas wells will be constructed with 2-inch casing. Figure 4-4 indicates that the deepest monitoring point will be constructed using 3-inch casing. Revise the Work Plan to indicate the correct casing diameter. If 2-inch casing is correct, confirm that all geophysical tools will fit in 2-inch casing, given the neutron probe is described as being 60 mm in diameter (2.36 inches, see p.5-24 of the Groundwater Investigation Work Plan, first paragraph, last sentence) or make an appropriate change in tool size or casing size.

If 2-inch casing is correct, describe where the 2-inch casing will be located in the borehole (e.g., in the center, closer to one side), and if so, how geophysical logging conducted in the 2-inch

casing could be affected by the other soil-vapor monitoring points attached to 0.75-inch diameter casing in the same nested borehole.

Final Direction

The Permittee must meet the deadlines specified in the Compliance Schedule at the end of this letter. The Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans must be revised and resubmitted by the Permittee to the NMED for its review and approval by **March 31, 2011**. The revisions of the Vadose Zone, Interim Measures, and Groundwater Investigation Work Plans must address the comments 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 1 of this letter by the dates indicated and in accordance with the Compliance Schedule.

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 Department in writing regarding its best efforts and its failure to obtain such access.

The Permittee must document all field activities in accordance with Permit Part 6.5.2. All equipment that is not disposable must be decontaminated pursuant to Permit Part 6.5.3. All equipment that requires calibration must be calibrated as required under Permit Part 6.5.4. Sample handing, shipping, and custody procedures must comply with Permit Part 6.5.5. The collection and management of investigation-derived waste must conform to Permit Part 6.5.7. Well and boring locations must be surveyed in accordance with Permit Part 6.5.8. Field quality control samples must be collected and analyzed for all environmental media pursuant to Permit Parts 6.5.14 and 6.5.17.6. Laboratory analyses, including laboratory quality control samples, must be conducted as required under Permit Part 6.5.18. Field and laboratory quality control data must be reviewed and validated in accordance with Permit Part 6.5.18.3. Reporting of field activities, including sampling and analysis results, completion of soil borings, geologic and geophysical logging, and well installations, must be as directed by NMED's letter of June 4, 2010, for quarterly reporting.

The requirement under Permit Part 6.1.2 that the Permittee is to notify the NMED a minimum of 15 days in advance of field activities is waived for the work to be completed in the following sections of Part 1 of this letter: *A. Installation of New Groundwater Monitoring Wells, B. Development of Existing Wells, C. Geophysical Logging of Existing Wells, D. Completion of Soil Borings, Installation of New Soil-Gas Monitoring Wells, and I. Soil-Vapor Extraction.* The Permittee shall instead notify the NMED of these field activities by e-mail or letter by no later than the date that each of the activities begins.

Compliance Schedule

Revisions to Work Plans	
Submittal	**Due Date**
Interim Measures Work Plan	March 31, 2011
Vadose Zone Work Plan	March 31, 2011
Groundwater Investigation Work Plan	March 31, 2011
Well Installations, Soil Borings, Interim Measures, and other Actions	
Activity	**Completion Due Date**
Complete installation of new groundwater monitoring wells	April 28, 2011
Complete development of existing wells	February 15, 2011
Complete geophysical logging of existing wells	February 15, 2011
Complete soil borings	February 11, 2011
Complete installation of new soil-gas monitoring wells	February 11, 2011
Complete geophysical logging of new groundwater and soil-gas wells	June 1, 2011
Complete excavation of soil at former Fuel Offloading Rack	October 6, 2011
Complete investigation of piping from Building 1033 to storage tanks	March 7, 2011
Complete preparation of locations for soil-vapor extraction	February 15, 2011
Submit SVE Optimization Plan to NMED	March 31, 2011
Complete Radius of Influence tests	April 6, 2011
Complete Hydrocarbon Baildown tests	March 2, 2011
Complete PneuLog tests	December 21, 2011
Provide LNAPL sample to Scientific Laboratory Division of NM Department of Health	March 31, 2011
Notify NMED that LNAPL sample has been delivered to Scientific Laboratory Division of NM Department of Health	No later than 1 business day following delivery of the sample.

LNAPL Plume

NMED's directives as expressed in its April 2, 2010, letter and the August 6, 2010, NOD required the Permittee to provide an Interim Measures Work Plan to conduct interim measures to remediate the LNAPL plume within five years. The revised Interim Measures Work Plan submitted November 4, 2010, does not contain such a plan. Rather than complying with NMED's direction to take immediate action to conduct LNAPL remediation, the Permittee proposes in the revised Interim Measures Work

Plan to conduct various tests. This same approach was proposed in the Permittee's June 18, 2010 version of the Work Plan, and was found unacceptable by NMED (*see* August 6, 2010 NOD).

On December 1, 2010, the Permittee submitted a separate plan to contain the LNAPL plume by proposing to pump and treat contaminated groundwater at the leading edge of the LNAPL plume. NMED will review this plan to determine whether it meets NMED's directives of April 2, 2010, and the NOD issued August 6, 2010, and otherwise proposes a sound technical approach. NMED's action on that plan will be provided under separate cover.

The Permittee must respond to this letter to my attention, with copy to Mr. Bill Olson of the NMED 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.

Please contact me directly at 505-476-6016 should you have any questions. Questions of a technical nature may also be directed to William Moats of my staff at (505) 222-9551.

Sincerely,

James P. Bearzi
Chief
Hazardous Waste Bureau

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

ATTACHMENT 4

May 31, 2011 Correspondence from the NMED HWB to Colonel Robert L. Maness, Base Commander, 377 ABW/CC and Mr. John Pike, Director, Environmental Management Section, 377 MSG/CEANR

Re: LNAPL Containment Interim Measure Work Plan, Bulk Fuels Facility Spill, Kirtland Air Force Base, HWB-KAFB-10-037

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NEW MEXICO ENVIRONMENT DEPARTMENT

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SUSANA MARTINEZ
Governor

JOHN A. SANCHEZ
Lieutenant Governor

DAVE MARTIN
Secretary

RAJ SOLOMON, P.E.
Deputy Secretary

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

March 31, 2011

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: LNAPL CONTAINMENT INTERIM MEASURE WORK PLAN
BULK FUELS FACILITY SPILL
KIRTLAND AIR FORCE BASE
EPA ID# NM9570024423, HWB-KAFB-10-037

Dear Col. Maness and Mr. Pike:

The New Mexico Environment Department (NMED) received on December 1, 2010 the *Light Non-Aqueous Phase Liquid (LNAPL) Containment Interim Measure Work Plan* for Kirtland Air Force Base's (KAFB, or the Permittee) Bulk Fuels Facility Spill (Solid Waste Management Units (SWMUs) ST-106 and SS-111), dated November 2010, hereafter referred to as the Work Plan. In NMED's letter of April 2, 2010, the Permittee was directed to propose interim measures to stop the migration of the light nonaqueous phase liquid (LNAPL, or NAPL) plume and complete remediation of the plume within five years. The Work Plan has merit in that it presents a conceptual design for a pump-and-treat system to arrest migration of the LNAPL plume. Even though it does not have as a primary objective clean up of the bulk of the LNAPL that has been released, if successful, it could provide interim protection to allow for more time to develop and implement other remedial alternatives to clean up the vadose zone, LNAPL, and dissolved-phase groundwater contamination.

The Work Plan emphasizes that many details of the pump-and-treat system cannot be developed at this time because of the need to first obtain the requisite characterization information described

in the Work Plan primarily in Sections 1 through 6. The NMED concurs with the Permittee that collection of characterization data is a necessary precursor to the proposed interim measure, hence the need for a separate characterization plan. The revised Work Plan to be submitted in response to this letter, on the other hand, needs to focus on the design and operations aspects of the pump-and-treat system, and be developed after the characterization data has been obtained. Separating characterization work from the pump-and-treat system design will simplify the objectives of each plan, which is needed due to the complexity of the proposed pump-and-treat system.

The characterization plan must include proposed work to conduct the pumping tests and installation of the extraction and injection wells in addition to the other characterization activities proposed in Sections 1 through 6 of the Work Plan. Comments concerning characterization are addressed chiefly in Part 1 of this letter and primarily pertain to Sections 1 through 6 of the Work Plan.

Part 2 of this letter pertains chiefly to the design of the pump-and-treat system, found primarily in Sections 5 and 7 of the Work Plan. The design of the pump-and-treat system in the Work Plan must be revised to take advantage of the information obtained through implementation of the characterization plan, the Vadose Zone and Groundwater Investigation Plans, and the Interim Measures Work Plan.

PART 1 – COMMENTS ON CHARACTERIZATION

The following comments must be addressed in the characterization plan, and where directed in this Part, in both the characterization plan and the revised Work Plan.

1. Table 1-1 – Prepare the characterization plan to discuss the type of analyses that are intended for the parameter "NAPL cleaning." Identify the analytical laboratory that will be performing the analysis for hydrocarbon degrading bacteria.

2. Section 2.3 – NMED approval must be obtained for any changes to previously-approved work plans

3. Section 2.3 – Prepare the characterization plan to indicate where the Field Change Request form is to be found.

4. Section 4.4.1 – Prepare the characterization plan to indicate where Building 2405, the JP-8 offloading rack, is located on Figure 3-2.

5. Section 4.7 – Specific receptor points must be identified, such as the WUA, KAFB, and the Veterans Administration water supply wells.

6. Figure 5-2 – It is difficult to review data on Figure 5-2 due to the background aerial photograph. Provide an additional figure that leaves only major streets and/or other major features for reference to improve readability of the presented data.

7. Section 5.2.1 – Slug tests are proposed for wells KAFB-1065, KAFB-1066, KAFB-1068, KAFB-1069, KAFB-10610, and KAFB-10614. Additional hydraulic conductivity data for locations closer to the proposed extraction and injection wells are needed to better define the magnitude and spatial variability of hydraulic conductivity within the proposed containment area. At a minimum, conduct additional slug tests at wells KAFB-10613, KAFB-10617, KAFB-10618, KAFB-10619, KAFB-10620, KAFB-10628, and as appropriate, at new wells installed under the Groundwater Investigation Work Plan.

8. Section 5.2.1 – There is a high likelihood that the presence of LNAPL will affect the outcome of the slug tests. It is therefore critical that the thickness of the LNAPL be measured immediately prior to and after the slug tests are performed, and the results recorded. Specify how the presence of LNAPL will be addressed during field data collection and how it may affect the slug test results.

9. Section 5.2.1 – Indicate and explain the method that will be used to evaluate slug test data.

10. Section 5.2.1 – Specify the size of slug or slugs that will be used.

11. Section 5.2.2 – In addition to the locations specified in Section 5.2.2, collect and analyze LNAPL and groundwater samples from well KAFB-10628, the extraction and injection wells, and any additional observation wells (see Comments #21 and 22 of Part 1 of this letter) installed for conducting the pumping tests.

All wells must be properly developed and purged before groundwater samples are collected for analysis in accordance with the KAFB Hazardous Waste Facility Permit (Permit) Parts 6.5.17.10.6 and 6.5.17.4.

12. Section 1.2, Item #2 – This section discusses various analytes for testing but is not consistent with worksheet 18g in Appendix B, UFB-QAPP. Correct the work sheet as appropriate.

13. Section 5.2.3 – Indicate whether the 3D model incorporates the potential for transient flow from KAFB and Veterans Administration water-supply wells.

14. Section 5.2.3 – NMED assumes the Permittee has a conceptual geologic model for the capture-zone modeling. It was therefore surprising that a RockWorks™ model for the Bulk Fuels Facility Spill was not provided in the Work Plan. Such a geologic model must be included in both the characterization plan and the revised Work Plan. Update the geologic model for each

of the plans to include newly collected geological and geophysical data, as applicable, obtained through implementation of the Vadose Zone and Groundwater Investigation Plans.

15. Section 5.3.1 – Clarify if the definition for residual saturation only applies to nonwetting liquids (as indicated in the first sentence), given that annotations for both wetting fluid and nonwetting fluid (S_{rw} and S_{rnw}) are provided in the second sentence.

16. The Permittee's analysis indicates that two extraction wells will capture the LNAPL plume, assuming the hydraulic parameters used in the analysis are reasonably accurate. However, there is considerable uncertainty regarding these parameters. The last three bullets of Section 5.1 indicate that a feasibility analysis was performed that resulted in the selection of a two-well hydraulic extraction system. NMED agrees that a system with two vertical extraction wells is better than one vertical well for the reasons described. However, the same logic can be used to validate the efficiency of three vertical extraction wells or more. While the Permittee has demonstrated that one extraction well is inadequate, the optimum number is still in question. The proposed two-well system may in fact not provide adequate capture of the LNAPL plume. At least one additional extraction well should be considered to provide system redundancy, enhance system flexibility, and facilitate monitoring during system performance and pumping tests. The suggested location for the well is midway between proposed wells KAFB-106108-NAPL and KAFB-106109-NAPL (see Figure 1 of this letter).

This additional extraction well would provide additional benefits, including system back-up for the proposed primary extraction wells during down times, and (if not being pumped) water-level measurements within the capture zone between the active extraction wells. Even if not brought online immediately, it could be activated as a primary extraction in the future well to facilitate adequate capture.

17. NMED does not approve of a cross-gradient location of the injection well, as specified in Section 6.2 and as shown on Figures 5-1, 5-2, and 6-1 of the Work Plan. This objection was first expressed by the NMED in its public meeting held on January 12, 2011, where representatives of KAFB were present. The injection well must be located upgradient of the LNAPL plume within the area shown on Figure 1 of this letter such that any contaminated water for which treatment fails to achieve clean up goals will be recaptured by the containment system or other future remedial system. The proposed injection well location is not acceptable because detectable levels of contaminants would be introduced into a portion of the aquifer near a water supply well where contamination is not known to exist. Also, this area would not be subject to capture and subsequent treatment, putting the water supply unnecessarily at risk.

The combination of a pump-and-treat system with an upgradient injection area provides a circulation cell whereby treated water is drawn into the upgradient portions of the plume in the capture zone. This imparts a flushing effect and serves to enhance hydraulic movement of the plume toward the extraction location, which should accelerate cleanup of the LNAPL and dissolved phase plume. NMED acknowledges the Permittee's March 24, 2011 letter and attachment to the Albuquerque Bernalillo County Water Utility Authority (WUA), in which Dr.

Gary Hecox opines that upgradient injection would "lead to spreading of the dissolved-phase contaminant plume outside containment area" due to influx of regional groundwater into the capture zone. NMED has not noted this phenomenon at other pump-and-treat systems with upgradient injection in New Mexico, and without supporting data, is not persuaded by this argument.

18. Collect samples for lab measurements of grain size distribution, hydraulic conductivity, specific yield, and porosity at the injection well, extraction wells, and any additional observation wells (see Comments #21 and 22 of Part 1 of this letter).

19. Sections 6.2.1.3 and 6.2.1.5 and Figures 6.2 and 6.3 – The text of these sections do not agree in all cases with what is shown on Figures 6-2 and 6-3.

a) Section 6.2.1.5 states that the thickness of bentonite seal will be a minimum of 5 feet but Figures 6-1 and 6-2 show the thickness as 10 ft.

b) Sections 6.2.1.3 and 6.2.1.5 state the estimated depth of the extraction wells as 550 feet, but Figure 6-2 shows the bottom of each well's filter pack to be 600 feet.

c) Section 6.2.1.3 states "the injection well boring will be drilled to 100 ft below the first encountered groundwater (approximately 550 feet)." It is unclear if the 550 feet refers to groundwater or well depth, but in any case, the water level is shown on Figure 6.3 at 500 feet and the bottom of the well at 600 feet.

d) Figure 6-3 shows 6-inch inside diameter (ID) casing as having an 8-5/8- inch outside diameter (OD). Correct these specifications as applicable.

e) Clarify if the 13-3/8-inch surface casing shown on Figures 6-2 and 6-3 extends down to approximately 200 feet (the approximate depth of the 13-¾-inch drive casing mentioned in Section 6.2.1.3). If the latter is true, clarify also in the well installation procedure in Section 6.2.1.5, which does not mention a 13-¾-inch borehole diameter.

20. Section 6.2.1.4 – Prepare geologic logs for all wells, including any observation wells (see Comments #21 and 22 of Permit Part 1 of this letter).

21. Section 6.2.2 –

a) The expected drawdowns at wells that are to serve as observation wells for the pumping tests are not discussed. It is unclear which wells are to be used as observation wells, and the closest monitoring well (which has yet to be installed) would be about 200 feet from the nearest extraction well. A pumping test conducted at approximately 50 gpm in nearby well KAFB ST-105 achieved drawdown of only about 0.3 feet in an observation well only 70 feet away. NMED is therefore concerned that the distances between possible observation wells and

the extraction/injection wells may be too large for the observation wells to serve effectively for pumping tests. To resolve this, an extraction/injection well can be moved closer to an existing well to increase the likelihood of achieving a predicted drawdown scenario, provided the well can still adequately serve its intended purpose for the pump and treat system.

b) At a minimum, initially model drawdown for each pumping well at 50, 100, and 250 feet, or the distance between the pumping well and the intended observation wells, using hydraulic conductivities of 131 and 246 ft/day for 24 and 72 hour tests, the hydraulic conductivities reported in Table 3-2 of Appendix B of the *Stage 2 Abatement Plan for Nitrate Contaminated Groundwater at Kirtland Air Force Base*, dated December 2009. Site-specific gradients and other hydraulic parameters must be used in the modeling to the extent that they are known. All modeling parameters and assumptions must be discussed in detail. Additional monitoring wells may be required for the pumping tests based on initial modeling.

c) Specify which wells will be used for observation wells for each of the well pumping tests and their distances from the pumping well, which wells will undergo pumping tests for 24 hours and which for 72 hours, and the minimum drawdown that the Permittee believes can be measured in the field with reasonable certainty that the measurements are accurate. Discuss the potential error in the drawdown measurements and demonstrate that the expected minimum drawdown value can be distinguished from water-level decreases caused by changes in barometric pressure or other possible sources of error.

d) Propose a plan to determine specific yield from the pumping tests.

e) The NMED recommends that the Permittee consider using at least two observation wells for each pumping test, and also to consider using observation wells oriented parallel to and perpendicular to the major axis of the LNAPL plume. Horizontal anisotropy may be present with greater hydraulic conductivity in a north-south direction compared to that in the east-west direction (see U. S. Geological Survey Water-Resources Investigations Report 02-4200, page 19).

22. If appreciable drawdown is not observed for at least one observation well for a given pumping test, and taking other actions fail to produce appreciable drawdown, at least one observation well closer to the pumping well must be installed, and the pumping test for the well repeated. The location of new observation wells must be approved by NMED prior to their installation.

23. The volume of wastewater expected from the pumping tests could exceed 200,000 gallons. According to Table 2 of Appendix C, the proposed method for treatment/disposal of investigation-derived wastewater is "Discharge to ground surface per approval." Discharge of pumping-test water to the ground may not be acceptable given the expected contaminated nature

of the water from the extraction wells, which potentially may be a hazardous waste because of the toxicity of benzene. Even if treated, the wastewater from the pumping tests must be contained, sampled, and disposed of in accordance with Permit Part 6.5.7. Discharge to the ground surface must be approved in advance by NMED's Ground Water Quality Bureau. Discuss in detail in the characterization plan the means by which investigation-derived wastewater and other investigation-derived waste will be managed and disposed of.

24. Section 6.3 – This section implies that geophysical logging for the extraction and injection wells will be performed within steel-drive casing after total depth has been reached and before well construction. EM induction logging is generally used for uncased boreholes or polyvinyl chloride (PVC) cased wells, and therefore may not be effective under these circumstances. Describe the effectiveness of each logging tool when employed in steel-drive casing if this is indeed the plan.

25. Section 6.3.1 – Prepare geophysical logs for all wells, including any observation wells (see Comments #21 and 22 of Permit Part 1 of this letter).

26. Section 6.3.1 – This section discusses the use of a caliper tool. Because geophysical logging is presumably planned to be conducted within drive casing having a constant inside diameter, the purpose of the caliper logging in this application is unclear and its use potentially unnecessary.

27. Section 6.3.2 – This section states "The borehole induction system can be used in boreholes that range from 2 to 8 inches in diameter without significant borehole effects." Because the proposed boreholes are larger than 8-inches in diameter, explain what the significant borehole effects are or could be expected, and how these effects will be mitigated or taken into account.

28. Section 6.3.2 – Prepare the characterization plan to indicate whether the induction logging tool will be centralized. Provide the focusing radii of the medium and deep dual induction tool.

29. Section 6.3.5.1 – The Work Plan states that the cable to be used to conduct geophysical logging tool is long enough to log to depths of 600 ft. Section 6.3.2 says "the depth of measurement ...will be 650 ft." Correct the text of these sections to be consistent in that logging must be conducted from surface to total depth of each well.

30. Section 6.4 – Include a proposal to submit quarterly reports to the NMED.

31. The thickness of the aquifer is likely greater than 60 ft, and thus, the pumping wells will likely not fully penetrate the aquifer. Provide a detailed discussion in the characterization plan on how the true thickness of the aquifer may affect the results of pumping-test drawdown and how the modeling of drawdown has taken this into account.

32. Include a water-level map in the characterization plan (see Comment #2 in Part 2 of this letter).

PART 2 – COMMENTS ON DESIGN OF PUMP-AND-TREAT SYSTEM

The following comments must be addressed in the revised Work Plan, and where directed in this Part, in both the characterization plan and the revised Work Plan.

1. The thickness of the aquifer is likely greater than 60 ft. It is therefore likely that the extraction wells will probably not fully penetrate the aquifer. The revised Work Plan must contain a detailed discussion on how the true thickness of the aquifer may affect the results of drawdown, and thus, the extent of the capture zone and how the modeling of the capture zone has taken this into account.

2. Figure 5-2 – Prepare an additional figure showing the water table utilizing data from the wells shown on this figure, new monitoring wells to be installed under the Groundwater Investigation Work Plan, and the following wells: KAFB-0508, KAFB-0510, KAFB-0118, KAFB–0119, KAFB-0121, KAFB-0524, KAFB-3, KAFB-14, KAFB-15 and KAFB-16.

3. Section 5.2.3 – As indicated in Comment #14 in Part 1 of this letter, include a geologic model in the characterization plan and the revised Work Plan.

4. Section 5.2.4 – Clarify in the revised Work Plan if the vertical capture of contaminants is an objective of this interim action.

5. Section 7 – This section of the Work Plan does not provide an adequate discussion of the sampling and analysis of groundwater after it has been treated. Provide in the revised Work Plan details concerning:

a) a sampling port for effluent;

b) parameters to be tested for;

c) laboratory testing methods and detection limits;

d) frequency of analysis of effluent; and

e) quality assurance/quality control.

NMED's Ground Water Quality Bureau may direct further sampling and analysis requirements through any permits it may issue regarding reinjection of treated water.

6. Explain in the revised Work Plan the corrective action procedures that will be conducted if a sample of effluent fails any clean up goals.

7. Figure 7-1 – Explain in the revised Work Plan with notes added to the figure all acronyms used on the figure.

8. Section 7.2.2 – This section discusses discharge limits established under 20.6.2.3103 NMAC. The Permittee must also abide by the clean up goals established in Permit Part 6.2.3.

9. Section 7.3.1 –Indicate in the revised Work Plan what pre-design data will be collected to refine the design of the treatment process.

10. Section 7.4 – This section does not discuss the vapor GAC unit seen on Figure7-1. Discuss in the revised Work Plan if there are any air emissions from this GAC unit (or anywhere else in the system) and discuss if an air quality permit will be or may be necessary. Discuss if there will be a sampling port for vapor at the unit.

11. Section 7.4 – Indicate in the revised Work Plan if the piping to and from the treatment building is to be located above ground or below ground. Indicate also if cathodic protection or freeze protection is necessary.

12. Appendix B: Uniform Federal Policy – Quality Assurance Project Plan (UFP-QAPP) (labeled as Pending Review) – The plan appears to be a combination of many types of plans, such as project management, training, data validation, quality assurance, and sampling and analysis plans. Much of the information presented appears to be overly burdensome and not particularly useful in the present format.

Revise Appendix E into multiple appendices to separate the various types of plans (e.g. project management, training, data validation, quality assurance, and sampling and analysis). As expressed in our meeting on January 6, 2011, NMED is expecting a Quality Assurance (QA) Plan that contains quality assurance and quality control activities specific to the project. The QA plan is to integrate all technical and quality aspects of the project to ensure that the necessary type and quality of data are obtained.

Explain also what is meant by "Pending Review." If the document is considered a draft document because it is labeled "Pending Review," it must be finalized before re-submitting it to the NMED.

13. Provide more detail and clarification of the criteria to be used to demonstrate adequate capture of the LNAPL plume by the extraction wells. Refer to the "Six Steps for Systematic Evaluation of Capture Zones" provided in Environmental Protection Agency (EPA), 2008a, available at http://www.epa.gov/nrmrl/pubs/600R08003/600R08003.pdf. The approach must include, but not be limited to:

a) Documentation of pumping performance over time (e.g., were there any down times);

b) Water-level measurements and interpreted flow paths that demonstrate drawdown at or near the extraction wells, and reverse gradients north of the extraction wells;

c) Modeled water-level contours, particle tracks, and drawdown/buildup contours; and

d) Analytical monitoring data from downgradient wells.

Adequate capture of the plume must be demonstrated with empirical data derived from water-level measurements showing the presence of a groundwater divide at or beyond the leading edge of the LNAPL plume. Additional groundwater monitoring wells may be necessary to make this demonstration.

14. Section 5.2.4 lists the hydraulic gradient used as input for the capture zone model as 0.004 ft/ft. Because gradient has a significant influence on the predicted capture zone, explain why measured hydraulic gradient ranges from about 0.001 to 0.0015 ft/ft (based on water levels observed at existing wells) were not used.

15. In both the revised Work Plan and the characterization plan, evaluate and discuss the results of the existing step drawdown tests of nearby WUA or KAFB wells as they may relate to the capture zone model results and the proposed pumping tests. For example, the specific capacity of Ridgecrest #3 (on the order of 75 gpm/ft) and the specific capacities of wells KAFB-3, KAFB-15, KAFB-16 (60-80 gpm/ft) imply that a pumping rate of 50-100 gpm at the extraction wells may not yield the 5 ft of predicted drawdown shown on Figure 5-2 of the Work Plan. The pumping test conducted at ST-105 also suggests that the expected drawdown may not be achieved.

16. Section 5.2.4 does not seem to use representative site-specific water-level elevations. The fifth bullet of in Section 5.2.4 indicates "groundwater elevation 4900 used as reference head from measured water table elevations." However, the document *Kirtland Air Force Base, New Mexico, Quarterly Remediation and Site Investigation Report for the Bulk Fuels Facility Spill, July 2010 through September 2010* (dated November 2010) presents actual measured water-level elevations ranging from approximately 4,852 to 4,857 ft amsl, which are approximately 20 to 40 ft lower than those used in the model (see Figure 5-2, which shows groundwater elevations of 4,874 to 4,894). Explain the differences in water-level elevations or correct as appropriate, using site-specific data when available.

17. Section 5.2.4 – In the second full paragraph, first sentence, indicate whether the intent is to span the entire width of the dissolved plume for the target capture zone or just the width of the LNAPL plume.

18. Section 5.2.4 – This section contains the sentence: "The actual hydraulic capture zone will be determined using conventional capture-zone methods, including the Darcy Flow GIS

[geographic information system] method (e.g., EPA, 2008a)." The "Darcy Flow GIS method" is not discussed in the reference given. Include in the revised Work Plan the Six Steps for Systematic Evaluation of Capture Zones, as discussed in Exhibit 1, Section A of the given reference and as included below.

Step 1: Review site data, site conceptual model, and remedy objectives;

Step 2: Define site-specific target capture zone(s);

Step 3: Interpret water levels (from potentiometric surface maps and water level pairs);

Step 4: Perform calculations (capture zone width calculations, and numerical modeling);

Step 5: Evaluate concentration trends; and

Step 6: Interpret actual capture based on Steps 1-5.

See also Comment #13 of Part 2 of this letter.

19. Section 5.4 – Provide a description of the pump system planned for the extraction wells to recover LNAPL. Although the proposed extraction wells are to be located in an area with thin LNAPL, it is reasonable to expect that LNAPL will eventually accumulate in the resulting cone(s) of depression. LNAPL removal and inducing the formation of a cone of depression appear to be contradictory goals for a single pump in an extraction well. Indicate if a two pump system will be used, and if not, explain how the accumulated LNAPL will be removed and total fluids treated.

20. Section 5.4, Bullet 7 – Indicate specifically which wells are to be used to assess the performance of the remediation system. Also, define the term "liquid level measurement."

21. Section 6.1 – This section discusses permitting, which does not clearly indicate that a discharge permit for the injection well must be obtained from the NMED Ground Water Quality Bureau, which typically takes a minimum of four to six months to obtain (or more time if a public hearing is held). Furthermore, Section 6.1 does not mention if a treatment permit is or may be required under the New Mexico Hazardous Waste Management Regulations, 20.4.1 NMAC. Indicate in the revised Work Plan and the characterization plan that a discharge permit will be acquired from the NMED Ground Water Quality Bureau, and evaluate the need for a treatment permit under the New Mexico Hazardous Waste Act.

Additionally, permits may be required from the Office of the State Engineer. Indicate in the characterization plan and the revised Work Plan if permits must be obtained from the Office of the State Engineer to conduct the pumping tests or to operate the pump-and-treat system. Also indicate if water rights will need to be procured to conduct any of the proposed extraction.

The schedule in Appendix E implies a discharge permit would be obtained in about 3 months. The schedule should be revised to include a more realistic time frame for the acquisition of a discharge and any other required permits.

22. Section 6.2.1.5 – This section discusses a 60-feet length of screen for the extraction wells. Describe in the revised Work Plan the expected depths at which the pumps will be set in the extraction wells.

23. Quarterly reports must be prepared and combined with other quarterly reporting as specified in NMED's letter of June 4, 2010. The quarterly reports must document the construction, maintenance, and operation of the pump and treat system, and must summarize the analytical water-quality data for both treated and untreated groundwater.

25. Final Report (Interim Measures Report) – Appendix E, *Project Schedule*, indicates that an Interim Measures Report will be submitted after construction of the pump and treatment system. Provide additional details of the planned content of this report. At a minimum this report must meet the requirements of Permit Parts 6.2.2.2.12.5 and 6.2.4.10.

Final Direction

The Permittee's letter of December 3, 2010 states that the certification that accompanies documents like the revised Work Plan and the characterization plan must be signed by the commander of KAFB (currently Col. Maness). NMED notes that the certification that was submitted with the Work Plan was signed by Mr. Wayne Bitner, who does not appear to be authorized to sign for the Permittee in these matters. Submit the certification with the appropriate signature for the characterization plan and the revised Work Plan.

The characterization plan and the revised Work Plan must address the comments noted herein and incorporate the requirements set forth in this letter as they apply to each plan. The characterization plan must be submitted to the NMED no later than **June 15, 2011**. The characterization plan must also contain a schedule of the work to be completed under the plan, including the submittal of a report of the results to the NMED. The report must be submitted to the NMED by no later than **February 1, 2012**. The revised Work Plan must include sufficient detail that the pump-and-treat system could be constructed and operated under provisions of the plan with a reasonable expectation that its operation will be successful in stopping the migration of the LNAPL plume. The revised Work Plan must be submitted to the NMED no later than **April 1, 2012**. A certification must be included in the revised Work Plan, signed and stamped by a professional engineer registered in New Mexico, stating that the design and specifications of the pump and treat system have been reviewed by him/her, and a reasonable standard of care was used in designing the pump-and-treat system to meet the stated goal of stopping the migration of the LNAPL plume. The Permittee cannot construct or operate the pump-and-treat system until such time that it obtains NMED approval.

This corrective action is being conducted under the aegis of the Permit. Specifically, all field activities must be completed in accordance with Permit Part 6.5.2. All equipment that is not disposable must be decontaminated pursuant to Permit Part 6.5.3. All equipment that requires calibration must be calibrated as required under Permit Part 6.5.4. Sample handing, shipping, and custody procedures must comply with Permit Part 6.5.5. The collection and management of investigation-derived waste must conform to Permit Part 6.5.7. Well locations must be surveyed in accordance with Permit Part 6.5.8. Field quality control samples must be collected and analyzed for all environmental media pursuant to Permit Parts 6.5.14 and 6.5.17.6. Laboratory analyses, including laboratory quality control samples, must be conducted as required under Permit Part 6.5.18. Field and laboratory quality control data must be reviewed and validated in accordance with Permit Part 6.5.18.3. Reporting of field activities, including sampling and analysis results, completion of geologic and geophysical logging, and well installations, must be as directed by NMED's letter of June 4, 2010, for quarterly reporting.

NMED also notes that the WUA has submitted comments on the Work Plan to the Permittee, and urges the Permittee's thoughtful consideration of the WUA's comments in development of the characterization plan and the revised Work Plan.

As part of the response letters that accompany the characterization plan and the revised Work Plan, include a table that details where all revisions have been made to the plans and that cross-references NMED's numbered comments. Submittals (including maps and tables) must be in the form of two paper copies and one electronic copy in accordance with Permit Part 1.36.

Respond to this letter to my attention, with copy to Mr. Bill Olson of the NMED Ground Water Quality Bureau, and Mr. William Moats of my staff (NMED HWB, 5500 San Antonio NE, Albuquerque, NM 87109). NMED invites the Permittee to meet regarding the issues raised in this letter. Please contact me to arrange such a meeting, or should you have any questions.

Sincerely,

James P. Bearzi
Chief
Hazardous Waste Bureau

Attachment: Figure 1

cc: R. Solomon, Deputy Cabinet Secretary, NMED
J. Kieling, NMED HWB
W. Moats, NMED HWB
W. McDonald, NMED HWB
S. Brandwein, NMED HWB

B. Olson, HWB GWQB
B. Swanson, HWB GWQB
L. Barnhart, NMED OGC
B. Gallegos, AEHD
R. Shean, ABCWUA
L. King, EPA-Region 6 (6PD-N)
File: Reading and KAFB 2010

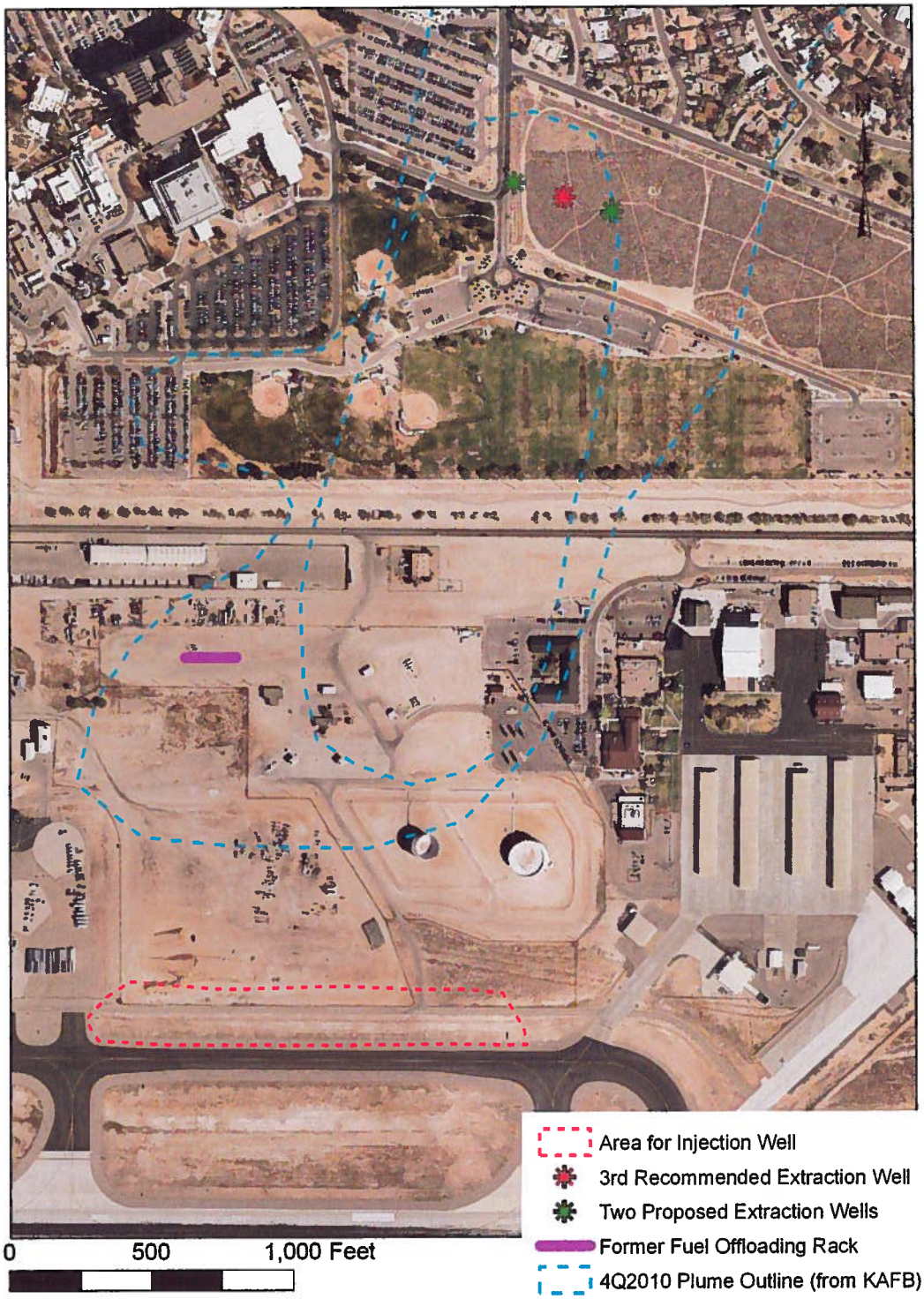

Figure 1. Locations for Extraction Wells and Injection Well

APPENDIX B

Quality Assurance Project Plan

(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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Tom Cooper, PG, PMP Project Manager, Shaw Environmental & Infrastructure, Inc.	Signature	Date
Pamela Moss Technical Manager, Shaw Environmental & Infrastructure, Inc.	Signature	Date
Mark Lyons Quality Control Manager, Shaw Environmental and Infrastructure, Inc.	Signature	Date

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 – Groundwater
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

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	
Project Manager: Mr. Tom Cooper, PG, PMP	Site Location: Kirtland AFB, New Mexico

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	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

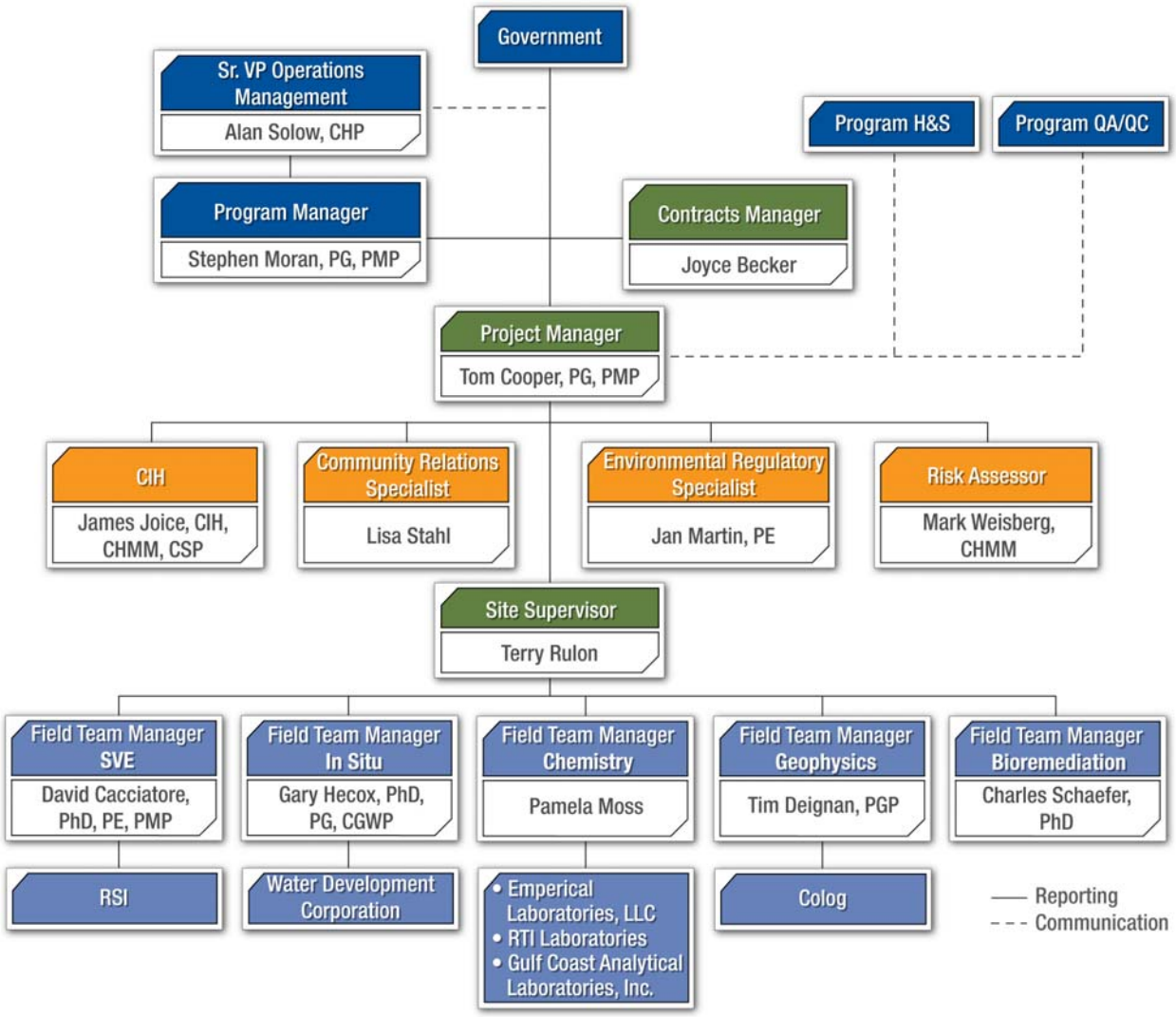

Figure 2. Site Map and Proposed Well Locations

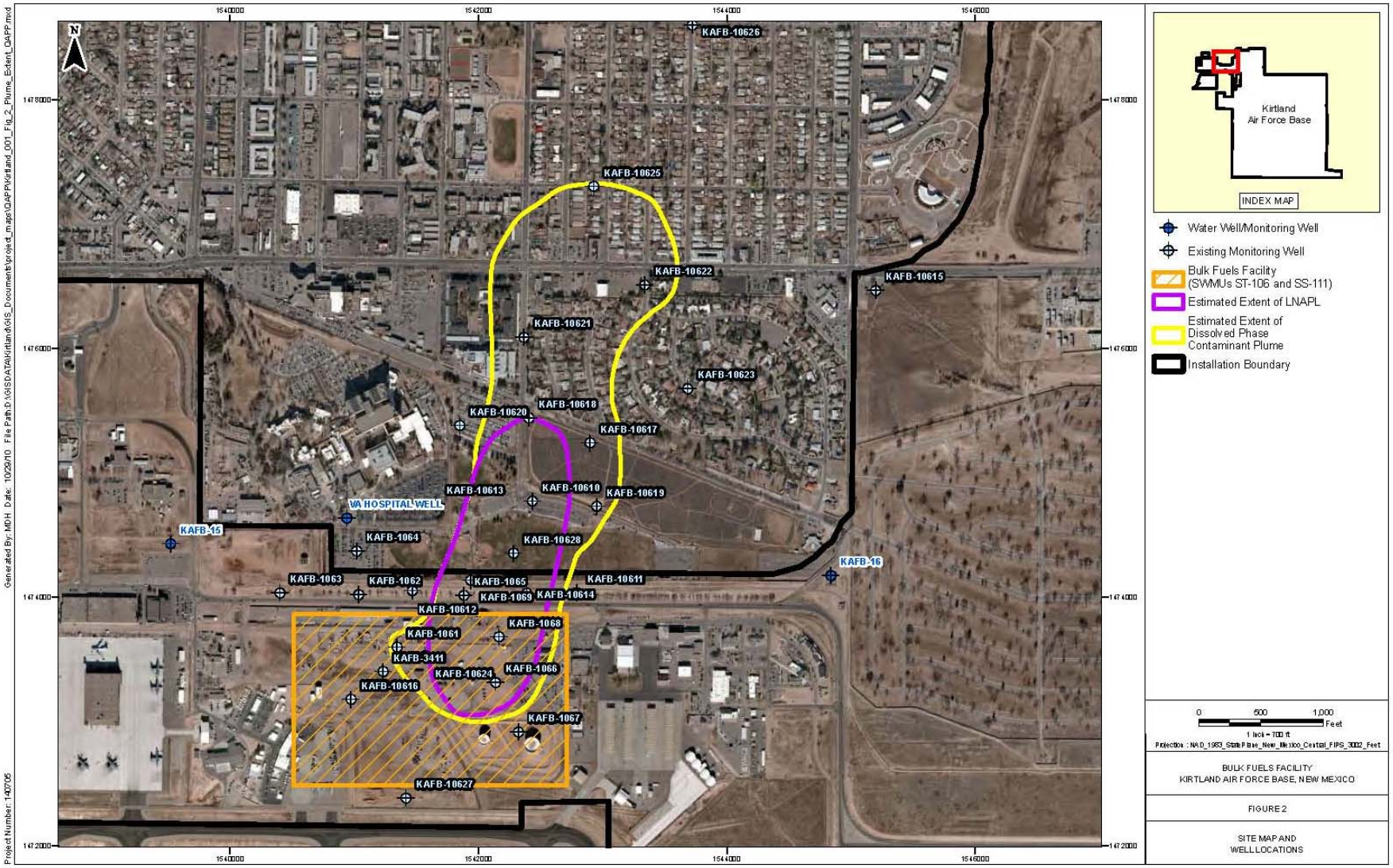

Figure 3. Chain of Custody

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 #: _____

Shipment Date: _____

Waybill/Airbill Number: _____

Lab Destination: _____

Lab Contact Name / ph. #: _____

Project Contact: _____ (Name & phone #)

Send Report To: _____

Phone/Fax Number: _____

Address: _____

City: _____

Sampler's Name(s): _____

Sample ID Number	Sample Description	Collection Information			Matrix	# of containers	Container type	Preservative						Analyses Requested									Turn Around Time Requested
		Date	Time	G/C				HCL	NaOH	HNO_3	H_2SO_4	Ice											

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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FS003.1_0

Shaw E & I COC Continuation Page

COC Ref. Document # _____ Page _____ of _____

Project Number: _____ Shipment Date: _____

Project Name / Location: _____

Sample ID Number	Sample Description	Collection Information			Matrix	# of containers	Container type	Preservative						Analyses Requested										Turn Around Time Requested
		Date	Time	G/C				HCL	NaOH	HNO_3	H_2SO_4	Ice												

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

[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

		Laboratory Specific Control Limits		
Method	**Analyte**	**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

		Laboratory Specific Control Limits		
Method	**Analyte**	**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

		Laboratory Specific Control Limits LCS			Laboratory Specific Control Limits Matrix Spikes		
Method	**Analyte**	**Lower**	**Upper**	**RPD**	**Lower**	**Upper**	**RPD**
EPH MA DEP	C12 - C40	50	150	20	50	150	50
Waters							
Surrogate:	o-Terphenyl	50	150				

		Laboratory Specific Control Limits		
Method	**Analyte**	**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

		Laboratory Specific Control Limits		
Method	**Analyte**	**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

		Laboratory Specific Control Limits LCS			Laboratory Specific Control Limits MS		
Method	**Analyte**	**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

		Laboratory Specific Control Limits LCS		
Method	**Analyte**	**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

		Laboratory Specific Control Limits LCS			Laboratory Specific Control Limits MS/MSD		
Method	**Analyte**	**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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					CCV			DUP	ICV		
	&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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						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

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

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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: Soil Classification Log

Form 4: Overburden Monitoring Well Construction Diagram

Form 5: Field Activity Daily Log

Form 6: Analytical Request/Chain of Custody

Form 7: Test Equipment and Calibration Log

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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.DATE	4.LOCATION
5.NAME OF DRILLER	6.MANUFACTURER'S DESIGNATION OF DRILL
7.SIZE AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	8.HOLE LOCATION
	9.SURFACE ELEVATION
	10.DATE STARTED / 11.DATE COMPLETED
12.OVERBURDEN THICKNESS	13.DEPTH GROUNDWATER ENCOUNTERED
14.DEPTH DRILLED INTO ROCK	15.DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED
16.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	Dioxins/TBPH	21.TOTAL CORE RECOVERY %

	SAMPLED	MONITORING WELL	OTHER (SPECIFY)	22.SIGNATURE OF INSPECTOR:

23.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.)		
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	Clean Gravels (Less than 5% fines)	
	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
	GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
	Gravels with fines (More than 12% fines)	
	GM	Silty gravels, gravel-sand-silt mixtures
	GC	Clayey gravels, gravel-sand-clay mixtures
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	Clean Sands (Less than 5% fines)	
	SW	Well-graded sands, gravelly sands, little or no fines
	SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with fines (More than 12% fines)	
	SM	Silty sands, sand-silt mixtures
	SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size.)		
SILTS AND CLAYS Liquid limit less than 50%	ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	CH	Inorganic clays of high plasticity, fat clays
	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS	PT	Peat and other highly organic soils

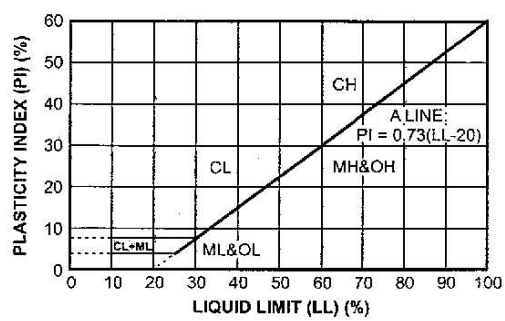
LABORATORY CLASSIFICATION CRITERIA

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

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

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

PLASTICITY CHART



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Form 3. Soil Classification Log

ASTM Soil Classification & USCS Group Symbols

					Group Symbol				Group Name
>50% Sand & Gravel	GRAVEL % gravel > % sand	≤5% fines	Well-graded		GW	<15% sand			Well-graded GRAVEL
						≥15% sand			Well-graded GRAVEL with Sand
			Poorly-graded		GP	<15% sand			Poorly graded GRAVEL
						≥15% sand			Poorly graded GRAVEL with Sand
		10% fines	Well-graded	fines - ML or MH	GW-GM	<15% sand			Well-graded GRAVEL with Silt
						≥15% sand			Well-graded GRAVEL with Silt and Sand
				fines - CL or CH	GW-GC	<15% sand			Well-graded GRAVEL with Clay
						≥15% sand			Well-graded GRAVEL with Clay and Sand
			Poorly-graded	fines - ML or MH	GP-GM	<15% sand			Poorly graded GRAVEL with Silt
						≥15% sand			Poorly graded GRAVEL with Silt and Sand
				fines - CL or CH	GP-GC	<15% sand			Poorly graded GRAVEL with Clay
						≥15% sand			Poorly graded GRAVEL with Clay and Sand
		≥15% fines		fines - ML or MH	GM	<15% sand			Silty GRAVEL
						≥15% sand			Silty GRAVEL with Sand
				fines - CL or CH	GC	<15% sand			Clayey GRAVEL
						≥15% sand			Clayey GRAVEL with Sand
	SAND % sand > % gravel	≤5% fines	Well-graded		SW	<15% gravel			Well-graded SAND
						≥15% gravel			Well-graded SAND with Gravel
			Poorly-graded		SP	<15% gravel			Poorly graded SAND
						≥15% gravel			Poorly graded SAND with Gravel
		10% fines	Well-graded	fines - ML or MH	SW-SM	<15% gravel			Well-graded SAND with Silt
						≥15% gravel			Well-graded SAND with Silt and Gravel
				fines - CL or CH	SW-SC	<15% gravel			Well-graded SAND with Clay
						≥15% gravel			Well-graded SAND with Clay and Gravel
			Poorly-graded	fines - ML or MH	SP-SM	<15% gravel			Poorly graded SAND with Silt
						≥15% gravel			Poorly graded SAND with Silt and Gravel
				fines - CL or CH	SP-SC	<15% gravel			Poorly graded SAND with Clay
						≥15% gravel			Poorly graded SAND with Clay and Gravel
		≥15% fines		fines - ML or MH	SM	<15% gravel			Silty SAND
						≥15% gravel			Silty SAND with Gravel
				fines - CL or CH	SC	<15% gravel			Clayey SAND
						≥15% gravel			Clayey SAND with Gravel
50% or More Fines	Low-Plasticity Clay				CL	<30% sand & gravel	<15% Sand and Gravel		Lean CLAY
							15-25% sand & gravel	% sand ≥ % gravel	Lean CLAY with Sand
								% sand < % gravel	Lean CLAY with Gravel
						≥30% sand & gravel	% sand ≥ % of gravel	< 15% gravel	Sandy lean CLAY
								≥ 15% gravel	Sandy lean CLAY with Gravel
							% sand < % gravel	< 15% sand	Gravelly lean CLAY
								≥ 15% sand	Gravelly lean CLAY with Sand
	Low-Permeability Silt				ML	<30% sand & gravel	15% sand & gravel		SILT
							15-25% sand & gravel	% sand ≥ % gravel	SILT with Sand
								% sand < % gravel	SILT with Gravel
						≥30% sand & gravel	% sand ≥ % of gravel	< 15% gravel	Sandy SILT
								≥ 15% gravel	Sandy SILT with Gravel
							% sand < % gravel	< 15% sand	Gravelly Silt
								≥ 15% sand	Gravelly Silt with Sand
	Plastic Clay				CH	<30% sand & gravel	< 15% sand & gravel		Fat CLAY
							15-25% sand & gravel	% sand ≥ % gravel	Fat CLAY with Sand
								% sand < % gravel	Fat CLAY with Gravel
						≥30% sand & gravel	% sand ≥ % of gravel	< 15% gravel	Sandy fat CLAY
								≥ 15% gravel	Sandy fat CLAY with Gravel
							% sand < % gravel	< 15% sand	Gravelly fat CLAY
								≥ 15% sand	Gravelly fat CLAY with Sand
	Plastic Silt				MH	<30% sand & gravel	< 15% sand & gravel		Elastic SILT
							15-25% sand & gravel	% sand > % gravel	Elastic SILT with Sand
								% sand < % gravel	Elastic SILT with Gravel
						≥30% sand & gravel	% sand ≥ % of gravel	< 15% gravel	Sandy elastic SILT
								≥ 15% gravel	Sandy elastic SILT with Gravel
							% sand < % gravel	< 15% sand	Gravelly elastic SILT
								≥ 15% sand	Gravelly elastic SILT with Sand
	Organics (Peat or Bay Mud)				OL/OH	<30% sand & gravel	< 15% sand & gravel		Organic SOIL
							15-25% sand & gravel	% sand ≥ % gravel	Organic SOIL with Sand
								% sand < % gravel	Organic SOIL with Gravel
						≥30% sand & gravel	% sand ≥ % of gravel	< 15% gravel	Sandy Organic SOIL
								≥ 15% gravel	Sandy Organic SOIL with Gravel
							% sand < % gravel	< 15% sand	Gravelly Organic SOIL
								≥ 15% sand	Gravelly Organic SOIL with Sand

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Form 3. Soil Classification Log (Continued 2 of 3)

Example

Visual Classification of Soils

PROJECT NUMBER:	PROJECT NAME:	
BORING NUMBER:	COORDINATES:	DATE:
ELEVATION:	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST:	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS:		PAGE: OF

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER PER ( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	MEASURED CONSISTENCY (TSF)	WELL CONSTRUCTION	REMARKS

NOTES:

Drilling Contractor: _____

Drilling Equipment: _____

Driller: _____

_____

1651-9-02

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Form 3. Soil Classification Log (Concluded 3 of 3)

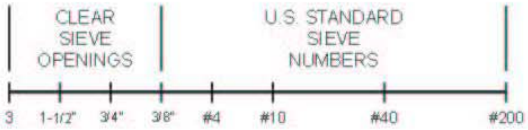
CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (TONS PER SQUARE FOOT)
VERY SOFT	LESS THAN 0.25
SOFT	0.25 to 0.50
FIRM	0.50 to 2.0
HARD	2.0 to 4.0
VERY HARD	MORE THAN 4.0

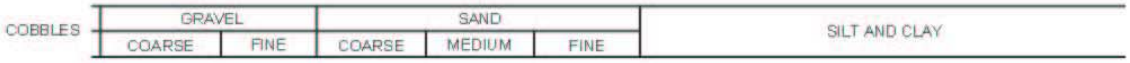
DENSITY OF GRANULAR SOILS

DENSITY	STANDARD PENETRATION RESISTANCE [1]
VERY LOOSE	0-4
LOOSE	5-10
MEDIUM DENSE	11-30
DENSE	31-50
VERY DENSE	OVER 50

[1] STANDARD PENETRATION RESISTANCE IS THE NUMBER OF BLOWS REQUIRED TO DRIVE A 2-INCH O.D. SPLIT BARREL SAMPLER 12 INCHES USING A 140-POUND HAMMER FALLING FREELY THROUGH 30 INCHES. THE SAMPLER IS DRIVEN 18 INCHES AND THE NUMBER OF BLOWS RECORDED FOR EACH 6-INCH INTERVAL. THE SUMMATION OF THE FINAL TWO INTERVALS IS THE STANDARD PENETRATION RESISTANCE.



GRAIN SIZE IN MM



USCS CLASSIFICATION FOR SOILS

COARSE-GRAINED SOILS

CLEAN GRAVELS (LITTLE OR NO FINES)	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
	GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
CLEAN SANDS (LITTLE OR NO FINES)	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES
	SC	CLAYEY SANDS, SAND-CLAY MIXTURES

FINE-GRAINED/HIGHLY ORGANIC SOILS

SILTS AND CLAYS LIQUID LIMIT (LESS THAN 50)	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR 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 (GREATER THAN 50)	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS
	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

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Form 4. Overburden Monitoring Well Construction Diagram

OVERBURDEN
MONITORING WELL
CONSTRUCTION DIAGRAM

WELL NO. _____

PROJECT _____
PROJECT NO. _____
DATE _____ BORING NO.: _____
ELEVATION _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____

ELEVATION OF TOP OF SURFACE CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____
STICK-UP TOP OF SURFACE CASING: _____
STICK-UP RISER PIPE: _____
TYPE OF SURFACE SEAL: _____

I.D. OF SURFACE CASING: _____
TYPE OF SURFACE CASING: _____

RISER PIPE I.D. _____
TYPE OF RISER PIPE: _____

BOREHOLE DIAMETER: _____

TYPE OF BACKFILL: _____

ELEVATION/DEPTH TOP OF SEAL: _____
TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION/DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____
SLOT SIZE X LENGTH: _____
TYPE OF SAND PACK: _____

ELEVATION/DEPTH BOTTOM OF SCREEN: _____

ELEVATION/DEPTH BOTTOM OF SAND PACK: _____
TYPE OF BACKFILL BELOW OBSERVATION WELL: _____

ELEVATION/DEPTH OF HOLE: _____

NOT TO SCALE

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Shaw Environmental, Inc.

DAILY LOG				
	DATE			
	NO.			
	SHEET	OF		

Form 5. Field Activity Daily Log

PROJECT NAME:	PROJECT NO.:
FIELD ACTIVITY SUBJECT:	
DESCRIPTION OF DAILY ACTIVITIES AND EVENTS:	
VISITORS ON SITE:	CHANGES FROM PLANS AND SPECIFICATIONS, AND OTHER SPECIAL ORDERS AND IMPORTANT DECISIONS:
WEATHER CONDITIONS:	IMPORTANT TELEPHONE CALLS:
SHAW PERSONNEL ON SITE:	
SIGNATURE:	DATE:

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FS003.1_0

Ref. Document # _____

Page _____ of ____

Form 6. Analytical Request/Chain-of-Custody

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			Matrix	# of containers	Container type	Preservative						Analyses Requested									Turn Around Time Requested
		Date	Time	G/C				HCL	NaOH	HNO_3	H_2SO_4	Ice											

Special Instructions:

QC/Data Package Level Required:
I II III IV/Project Specific: _____

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

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FS003.1_0

Form 6. Analytical Request/Chain-of-Custody (Concluded 2 of 2)

COC Ref. Document # _____ Page _____ of _____

Project Number: _____ Shipment Date: _____

Project Name / Location: _____

Sample ID Number	Sample Description	Collection Information			Matrix	# of containers	Container type	Preservative						Analyses Requested										Turn Around Time Requested
		Date	Time	G/C				HCL	NaOH	HNO_3	H_2SO_4	Ice												

Page _____

Form 7. Test Equipment and Calibration Log

Project Name: _____ Project No. _____

Equipent Number and Use (Screening or Analytical)	Equipment Name (Manufacturer and Model ID)	Date and Time (of Califbration)	Calibration Standard Used (Mnaufacturer and Lot Number)	Equipment Reading (Include Units and Tolerances)	Comments (and/or Observations)	Initials (of Person)

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APPENDIX E

Project Schedule

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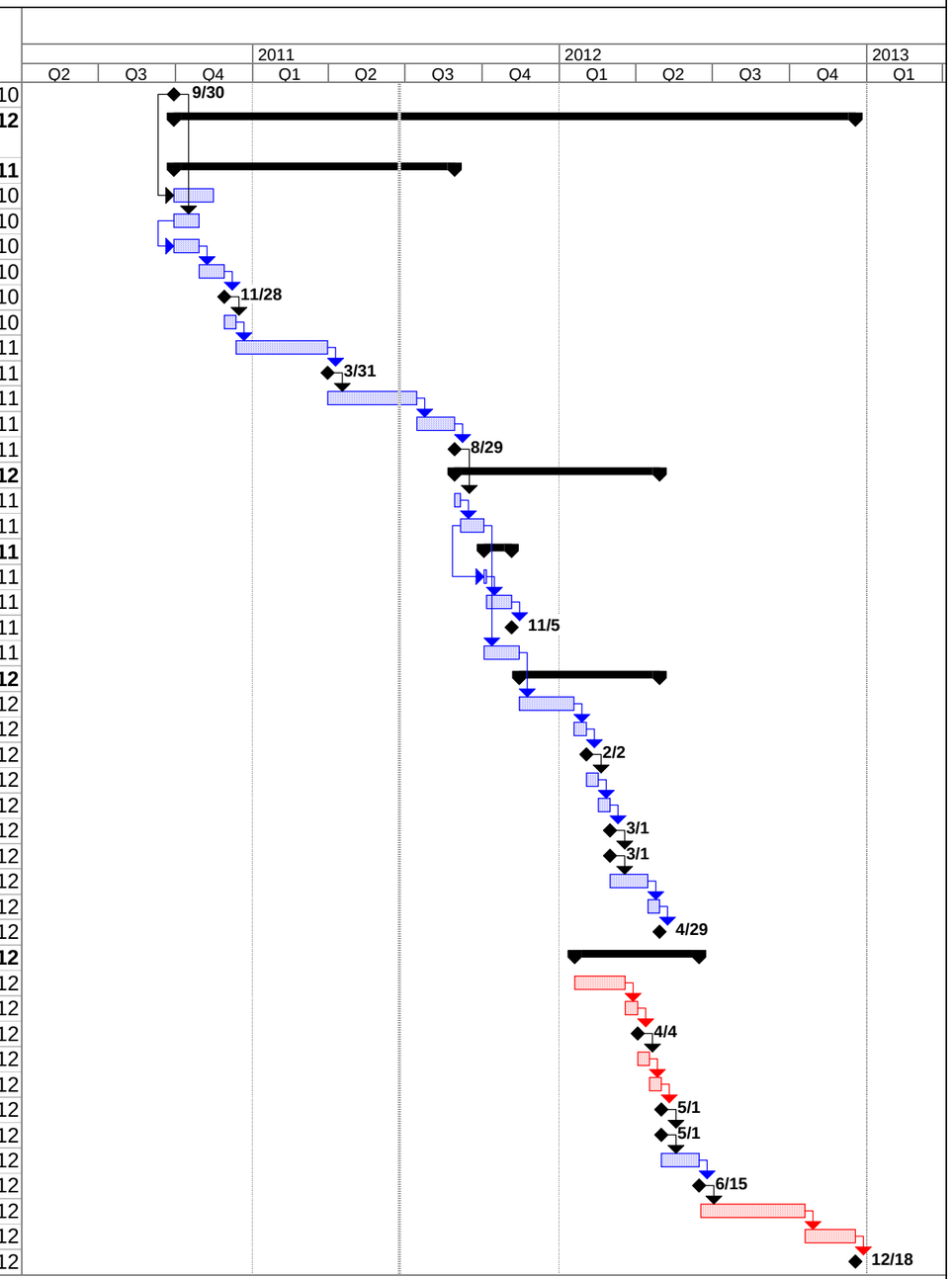
Activity ID	Task Name	Duration	Start	Finish
1	Task Order Award/Notice to Proceed	0 days	Thu 9/30/10	Thu 9/30/10
2	**Site Plans in Accordance w / Performance Work Statement (PWS) and Community Relations**	**811 days**	**Thu 9/30/10**	**Tue 12/18/12**
3	**Light Non-Aqueous Phase Liquid (LNAPL) Containment Work Plan**	**334 days**	**Thu 9/30/10**	**Mon 8/29/11**
4	Prepare / Submit Discharge Permit Application	47 days	Thu 9/30/10	Mon 11/15/10
5	Prepare Draft LNAPL Containment Work Plan	30 days	Thu 9/30/10	Fri 10/29/10
6	Prepare Draft ROE	30 days	Thu 9/30/10	Fri 10/29/10
7	Army/Air Force Review	30 days	Sat 10/30/10	Sun 11/28/10
8	Army/Air Force Approval of Draft	0 days	Sun 11/28/10	Sun 11/28/10
9	Prepare Draft Final LNAPL Containment Work Plan	14 days	Mon 11/29/10	Sun 12/12/10
10	Regulator/Stakeholder Review	109 days	Mon 12/13/10	Thu 3/31/11
11	Receive Regulator/Stakeholder Comments	0 days	Thu 3/31/11	Thu 3/31/11
12	**Prepare Final LNAPL Containment Work Plan Part 1 - Characterization**	106 days	Fri 4/1/11	Fri 7/15/11
13	Regulator/Stakeholder Review	45 days	Sat 7/16/11	Mon 8/29/11
14	Regulator/Stakeholder Approval of Final	0 days	Mon 8/29/11	Mon 8/29/11
15	**IM for Light Non-Aqueous Phase Liquid (LNAPL)/Characterization**	**244 days**	**Tue 8/30/11**	**Sun 4/29/12**
16	Obtain Discharge Permit	7 days	Tue 8/30/11	Mon 9/5/11
17	Install 2 Extraction Wells	20 days	Tue 9/6/11	Mon 10/3/11
18	**Well Completion Logs**	**33 days**	**Tue 10/4/11**	**Sat 11/5/11**
19	Review/Submit (2) Well Completion Logs to Army & Air Force	3 days	Tue 10/4/11	Thu 10/6/11
20	Army/Air Force Review	30 days	Fri 10/7/11	Sat 11/5/11
21	Army & Air Force Concurrence/Submit to State Engineer	0 days	Sat 11/5/11	Sat 11/5/11
22	Pump/Slug Test	30 days	Tue 10/4/11	Mon 11/14/11
23	**LNAPL Containment Interim Measure Characterization Report**	**167 days**	**Tue 11/15/11**	**Sun 4/29/12**
24	Prepare Draft LNAPL Containment Interim Measure Characterization Report	65 days	Tue 11/15/11	Wed 1/18/12
25	Army/Air Force Review	15 days	Thu 1/19/12	Thu 2/2/12
26	Army/Air Force Approval of Draft	0 days	Thu 2/2/12	Thu 2/2/12
27	Respond to Army/Air Force Comments	14 days	Fri 2/3/12	Thu 2/16/12
28	Commander's Review	14 days	Fri 2/17/12	Thu 3/1/12
29	Commander's Approval	0 days	Thu 3/1/12	Thu 3/1/12
30	Submit Work Plan To Regulators	0 days	Thu 3/1/12	Thu 3/1/12
31	Regulator/Stakeholder Review	45 days	Fri 3/2/12	Sun 4/15/12
32	Respond to Comments	14 days	Mon 4/16/12	Sun 4/29/12
33	Regulator/Stakeholder Approval of Final	0 days	Sun 4/29/12	Sun 4/29/12
34	**LNAPL Containment Work Plan Part 2 - Design**	**148 days**	**Fri 1/20/12**	**Fri 6/15/12**
35	Prepare Draft LNAPL Containment Work Plan Part 2 - Design	60 days	Fri 1/20/12	Mon 3/19/12
36	Army/Air Force Review	15 days	Tue 3/20/12	Tue 4/3/12
37	Army/Air Force Approval of Draft	0 days	Wed 4/4/12	Wed 4/4/12
38	Respond to Army/Air Force Comments	14 days	Wed 4/4/12	Tue 4/17/12
39	Commander's Review	14 days	Wed 4/18/12	Tue 5/1/12
40	Commander's Approval	0 days	Tue 5/1/12	Tue 5/1/12
41	Submit Work Plan To Regulators	0 days	Tue 5/1/12	Tue 5/1/12
42	Regulator/Stakeholder Review	45 days	Wed 5/2/12	Fri 6/15/12
43	Regulator/Stakeholder Approval of Final	0 days	Fri 6/15/12	Fri 6/15/12
44	Construct Pump and Treatment System	90 days	Mon 6/18/12	Fri 10/19/12
45	System Startup and Shakedown	60 days	Sat 10/20/12	Tue 12/18/12
46	System Online	0 days	Tue 12/18/12	Tue 12/18/12



Project: Kirtland Air Force Base Enviro
Date: Fri 6/24/11

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			