Revised

Programmatic Sampling and Analysis Plan
Lockheed Martin Corporation
Beaumont Sites 1 & 2
Beaumont, California

Prepared for:

LOCKHEED MARTIN

Prepared by:

TETRA TECH
301 E. Vanderbilt Way, Suite 450
San Bernardino, California 92408
TC# 23521-0601 / September 2010

Lockheed Martin Corporation, Shared Services
Energy, Environment, Safety and Health
2950 North Hollywood Way, Suite 125 Burbank, CA 91505
Telephone: 818.847.0197 Facsimile: 818.847.0256

LOCKHEED MARTIN

September 22, 2010

Mr. Daniel Zogaib
Southern California Cleanup Operations
Department of Toxic Substances Control
5796 Corporate Avenue
Cypress, CA 90630

Subject: Submittal of Revised *Programmatic Sampling and Analysis Plan, Lockheed Martin Corporation, Beaumont Sites 1 & 2 Beaumont, California*

Dear Mr. Zogaib:

Please find enclosed one hard copy and two compact disks of the Programmatic Sampling and Analysis Plan requested by DTSC for Beaumont Sites 1 and 2. The document has been revised in accordance with comments received from DTSC on June 23, 2010, responses to those comments submitted on July 19, 2010, and DTSC's request on August 24, 2010 to incorporate comment number 2 into a revised document.

If you have any questions regarding this submittal or the status of site activities, please contact me at 408.756.9595 or denise.kato@lmco.com.

Sincerely,

Denise Kato
Remediation Analyst Senior Staff

Enclosures

Copy with Enclosures:
Gene Matsushita , LMC (hard copy & electronic copy)
Tom Villeneuve, Tetra Tech, Inc. (hard copy)
Ian Lo, CDM (electronic copy)
Alan Bick, Gibson, Dunn, & Crutcher (electronic copy)

Linda S. Adams
Secretary for
Environmental Protection

Department of Toxic Substances Control

Maziar Movassaghi, Acting Director
5796 Corporate Avenue
Cypress, California 90630

Arnold Schwarzenegger
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June 23, 2010

Ms. Denise Kato
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PROGGRAMATIC SAMPLING AND ANALYSIS PLAN, LOCKHEED MARTIN CORPORATION, BEAUMONT SITES 1 AND 2, BEAUMONT, CALIFORNIA (Site Code: 400261)

Dear Ms. Kato:

The Department of Toxic Substances Control (DTSC) has reviewed the subject Plan. In addition to the comments below, enclosed are from DTSC's Geological Services Unit (GSU).

1. Page 3-12: Please review Table 3-1 to make sure that the definitions and formulas match the corresponding statistic terms. For example, the formula for "Relative Percent Difference (RPD)" appears in the line below, and there are two entries on "Percent Recovery" with different information.

2. Page 3-79/3-80: Some of the analytical methods used in the previous groundwater investigations are not listed on Table 3-13. For example, EPA Method 1624 and 1625C were used to analyze 1,4-dioxane and/or NDMA in groundwater samples (see Table 1 in Addendum #2 to Dynamic Site Investigation Work Plan for Beaumont Site 2). Please include all analytical methods used during the remedial investigations in the SAP for completeness

Please address the aforementioned and enclosed GSU comments by July 23, 2010.

Should you have any questions or comments, please contact me at (714) 484-5483.

Sincerely,

Daniel K. Zogaib
Project Manager
Brownfields and Environmental Restoration Program

Enclosure

cc: Mr. Gene Matsushita
Senior Manager
Environmental Remediation
Lockheed Martin Corporation
Energy, Environment, Safety & Health
2950 North Hollywood Way, Suite 125
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Department of Toxic Substances Control

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MEMORANDUM

TO: Daniel Zogaib
Hazardous Substances Engineer
Brownfields and Environmental Restoration Program

FROM: Dina Kourda, CEG
Engineering Geologist
Geological Services Branch (GSB)

DATE: April 1, 2010

SUBJECT: PROGRAMMATIC SAMPLING AND ANALYSIS PLAN, LOCKHEED MARTIN CORPORATION, BEAUMONT SITES 1 and 2, BEAUMONT, CALIFORNIA JANUARY 7, 2010

PCA: 11050 SITE CODE: 400200-00 TRACKING #: 940274

At the request of DTSC Project Manager, Mr. Daniel Zogaib, the Geological Services Branch (GSB) has reviewed the subject document for Lockheed Martin Corporation (LMC), Sites 1 and 2 in Beaumont, California.

BACKGROUND

On behalf of LMC, Tetra Tech, Inc. (Tetra Tech) prepared the subject document for LMC's former Beaumont Site 1 (Highland Springs Road) and Site 2 (Jackrabbit Trail) facilities (the "Sites"). The Programmatic Sampling and Analysis Plan (SAP) describes the quality assurance (QA) and quality control (QC) procedures that will be followed during sample collection and analysis, data reporting for samples collected during the ongoing remedial investigations, site mitigation/cleanup activities, and monitoring activities at Sites 1 and 2.

Site 1 is located approximately 70 miles east of Los Angeles in the city of Beaumont in San Bernardino County, California. Defective solid rocket propellant was washed out of the motor casings with groundwater supplied by a former production well (W-1), now properly abandoned. A high-pressure water jet was used to flush propellant from the motor casings in the Rocket Motor Production Area (Area B). The solid propellant pieces produced from the washout activities were collected in a sieve and later packed into drums and taken to the Burn Pit Area (BPA) landfill (Area C) for burning.

The three primary soil chemicals of potential concern (COPCs) are perchlorate, trichloroethylene (TCE), and poly-chlorinated biphenyls (PCBs). Perchlorate is the most extensive soil COPC at the Site, while TCE and PCBs are detected in a few areas of the Site. Although 1,4-dioxane is also a primary COPC with respect to groundwater, it has not been detected in soil other than a couple of locations outside the BPA (the primary source area for all COPCs), at concentrations near the method detection limit (MDL) (0.005-0.031 milligrams per kilogram [mg/Kg]); therefore, 1,4-dioxane is not considered a primary soil COPC in these areas. The primary groundwater COPCs which are detected most frequently and at the highest concentrations are perchlorate, 1,1-dichloroethene (1,1-DCE), TCE, and 1,4-dioxane.

Former Site 2 is a 2,668-acre parcel located southwest of the city of Beaumont in San Bernardino County, California. Grand Central Rocket Company (GCR) purchased the site from the US Government in 1958. The Site was utilized for small rocket motor assembly, testing operations, propellant incineration, and minor disposal activities from 1958 to 1974, when Site closure took place under Lockheed.

According to Tetra Tech, chemicals of concern (COCs) include the following six: perchlorate, trichloroethene (TCE), methylene chloride, bis-(2-ethylhexyl) phthalate, Royal Demolition Explosives (RDX), and arsenic. Arsenic and bis-(2-ethylhexyl) phthalate were also identified, however, arsenic is a likely related to background and bis-(2-ethylhexyl) phthalate is likely a laboratory contaminant, according to Tetra Tech. Perchlorate has been identified as the primary COC. TCE, methylene chloride, and RDX are considered secondary COCs.

GSB conducted a critical flaw review of the subject document.

SPECIFIC COMMENT

1. This document should be stamped, signed, and dated by a California licensed professional (geologist or civil engineer). An appropriate sized Professional Geologist stamp (no less than 1-1/2 inches), for example, should be included in the document according to page 17 of the Geologist and Geophysical Act with Rules and Regulations dated 2007 http://www.geology.ca.gov/laws/act.pdf.

2. Section 2.6.3.2, Page 2-53: Like soil-gas sampling, GSB does not recommend the use of polyethylene tubing as it may become impregnated with contaminants giving false lows or false detections when used with multiple monitoring wells. Polyethylene should be avoided.

3. Section 2.6.3.4.2, Page 2-56 and Section 2.6.5.1, Page 2-67: GSB recommends dedicated regulators for each Summa canister. Regulators should be laboratory decontaminated and not cleaned in the field.

4 Appendices: It should be noted in the table of contents that the appendices are only found on the CD.

Please provide 2 weeks notice prior to commencement of fieldwork. Please do not hesitate to contact me with any questions at 714.484.5408 or dkourda@dtsc.ca.gov.

Peer reviewed by: David Murchison, PG

cc: Fred Zanoria, CEG, CHg

Linda S Adams
Secretary for
Environmental Protection

Department of Toxic Substances Control

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August 24, 2010

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PROGGRAMATIC SAMPLING AND ANALYSIS PLAN, LOCKHEED MARTIN CORPORATION, BEAUMONT SITES 1 AND 2, BEAUMONT, CALIFORNIA (Site Code: 400261)

Dear Ms. Kato:

The Department of Toxic Substances Control (DTSC) has reviewed your responses to our comments regarding the subject Sampling and Analysis Plan (SAP). DTSC has the following comment:

1. Please revise the SAP to include your response to our Comment 2 (the one on analytical methods) in the final document for clarity.

Once we receive the revised document, we will proceed to approve the SAP.

Should you have any questions or comments, please contact me at (714) 484-5483.

Sincerely,

Daniel K. Zogaib
Project Manager
Brownfields and Environmental Restoration Program

cc: See next page.

cc: Mr. Gene Matsushita
Senior Manager
Environmental Remediation
Lockheed Martin Corporation
Energy, Environment, Safety & Health
2950 North Hollywood Way, Suite 125
Burbank, California 91505

RESPONSE TO COMMENTS TRANSMITTED JUNE 23, 2010
PROGRAMMATIC SAMPLING AND ANALYSIS PLAN

JULY 19, 2010

Comments from Daniel Zogaib, DTSC Project Manager		
Comment	**Response**	**Proposed Action**
Comment 1. Page 3-12: Please review Table 3-1 to make sure that the definitions and formulas match the corresponding statistic terms. For example, the formula for "Relative Percent Difference (RPD)" appears in line below, and there are two entries on "Percent Recovery" with different information.	The formula for calculating RPD in Table 3-1 was inadvertently exchanged with that for calculating percent recovery for laboratory control samples. Percent recovery is calculated differently for laboratory control samples (LCS) vs. matrix spike (MS) samples, and we agree that this should be further clarified.	Table 3-1 will be revised by exchanging the formulas for RPD and LCS percent recovery. The table will also be revised to clarify the difference in the percent recovery calculation for LCS vs. MS samples.
Comment 2. Page 3-79/3-80: Some of the analytical methods used in the previous groundwater investigations are not listed on Table 3-13. For example, EPA Method 1624 and 1625C were used to analyze 1,4-dioxane and/or NDMA in groundwater samples (see Table 1 in Addendum #2 to Dynamic Site Investigation Work Plan for Beaumont Site 2). Please include all analytical methods during the remedial investigations in the SAP for completeness.	The analytical methods noted in this comment have been superseded by alternate methods described in the SAP, and are not planned to be used for future work at Sites 1 & 2. These methods were intentionally not included in the SAP to avoid possible confusion. Analytical methods not included in the SAP which were used for analysis of contaminants during previous investigations include the following: E1624 (1,4-dioxane) – superseded by SW8270C–SIM E1625C (NDMA) – superseded by E521 E7196 (hexavalent chromium) – superseded by E7199/E218.6 SW8260B-SIM (1,2,3-trichloropropane) – superseded by E524.1 In addition to the above, a number of methods previously used for analysis of general minerals have been replaced in the SAP by more recently developed methods, and radiological analyses used during a one-time investigation at Site 1 (Gross Alpha, Tritium, Carbon-14, and Sulfur-35) are not included in the SAP.	No changes to document proposed.

RESPONSE TO COMMENTS TRANSMITTED JUNE 23, 2010
PROGRAMMATIC SAMPLING AND ANALYSIS PLAN

JULY 19, 2010

Comments from Dina Kourda, CEG, DTSC Geological Services Branch		
Comment	**Response**	**Proposed Action**
Comment 1. This document should be stamped, signed and dated by a California licensed professional (geologist or civil engineer). An appropriate sized Professional Geologist stamp (no less than 1-1/2 inches), for example, should be included in the document according to page 17 of the Geologist and Geophysical Act with Rules and Regulations dated 2007 http://www.geology.ca.gov/laws/act.pdf.	At the request of DTSC, the document will be stamped by a California-licensed Professional Geologist. However, we note that 16 CCR §3003 states that *"Professional geological work" specifically does not include such routine activities as drafting, sampling, sample preparation, routine laboratory work, etc., where the elements of initiative, scientific judgment and decision making are lacking, nor does it include activities which do not use scientific methods to process and interpret geologic data."* The Programmatic Sampling and Analysis Plan describes established methodologies for the collection of geologic data. Preparation of the plan did not include the processing or interpretation of geologic data. We submit that preparation of the SAP does not meet the definition of professional geological work, and therefore a Professional Geologist stamp should not be required for this or similar documents in the future.	The document will be stamped, signed and dated by a California-licensed Professional Geologist.
Comment 2. Section 2.6.3.2, Page 2-53: Like soil gas sampling, GSB does not recommend the use of polyethylene tubing as it may become impregnated with contaminants giving false lows or false detections when used with multiple monitoring wells. Polyethylene should be avoided.	In general, dedicated low-flow pump systems are used for groundwater sampling at both Site 1 and Site 2, which eliminates issues associated with the reuse of pump tubing between wells. However, non-dedicated low-flow pumps may be used in some instances, such as when wells are sampled prior to the installation of a dedicated pump, or when a dedicated pump cannot be operated due to declining water levels. Tetra Tech concurs that the references cited in DTSC draft soil gas guidance (DTSC, 2010) and elsewhere (e.g., Parker and Ranney, 1996) suggest that polyethylene tubing may not be appropriate for sampling organic compounds. When non-dedicated pumps are used for groundwater sampling, polyethylene tubing will be avoided.	The text of Section 2.6.3.2, second paragraph, will be revised by adding the following sentence: *"In addition, the use of sorptive pump tubing, such as polyethylene tubing, will be avoided."*

Comments from Dina Kourda, CEG, DTSC Geological Services Branch		
Comment	**Response**	**Proposed Action**
Comment 3. Section 2.6.3.4.2, Page 2-56 and Section 2.6.5.1, Page 2-67: GSB recommends dedicated regulators for each Summa canister. Regulators should be laboratory decontaminated and not cleaned in the field.	Tetra Tech concurs with the comment on Section 2.6.5.1. Section 2.6.3.4.2 refers to procedures for sampling vapor extraction wells, which differs in several respects from sampling the small volume soil gas probes described in DTSC soil gas survey guidance (DTSC, 2010). For example, sampling operating vapor extraction wells requires drawing a vacuum greater than the system vacuum, a condition which cannot be met using a canister with a flow regulator. However, when flow regulators are used in sampling vapor extraction wells (for example, when conducting rebound sampling), dedicated laboratory-decontaminated regulators will be specified.	The text of Section 2.6.5.1, second sentence, will be revised as follows: "A *dedicated, laboratory-decontaminated* flow regulator calibrated by the laboratory for a flow rate of 200 ml/minute or less will be installed on the Summa canister, and the canister/flow regulator assembly will be attached to a fitting on a sampling manifold ahead of the purge pump." The text of Section 2.6.3.4.2, third paragraph, will be revised by adding the following sentence: *"The Summa canisters will be equipped with dedicated, laboratory-decontaminated flow regulators."*
Comment 4. Appendices: It should be noted in table of contents that the appendices are only found on CD.	Comment noted.	The TOC will be revised to indicate that the Appendices are only found on CD.

References

DTSC, 2010. Advisory – Active Soil Gas Investigation (Public Comment Draft). California Department of Toxic Substances Control, March 13, 2010.

Parker, L.V. and Ranney, T.A. (1996) Sampling Trace Level Organics with Polymeric Tubings. United States Army Corps of Engineers, Cold Regions Research & Engineering Laboratory, Special Report 96-3, February, 1996.

Linda S Adams
Secretary for
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1. Please revise the SAP to include your response to our Comment 2 (the one on analytical methods) in the final document for clarity.

Once we receive the revised document, we will proceed to approve the SAP.

Should you have any questions or comments, please contact me at (714) 484-5483.

Sincerely,

Daniel K. Zogaib
Project Manager
Brownfields and Environmental Restoration Program

cc: See next page.

cc: Mr. Gene Matsushita
Senior Manager
Environmental Remediation
Lockheed Martin Corporation
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TETRA TECH

REVISED

PROGRAMMATIC SAMPLING AND ANALYSIS PLAN LOCKHEED MARTIN CORPORATION, BEAUMONT SITES 1 & 2, BEAUMONT, CALIFORNIA

September 2010
23521-0601

Prepared for
Lockheed Martin Corporation
Burbank, California

Prepared by
Tetra Tech, Inc.

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Engineer

Mark Feldman, CHG CEG
Principal Geologist

REGISTERED GEOLOGIST
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STATE OF CALIFORNIA

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QAPP Manager

Thomas J. Villeneuve
Program Manager

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APPENDICES (INCLUDED ON CD ONLY)

1.0 INTRODUCTION

This Programmatic Sampling and Analysis Plan (SAP) has been prepared by Tetra Tech, Inc. (Tetra Tech) for the Lockheed Martin Corporation (LMC) Beaumont Site 1 and Site 2, herein referred to as "Sites 1 & 2" located in Beaumont, California. The SAP describes the quality assurance (QA) and quality control (QC) procedures that will be followed during sample collection, sample analysis, and data reporting for samples collected during ongoing remedial investigations, site mitigation/cleanup activities, and monitoring activities at Sites 1 & 2. The SAP is comprised of a Field Sampling Plan (FSP; Section 2.0) and a Quality Assurance Project Plan (QAPP; Section 3.0).

1.1 SAMPLING AND ANALYSIS PLAN OVERVIEW

The SAP establishes methodologies for obtaining field measurements and describes techniques for identifying sampling locations and for obtaining samples of environmental media, and describes means for packaging and transporting samples to the selected laboratory for analysis. The SAP also describes the laboratory procedures and quality assurance objectives to meet analytical detection limits to support the human health and ecological risk assessment.

1.2 SITE BACKGROUND

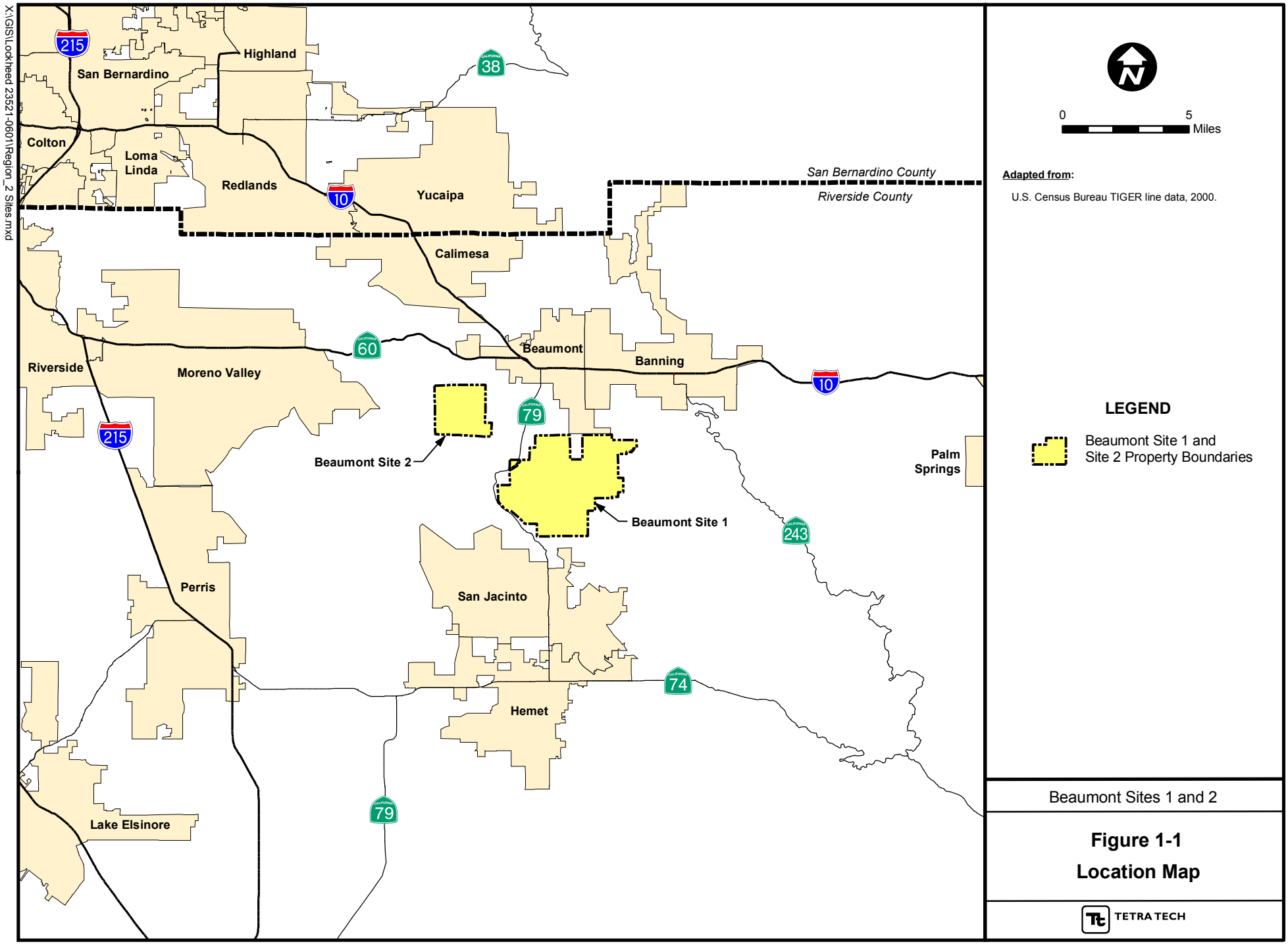
A site history and description of the previous investigations conducted at Sites 1 & 2 are included in the following subsections.

1.2.1 Beaumont Site 1

1.2.1.1 Site 1 History

Site 1 is a 9,117 acre parcel located south of the City of Banning, California (Figure 1-1). The Site was primarily used for ranching prior to 1960. From 1960 to 1974, the Site was used by Lockheed Propulsion Company (LPC) for solid rocket motor and ballistics testing (Tetra Tech, 2003). Activities at the Site also included burning of process chemicals and waste rocket propellants in an area commonly referred to as the burn pit area (BPA). The company utilized explosives in their work; however, since this work was focused on propulsion systems and weapons delivery systems, most munitions used on site were reportedly practice rounds that did not contain high explosives. In 1970, LMC began offering their test services to outside parties, and leased property to Aerojet Corporation and allowed General Dynamics to conduct testing on several occasions.

As a result of the discovery of apparently discarded munitions at the Site in 2005, Tetra Tech was tasked by LMC to provide rapid response to assess and, if necessary, mitigate immediate ordnance related hazards potentially present on site. Therefore, the munitions and explosives of concern (MEC)


X:\GIS\Lockheed 23521-0601\Region_2 Sites.mxd
215
Highland
San Bernardino
38
Colton
Loma Linda
Redlands
10
Yucaipa
San Bernardino County
Riverside County
Calimesa
60
Beaumont
Banning
Riverside
Moreno Valley
10
79
215
Beaumont Site 2
Palm Springs
Beaumont Site 1
243
Perris
San Jacinto
74
Hemet
79
Lake Elsinore
0
5
Miles
Adapted from:
U.S. Census Bureau TIGER line data, 2000.
LEGEND
Beaumont Site 1 and Site 2 Property Boundaries
Beaumont Sites 1 and 2
Figure 1-1
Location Map
TETRA TECH

investigation and mitigation activities are being conducted on a different track than the remedial investigations. The MEC investigations completed to date are not discussed in the following sections.

Nine former operational areas have been identified at the Site. A Site historical operational areas and features map is presented as Figure 1-2. Each historical operational area was responsible for various activities associated with rocket motor assembly, testing, and propellant incineration. A brief description of the nine historical operational areas follows.

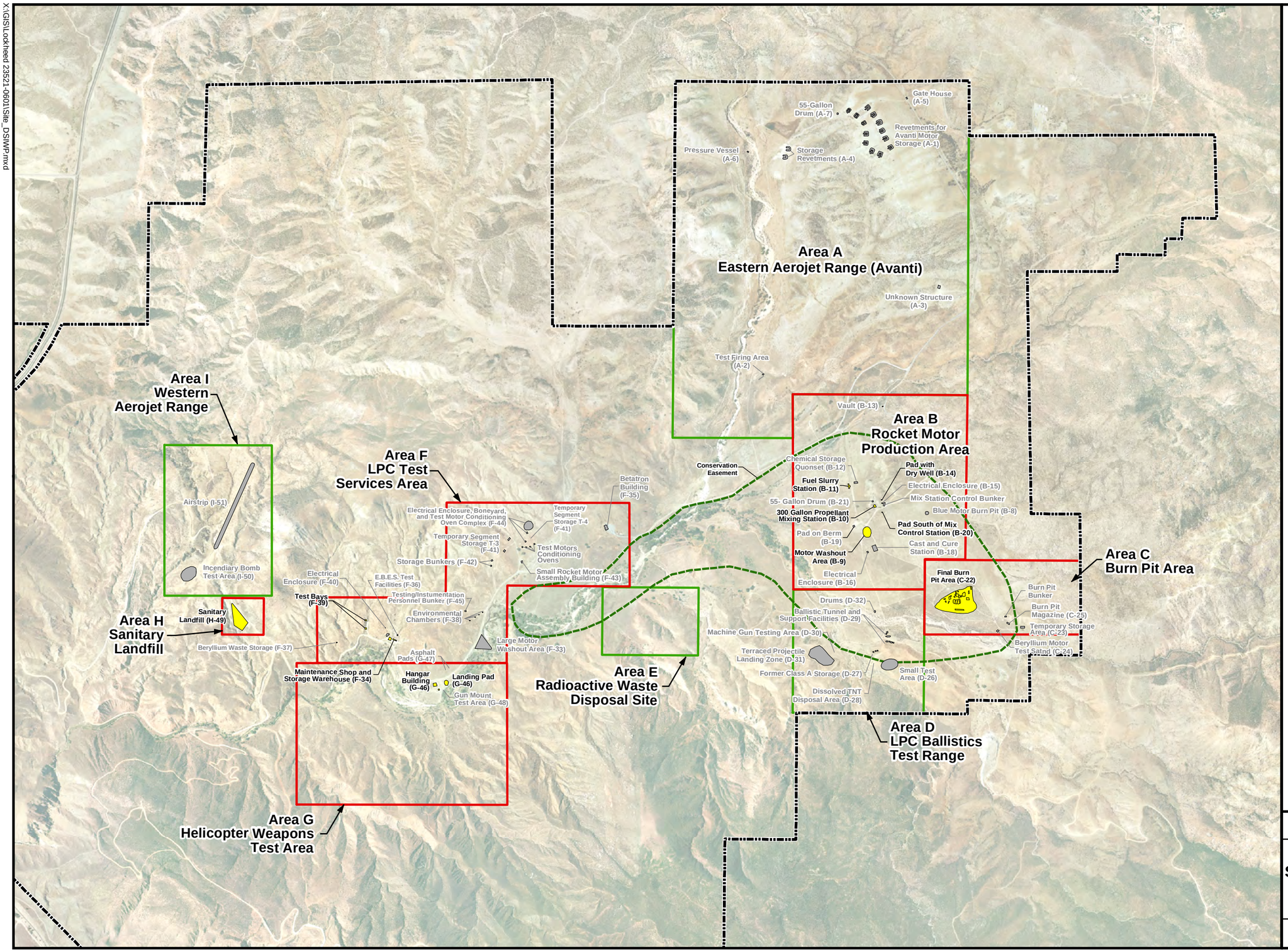
1.2.1.1.1 Historical Operational Area A – Eastern Aerojet Range

Between 1970 and 1972, Aerojet leased two areas along the eastern (referred to as the Eastern Aerojet Range) and western portions of the Site. The Eastern Aerojet Range was used periodically for research and development (R&D) experimentation on several types of rounds for long-range 30-mm weapons. According to a former supervisor of the Aerojet site activities, only specially machined and dummy aluminum bullets were used and all rounds were accounted for during the test procedures. At the conclusion of Aerojet's testing activities at the Site, the area was plowed and planted by a sheep farmer. Near the head of the canyon of the former Eastern Aerojet Range, the Soil Conservation Service constructed a berm to retain runoff and minimize downstream erosion. Avanti, a highly classified project, utilized the land directly east of the Eastern Aerojet Range including several U-shaped revetments for the storage of explosive materials and motors. Due to its highly classified status, the purpose of the Avanti project and its operational procedures are unknown (Radian, 1986).

1.2.1.1.2 Historical Operational Area B – Rocket Motor Production Area

The Rocket Motor Production Area (formerly known as the Propellant Mixing Area) was used for the processing and mixing of rocket motor solid propellants. The rocket motor production process consisted of: 1) fuel slurry station, 2) mixing station, and 3) cast and curing station. The fuel slurry station and mix station were utilized to generate the solid propellants. The principal mix station was Building 315, which was used during the Large Solid Motor (LSM) program until early 1966. In 1970 it was reactivated as a back-up mixer for the Short Range Attack Missile (SRAM) program. At the mix station, dry oxidizer, primarily ammonium perchlorate, was blended with liquid ingredients consisting of butadiene derivatives and a burn rate modifier (primarily ferrocene). During the LSM program, the liquid ingredients were weighed and pre-mixed at the fuel slurry station, located in Building 317. The chemicals associated with the mixing process were stored in Building 319. All mix station operations were controlled from Building 315-A, a nearby bunker built into the side of a hill. Clean-up was performed by scraping and wiping down all containers and mixing equipment to remove all remaining propellant. Batches of propellant that did not meet specifications, as well as all cleaning materials (including materials used during wipe down), were taken to the burn pit area for incineration (Radian, 1986).

X:\GIS\Lockheed 23521-06011\Site_DSI\WP.mxd



0 1,000 2,000 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- Beaumont Site 1 Property Boundary
- Historical Operational Area Boundary - Further Investigation
- Historical Operational Area Boundary - No Further Investigation
- Conservation Easement

Notes:

Beaumont Site 1 property boundary is approximate.

Black - Features investigated as part of the DSI.

Gray - Features not investigated during the DSI.

Beaumont Site 1

Figure 1-2
Site 1 Historical Operational Areas, Site Features, and Conservation Easement

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After the mixing process, the thick, viscous propellant was poured under a vacuum into insulated and lined metal motor casings. The propellant cast was then cured by heating. During the LSM program, casting and curing was done at a stand located a short distance to the southwest of the mix station.

If a defect was found in the solid propellant mix, the rocket motor was scrapped. The solid propellant was removed from the casings by water jetting at the motor washout located south of the mix station. The water leached much of the ammonium perchlorate out of the solid propellant. The water slurry produced at this washout area was collected in a lined basin. The remaining solid residue was collected in a flume-type apparatus, put in barrels, and taken to the burn pit area for incineration. After operations ceased, a flamethrower was applied to the motor washout area to burn any residue left lying on the ground (Radian, 1986).

In 1973, an area east of the mix station, known as the blue motor burn pit, was utilized for the destruction of four motors, which included a motor with "Maloy blue" solid propellant. Charges were used to cut open the SRAM motor casings, exposing and destroying the solid propellant and motors. The blue motor burn pit was approximately 6 feet deep, 5 feet wide, and 12 feet long (Radian, 1986).

1.2.1.1.3 Historical Operational Area C – Burn Pit Area

The Burn Pit Area consisted of three primary features: 1) chemical storage area, 2) burn pits, and 3) the beryllium test stand. Hazardous waste materials generated at the Site were stored in 55-gallon drums on a concrete pad east of the burn pits at the chemical storage area until enough material was generated for a burning event. The hazardous materials burned in the pits included: ammonium perchlorate, wet propellant from motor washout, dry propellant, batches of out-of-specification propellant, various kinds of adhesives, resin curatives such as PBAN (a polybutadiene acrylonitrile/acrylic acid copolymer), burn rate modifiers such as ferrocene, pyrotechnic and ignition components, packaging materials (e.g., metal drums, plastic bags, and paper drums), and solvents (Radian, 1986).

A total of 20 to 40 burn pits were excavated at the Site; some burn pits were used more than once. Burn pits were created by excavating a pit that was approximately 6 to 8 feet wide, 4 to 6 feet deep and 50 to 100 feet long. The pits generally were oriented north to south. During burn pit procedures, the hazardous materials were placed in the center of the burn pits, saturated with fuel (specifically ammonium perchlorate oxidizer or diesel fuel), and ignited with an electric match from a remote location. After burning activities, the burn pit trench was visually inspected for items that did not burn. If the trench was suitable for reuse, it was left open for additional burns. Otherwise, the trench was filled and covered with soil (Radian, 1986).

On the south side of the spur, where the burn pit instrumentation bunker was located, there was a one-time firing of small beryllium research motors (Radian, 1986).

1.2.1.1.4 Historical Operational Area D – LPC Ballistics Test Range

The LPC Ballistics Test Range facilities included gun mounts, a ballistic tunnel, and storage buildings and trailers. Guns were tested by firing toward a terraced hill. After firing, the hill was policed to pick up the remains of any rounds. Live rounds were not used although projectiles were often specially shaped and weighted to simulate actual live rounds.

The ballistics tunnel consisted of large sections of drainage culvert cut lengthwise and supported on a concrete foundation. Various weapons were fired through the tunnel and photographed with special high-speed strobe photographic equipment. Another major project conducted in this area was experimentation on a rocket-assisted projectile to test penetration capability. Additional experiments included impact testing of various motors and pieces of equipment.

Class A explosives were stored in two or three 10-foot by 10-foot buildings located behind a berm. During the closure of the facility, all explosive materials were detonated on-site. A small canyon behind the hill to the south of the former storage buildings was used as a small test area for incendiary bombs. An incendiary bomb was detonated in the center of drums containing various types of fuel (e.g., jet fuel, gasoline, and diesel) set in circles of different radii to observe shrapnel and penetration patterns. At a small area near the bend in the road, acetone was used to dissolve trinitrotoluene (TNT) out of incendiary bombs before they were burned. This was a one-time occurrence, and the resulting TNT crystals were collected and destroyed. (Radian, 1986).

1.2.1.1.5 Historical Operational Area E – Radioactive Waste Disposal Site

During 1971, low-level radioactive waste was buried in one of four canyons southeast of the LPC test services area as reported by former Site employees. In 1990, the radioactive waste was located and removed. Confirmation soil samples were analyzed for gross alpha, gross beta, and gamma reactivity. The analytical results indicated that detected concentrations were within the range of naturally occurring concentrations (Radian, 1990).

1.2.1.1.6 Historical Operational Area F – LPC Test Services Area

The LPC Test Services Area included the following features: 1) three bays for structural load tests, 2) a 13-foot-diamater spherical pressure vessel, 3) six temperature conditioning chambers, 4) five environmental chambers, 5) a 25-million electron volt (MeV) Betatron for X-raying large structures, 6) personnel and instrumentation protection bunkers, and 7) supporting work shops and storage areas.

Once a motor casing was prepared with solid propellant, the casing was transported to the LPC Test Services Area for integrity testing. Nondestructive inspection of the motor casing with a radiographic unit was performed in Building 303. The testing process also included simulated extreme environmental conditions. A spherical pressure vessel was utilized to simulate extreme pressures and was used as a source of high-pressure, high-volume gas or water for flow tests of valves, meters, and pumps. Temperature chambers exposed motors to temperatures ranging from –100 to +200°F. Environmental chambers simulated conditions of humidity, rain, immersion, infrared radiation, salt spray, sand and dust, and altitude. Buildings 306 and 314 of the LPC Test Services Area were work shops and storage facilities.

If defects were identified during the integrity and environmental testing activities, the rocket motors were taken to a secondary washout area located south of the conditioning chambers adjacent to Potrero Creek. A shaking sieve caught most of the solid propellant as it was washed out of the motor casing. This solid propellant was packed in barrels and taken to the burn pit area to be incinerated. A long trench, leading to an unlined catch basin, caught the overspray and contained the water and smaller pieces of solid propellant that passed through the sieve. After the water percolated into the soil, the remaining pieces of solid propellant were gathered and burned in the catch basin.

Rocket motor structural load testing under static and captive firing conditions occurred at the LPC test bays. During several of the initial tests conducted at Bay 309, the readied motor exploded instead of firing. Buildings 304 and 305 (bunkers) provided protection for personnel and instrumentation during various test activities. These buildings were all designated as inert and were not to contain any propellant.

Several storage areas existed at the LPC Test Service Area. Beryllium scrap from LMC's Redlands Facility was stored in 55-gallon drums near the igniter magazine in a small structure over a hill just to the west of Test Bay 310. An igniter magazine existed near the beryllium storage structure. This was a small, half-buried barrel with a door where squibs (small electric or pyrotechnic devices used to ignite a charge) were stored. A bone-yard was used as a storage area for a variety of steel framework and other heavy equipment used in the structural testing activities (Radian, 1986).

1.2.1.1.7 Historical Operational Area G – Helicopter Weapons Test Area

The helicopter weapons test area was used to develop equipment for handling helicopter weapons systems. The facilities within this area included a hanger (Building 302), helicopter landing pad, stationary ground mounted gun platforms, and a mobile target suspended between towers. The primary project at this test area was testing of both stationary guns and guns mounted on helicopters. Experimentation also was performed on the solid propellant portion of an armor-piercing round. The majority of rounds were fired into the side of the creek wash, about 100 yards to the south of the hanger.

A longer impact area labeled with distance markers was located in the canyon to the south of the wash. Projectiles were steel only; warheads were not used during tests at this facility (Tetra Tech, 2003).

1.2.1.1.8 Historical Operational Area H – Sanitary Landfill

A permitted sanitary landfill was located along the western side of the Site. The permit for the landfill permitted LPC to dispose of trash such as paper, scrap metal, concrete, and wood generated during routine daily operations. Lockheed policy strictly dictated that hazardous materials were not to be disposed of at this landfill. The trenches were later covered and leveled, with only an occasional tire, metal scrap, or piece of wood remaining on the surface (Tetra Tech, 2003).

1.2.1.1.9 Historical Operational Area I – Western Aerojet Range

Lockheed conducted an incendiary test with a 500-pound bomb at the southwest end of the Western Aerojet Range. This test was similar to testing performed at the LPC Ballistics Test Area. According to a historical report prepared by Radian in 1986, the Western Aerojet Range was originally leveled to be used as an airstrip (Radian, 1986). Based on employee interviews, the airstrip may have been used only on one occasion.

1.2.1.1.10 Post LPC and Aerojet Facility Usage

LMC leased portions of the Site to several outside parties for use in various activities. The International Union of Operating Engineers (IUOE) utilized the Site from 1971 through 1991 for surveying and heavy equipment training. The main office of the IUOE was formerly located within Bunker 304 of Historical Operational Area F (LPC Test Services Area). The IUOE had approximately 75 to 100 pieces of heavy equipment on-site, including a rock crusher, for road building and other purposes (e.g., grading operations and landscaping) (Tetra Tech, 2003). Additionally, IUOE operated an underground fuel storage tank (UST). In 1984, the UST was removed and a letter was issued by the Riverside County Department of Health stating that no further action was necessary (Radian, 1986). Based on interviews, degreasing of the IUOE equipment was reportedly conducted by steam cleaning with no solvent usage. The IUOE earth-moving activities involved maintaining roads and reshaping various parts of the Site, primarily within Historical Operational Areas F and G (Tetra Tech, 2003).

A portion of the Site was also leased by a farmer who utilized a number of areas for sheep grazing and dry-land farming. Portions of the Site have also been utilized for cattle grazing. Most level areas throughout the Site, including the burn pit area and the LPC and Aerojet test ranges, were planted with barley. Planting activities were preceded by mechanical cultivation of the soil to depths of approximately one foot (Radian, 1986).

On several occasions, General Dynamics utilized Historical Operational Area D (LPC Ballistics Test Range) for testing activities. In 1983, General Dynamics conducted a test of the Viper bazooka by firing rounds comprised of a 2.7-inch rocket motor, explosives, and shaped charges toward steel targets in Historical Operational Area D. Only shrapnel remained from this test. General Dynamics also fired 20mm and 30mm Phalanx Gatling guns from west to east toward a berm that was built near the former SRAM motor washout area. Only solid rounds were used during this activity (Radian, 1986).

Structural Composites used the steep terrain of the Site for vehicle rollover tests on a number of occasions. Structural Composites also conducted heat and puncture tests on pressurized fiberglass and plastic reinforced cylinders. The tests involved shooting a single 30-caliber round at the cylinders and recording the result (Radian, 1986).

1.2.1.2 Site 1 Findings of Previous Investigations

The three primary soil chemicals of potential concern (COPC) at the Site are perchlorate, trichloroethene (TCE), and polychlorinated biphenyls (PCBs). Perchlorate is the most extensive soil COPC at the Site, while TCE and PCBs are only detected in a few areas of the Site. Although 1,4-dioxane is also a primary COPC with respect to groundwater, it has not been detected in soil other than a couple of locations outside the BPA, the primary source area, at concentrations near the method detection limits (MDLs) of 0.005 to 0.031 milligrams per kilogram (mg/kg); therefore, 1,4-dioxane is not considered a primary soil COPC for this Site.

The groundwater COPCs identified for the Site based on past site activities and groundwater monitoring results include perchlorate, 1,1-dichloroethene (1,1-DCE), TCE, 1,4-dioxane, 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), cis-1,2-dichloroethene (cis-1,2-DCE), and 1,1,1-trichloroethane (1,1,1-TCA). The primary groundwater COPCs which are detected most frequently and at the highest concentrations are perchlorate, 1,1-DCE, TCE, and 1,4 dioxane.

1.2.1.2.1 Nature and Extent of Soil Impacts

Perchlorate is the most extensive contaminant detected in soil at the Site. Perchlorate impacted soil has been identified at 12 features within the Site (Figure 1-3), with the highest concentrations detected at the Large Motor Washout Area (302,000 micrograms per kilogram [µg/kg]), the BPA (171,000 µg/kg) and the Sanitary Landfill (67,300 µg/kg). Relatively high concentrations (up to 20,400 µg/kg) have also been detected in the Rocket Motor Production Area (RMPA) which is considered a secondary source area for perchlorate in soil in comparison to the BPA. In general, the perchlorate concentrations at the RMPA are an order of magnitude less than the BPA but have a much larger areal extent, possibly due to the transport mechanism resulting from the historical operations (processing and mixing of rocket motor solid

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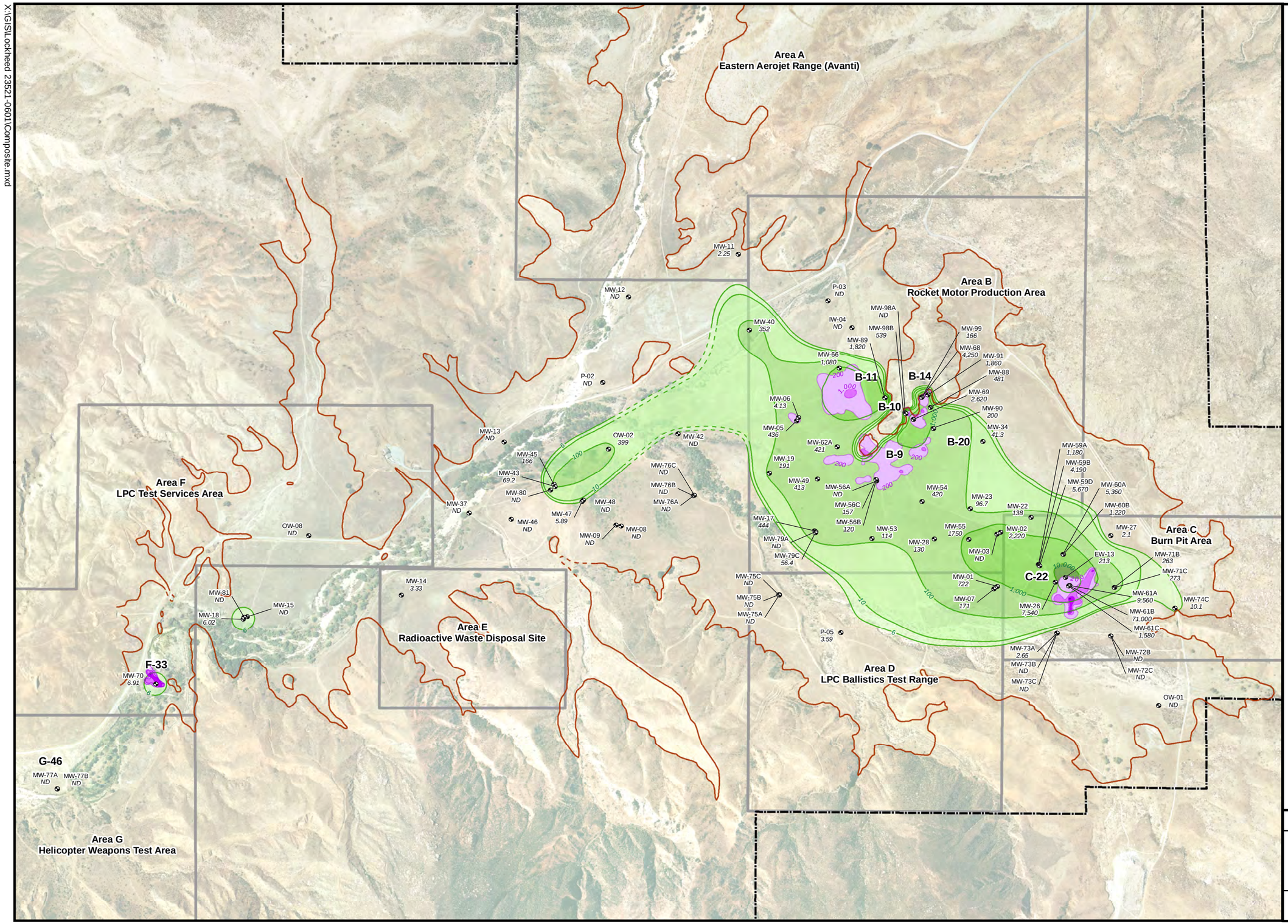

0 500 1,000 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- Well Location
- Alluvium / Bedrock contact (dashed where inferred)

Perchlorate Concentration in Soil

- >200 µg/kg
- >1,000 µg/kg
- >10,000 µg/kg
- >100,000 µg/kg

Perchlorate Concentration in Groundwater

- >6 µg/L
- >10 µg/L
- >100 µg/L
- >1,000 µg/L
- >10,000 µg/L

- Beaumont Site 1 Property Boundary
- Historical Operational Area Boundary

Beaumont Site 1

Figure 1-3
Site 1 Perchlorate Soil Source Areas and Groundwater Impacts

TETRA TECH

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Area I
Western Aerojet Range

Area H
Sanitary Landfill

MW-84B
ND

MW-84A
ND

200
1,000

10,000
1,000
200

MW-97
ND

MW-96
ND

Sanitary Landfill
(H-49)

Area F
LPC Test Services Area

Test Bays
(F-39)

MW-85B
ND

MW-85A
ND

MW-86A
ND

MW-86B
ND

6
10

MW-92
24.5

MW-95
ND

MW-87A
ND

MW-87B
35.2

6
10

Maintenance Shops
and Warehouse
(F-34)

F34-TW1
ND

MW-93
3.03

MW-94
ND

Area G
Helicopter Weapons Test Area

0 150 300 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- Well Location
- Alluvium / Bedrock contact (dashed where inferred)

Perchlorate Concentration in Soil

- >200 µg/kg
- >1,000 µg/kg
- >10,000 µg/kg
- >100,000 µg/kg

Perchlorate Concentration in Groundwater

- >6 µg/L
- >10 µg/L
- >100 µg/L
- >1,000 µg/L
- >10,000 µg/L

- Beaumont Site 1 Property Boundary
- Historical Operational Area Boundary

Beaumont Site 1

Figure 1-3 (cont.)
Site 1 Perchlorate Soil Source Areas and Groundwater Impacts

TETRA TECH

propellants and motor washouts) which may have governed the distribution of perchlorate on the surface and eventually into the subsurface.

The only TCE soil source identified at the Site (Figure 1-4) is the BPA, which was remediated through soil vapor extraction (SVE) in the mid to late 1990s, with the system being shut down in 1998 after volatile organic compound (VOC) concentrations in vapor had decreased by 99.6 percent (%). Elevated concentrations of TCE in soil gas still remain at the BPA and are attributed to off gassing of affected groundwater beneath this feature and/or possibly residual contamination in the vadose zone. Although TCE impacted groundwater was also detected at Features F-34 and F-39, no soil source was identified at either feature. The soil gas concentrations and trends at these features indicate off gassing of the TCE impacted groundwater and therefore soil source areas may no longer be present.

PCBs were detected at four features with very localized shallow impacts at three of the four features (F-35, F-36, and F-40) with concentrations up to 250 µg/kg. At the Sanitary Landfill (Feature H-49), PCBs were detected in several areas with detected concentrations up to 1,400 µg/kg and appear to be fairly localized and limited to shallow soils except on the east side where PCBs were detected at 20 feet below ground surface (bgs) in two locations.

1.2.1.2.2 Nature and Extent of Groundwater Impacts

In general the Site 1 groundwater plume (perchlorate, Figure 1-3; TCE, Figure 1-4; 1,1 DCE; and 1,4-dioxane, Figure 1-5) has remained relatively stable over time. Slight modifications to the definition of the plume over time are generally the result of newly installed wells better defining the lateral extent of the plume. The overall areal extent of the Site 1 groundwater plume above the maximum contaminant level (MCL) or drinking water notification level (DWNL) is roughly 275 acres.

The highest groundwater COPC concentrations detected at the Site since 2002 are as follows: perchlorate (141,000 micrograms per liter [µg/L]), 1,4-dioxane (3,400 µg/L), 1,1 DCE (14,000 µg/L), TCE (3,500 µg/L), cis-1,2-DCE (990 µg/L) 1,1 DCA (260 µg/L), 1,2-DCA (680 µg/L), and 1,1,1-TCA (23 µg/L). The highest concentrations of the groundwater COPCs have consistently been reported in samples collected from shallow screened wells located in the BPA with concentrations rapidly decreasing outside, and downgradient, of the former BPA. However, secondary perchlorate source areas are also present at the RMPA including the Motor Washout Area (Feature B-9), the Propellant Mixing Station (Feature B-10), the Fuel Slurry Station (Feature B-11), and the Pad with Dry Well (Feature B-14). In addition to the BPA and RMPA, small localized plumes (TCE, 1,4-dioxane, and/or perchlorate) have also been detected at the Large Motor Washout Area (Feature F-33), the Maintenance Shop and Storage Warehouse Area (Feature F-34), and the Test Bays (Feature F-39) located in the western portion of the Site near Potrero Creek.

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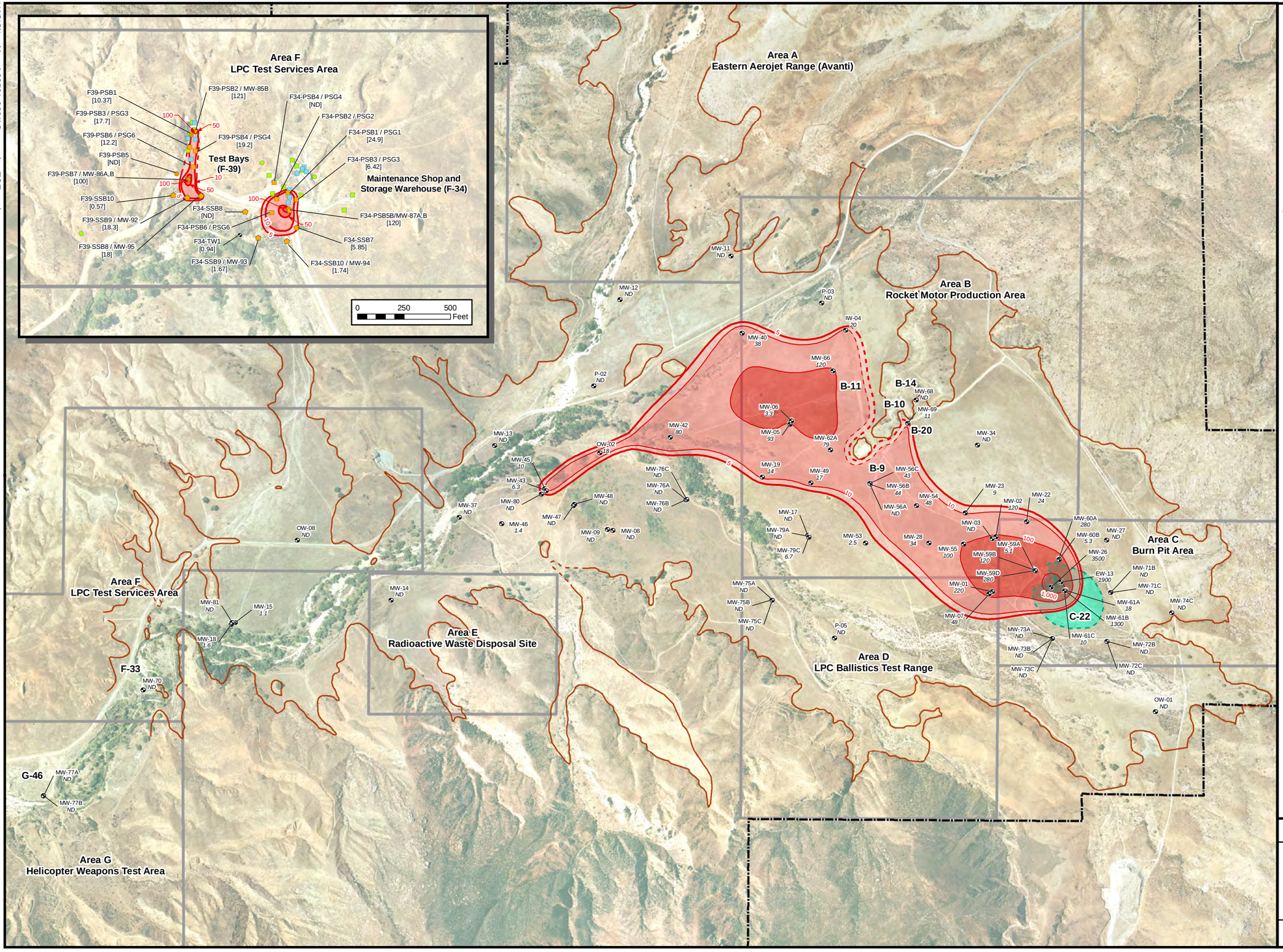

Adapted from: March 2007 aerial photograph.

LEGEND

Sample Locations

- Primary Soil Boring, 2008
- Secondary Soil Boring
- Primary Soil Boring/Soil Vapor, 2008
- Soil Vapor, 2002
- Soil Boring/Soil Vapor, 2007
- Soil Boring, 2004
- Soil Boring/Soil Vapor, 2004
- Well

Trichloroethene (TCE) in Soil

- VOC Soil Source Area

Trichloroethene (TCE) Concentration in Groundwater

- >5 µg/L
- >10 µg/L
- >50 µg/L
- >100 µg/L
- >1,000 µg/L

- Alluvium / Bedrock contact
- Beaumont Site 1 Property Boundary
- Historical Operational Area Boundary

Note:

[#] - TCE results in µg/L.

µg/L - Micrograms per liter.

[ND] - Non-Detect.

Boring symbols with no labels indicate sample was not tested at depth interval.

Beaumont Site 1

Figure 1-4

Site 1 TCE Soil Source Areas and Groundwater Impacts

TETRA TECH

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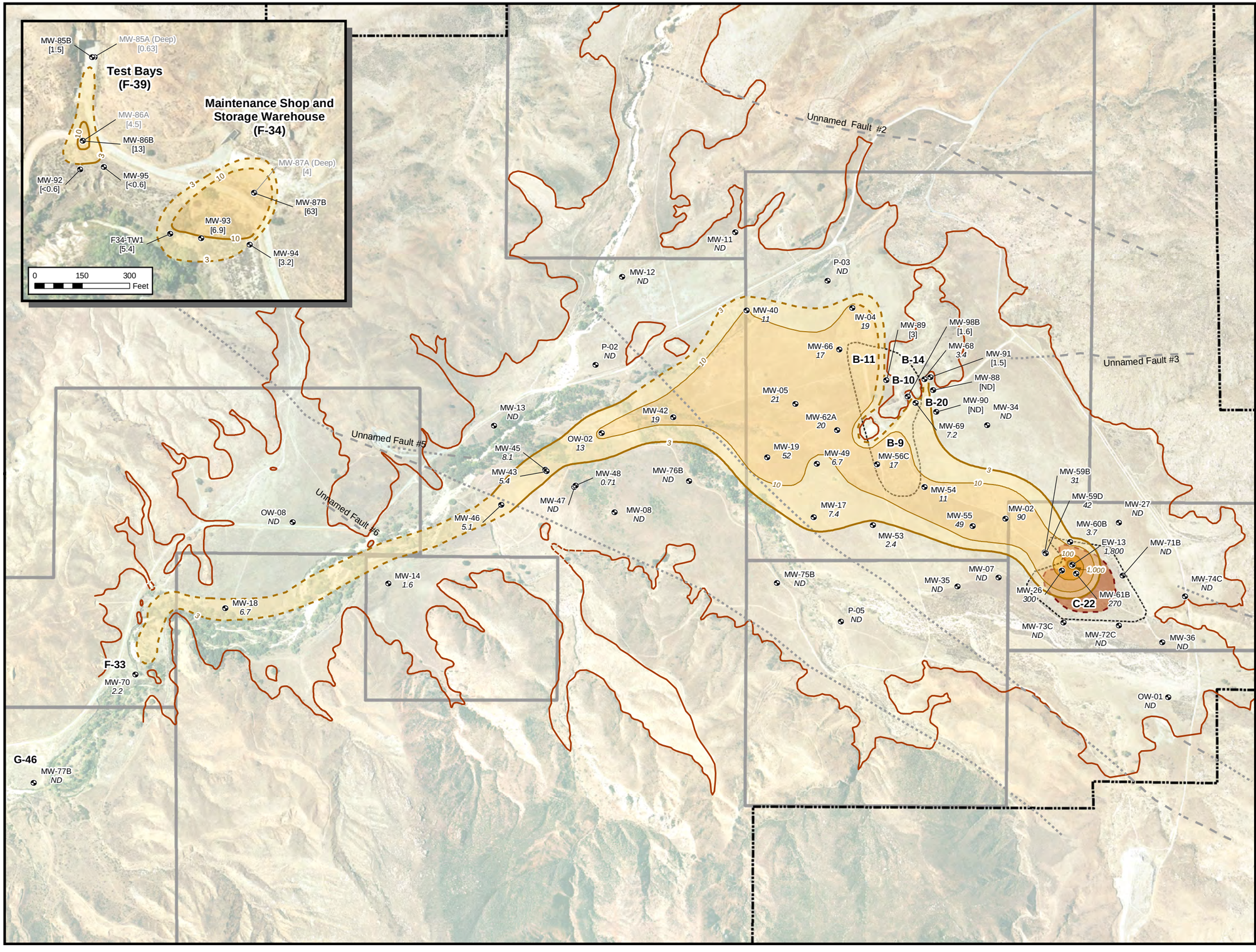

0 500 1,000 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

MW-01 Well ID

600 1,4-Dioxane Concentration

1,4-Dioxane in Soil

1,4-Dioxane Soil Source Area

1,4-Dioxane Concentration in Groundwater

>3

>10

>100

>1,000

Mt. Eden/Alluvium Surface Contact (dashed where inferred)

Beaumont Site 1 Property Boundary

Notes: Beaumont Site 1 property boundary is approximate.

contour interval 3, 10, 100, 1,000.

Beaumont Site 1

Figure 1-5

Site 1 1,4-Dioxane Source Areas and Groundwater Impacts

TETRA TECH

1.2.1.2.3 Nature and Extent of Surface Water Impacts

All groundwater COPCs have been detected in the surface water ponds located near the west end of the alluvial valley, which are directly fed by discharging groundwater. COPC concentrations within these surface water ponds, which are not directly connected to the streambed, are consistent with groundwater concentrations detected in nearby monitoring wells. In addition, several groundwater COPCs have been detected in surface water samples collected from within the streambed of Potrero Creek with the highest concentrations generally detected where surface water first daylights within the streambed from discharging groundwater. Concentrations then generally decrease in surface water samples downstream of the first surface water occurrence. As stated above, these areas of intermittent surface flow where the samples are collected represent groundwater discharge where the stream is gaining in some reaches. The highest groundwater COPC concentrations detected in surface samples collected from within the streambed are as follows; perchlorate (8.54 µg/L), 1,4-dioxane (4.2 µg/L), 1,1-DCE (1.2 µg/L), TCE (0.42 µg/L), and cis-1,2-DCE (0.42 µg/L). 1,4-dioxane has been persistent in surface water samples collected within the streambed at the Site and is the only analyte that has been detected within Potrero Creek at the site boundary. Concentrations of 1,4-dioxane detected in surface water in the western portion of the Site at the property boundary have been about 1 µg/L and have never exceeded the DWNL of 3 µg/L.

1.2.2 Beaumont Site 2

1.2.2.1 Site 2 History

Site 2 consists of 2,668 acre of land located southwest of Beaumont, California (Figure 1-1). Prior to 1958, the parcels that comprise the Site were owned by individuals and the United States government, and were used for agricultural purposes. Between 1958 and 1960, portions of the Site were purchased by Grand Central Rocket Company (GCR) for use as a remote rocket motor test facility (Radian, 1986). In 1960, Lockheed Aircraft Corporation (LAC) purchased one half interest in GCR. In 1961, GCR became a wholly owned subsidiary of LAC. The remaining parcels of land that comprise the Site were purchased from the U.S. government between 1961 and 1964. In 1963, LPC became an operating division of LAC, and was responsible for the operation of the Site until its closure in 1974. In 2006, the Site was sold to the County of Riverside.

From 1958 to 1974, the Site was utilized by GCR and LPC for small rocket motor assembly, rocket motor testing operations, propellant incineration, and minor disposal activities (Radian, 1986). Ogden Technology Laboratories, Inc. (Ogden) is known to have leased portions of the Site in the 1970s (Radian,

1986). According to interviews with LPC personnel familiar with the Site, a portion of the Site was also used by General Dynamics for testing remote sensing devices in the late 1980s (Tetra Tech, 2009a).

Four primary historical operational areas were identified at the Site by Tetra Tech (2003). Based on new information obtained since 2003, a fifth area (the Waste Discharge Area [WDA]) has been identified at the Site as a potential source area (Tetra Tech, 2007). Each area was responsible for various activities associated with rocket motor assembly, testing, and propellant incineration. The locations of the four historical operational areas and the WDA are shown on Figure 1-6. A brief description of each operational area follows.

1.2.2.1.1 Historical Operational Area J – Final Assembly

Area J consists of a former building (Building 250) and related facilities which were used for the final assembly and shipment of rocket motors for the SRAM program from 1970 to 1974. Rocket motor casings containing solid propellant were manufactured off Site and transported to Building 250, where final hardware assembly was conducted (Radian, 1986). Assembly operations reportedly included installation of the motor nozzle and headcap, pressure check of the motor, installation of electrical systems, and preparation of the assembled motor for shipment (Radian, 1986). During facility closure in 1974, all usable parts of this facility were dismantled, taken off Site and sold. Building 250 was demolished in 1991 (Radian, 1993). At present, only the building foundation remains.

Two groundwater production wells (W2-2 and W2-5) were formerly located in Area J. Wells W2-2 and W2-5 were destroyed in accordance with California well standards and permits issued by the Riverside County Department of Environmental Health (RCDEH) in December 2007 (Tetra Tech, 2009b).

1.2.2.1.2 Historical Operational Area K – Test Bays and Miscellaneous Facilities

Area K is divided into 2 subareas. Subarea K 54 is located in Test Bay Canyon, and includes a test centrifuge, 4 rocket motor test bays, 2 bunkers, and a large earthen structure referred to as the "Prism." Subarea K 55 is located in Laborde Canyon immediately south of Test Bay Canyon, and includes 3 groups of conditioning chambers.

The centrifuge was located in a small side canyon on the western side of the northern portion of Test Bay Canyon. Rocket motors were attached parallel to the centrifuge arm and test fired to evaluate whether the solid propellant would separate from the motor casing under increased gravitational forces. Structures remaining at this location include the centrifuge mounting pedestal, and an earthen berm separating the centrifuge area from the main portion of Test Bay Canyon. A second bermed area, which contains the remains of an electrical control panel, is located to the north of the centrifuge.

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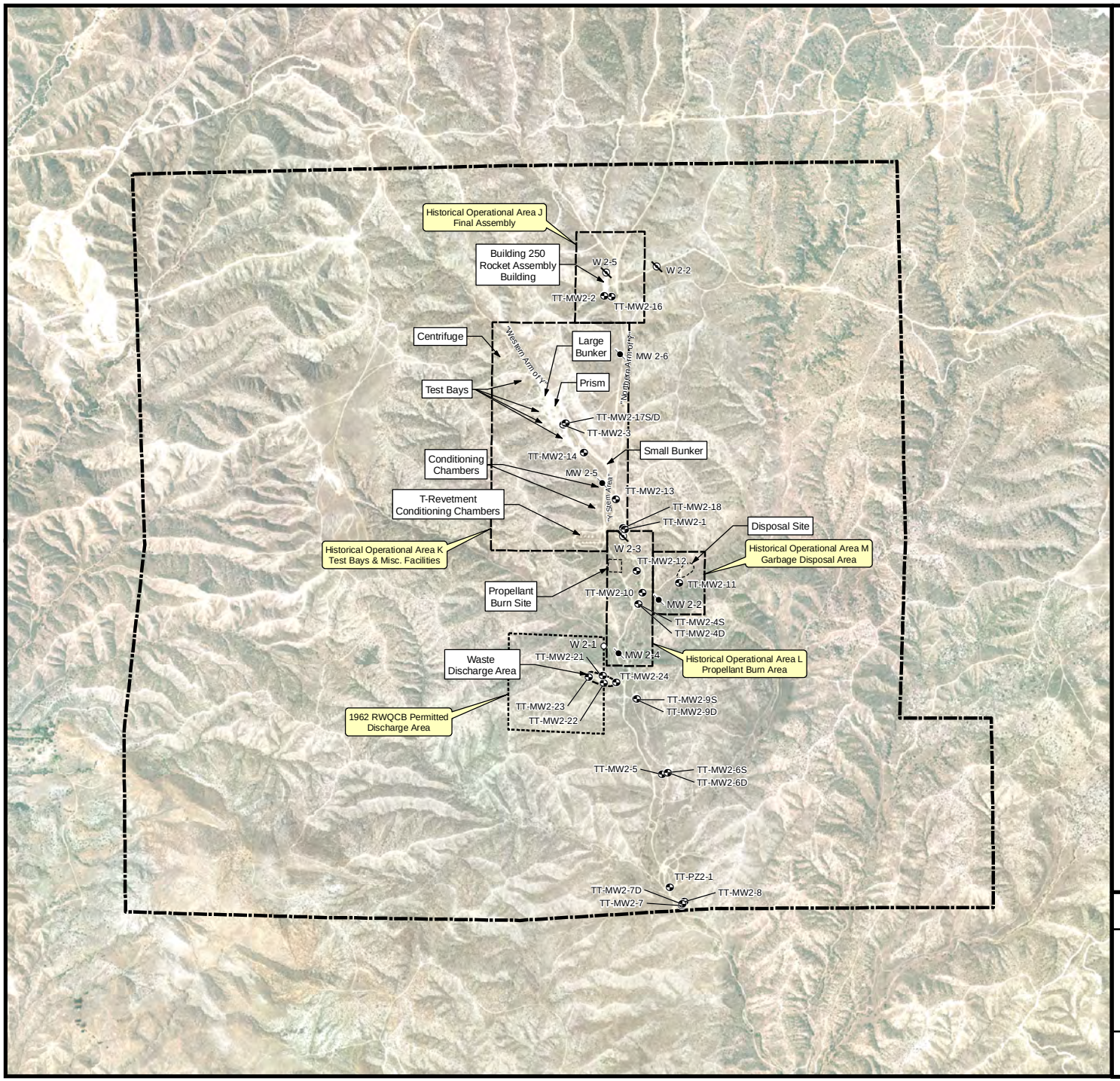

0 1,000 2,000
Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- Groundwater Monitoring Well Location
- Destroyed Production Well Location
- Destroyed Monitoring Well Location
- Reported Production Well Location
- Beaumont Site 2 Property Boundary
- Historical Operational Area Boundary
- RWQCB Permitted Discharge Area
- Liquid Waste Disposal Area

Note: Beaumont Site 2 property boundary from Hillwig-Goodrow survey, May 2004.

Disposal and Propellent Burn Site perimeters are estimated (Radian, 1986a).

Beaumont Site 2

Figure 1-6
Site 2
Historical Operational Areas and Site Features

TETRA TECH

The test bays were located in small side canyons on the western side of the central portion of Test Bay Canyon. Initially, only 3 test bays (Test Bays 1, 2, and 3) were recognized; a fourth test bay (Test Bay 4) was subsequently identified based on interviews with former LPC employees. The test bays were used for test firing rocket motors. Historic photographs included in Radian (1986) and Tetra Tech (2009a) show that rocket motors were mounted horizontally in the test bays so that the exhaust plume extended into Test Bay Canyon. Features remaining at Test Bays 1, 2, and 3 include the concrete test bay structures and concrete pads which extend eastward from the test bays. The test bays were filled with soil in 2003 to reduce potential safety hazards. Structures remaining at Test Bay 4 include a metal faced concrete feature, which appears to be a thrust block, and a concrete pad extending to the east of the thrust block.

The bunkers include a small bunker located near the junction of Test Bay Canyon and Laborde Canyon, and a large bunker located between Test Bays 1 and 4. The small bunker was used as a control bunker during early operations at the Site. The large bunker, which is partitioned into several rooms, was used as a control bunker during later testing operations. By 2003, the roof of the small bunker had collapsed. This structure was filled with soil in 2003 to reduce potential safety hazards. The large bunker is largely intact.

The Prism is a large earthen structure located in the central portion of Test Bay Canyon. The Prism was reportedly constructed by General Dynamics for testing remote sensing equipment (Tetra Tech, 2009a). It is not known exactly when the Prism was constructed. However, the Prism was not observed in 1984 aerial photos and was not noted in the Radian historical report (Radian, 1986), but was observed in 1990 aerial photos (Tetra Tech, 2009a). Field observations suggest that up to 10 feet of soil may have been excavated from the surrounding area and used for construction the Prism. The Prism is largely intact, although evidence of erosional failure is apparent on the southern face of the structure.

The conditioning chambers were located in 3 box canyons on the western side of Laborde Canyon, to the south of Test Bay Canyon. The conditioning chambers were reportedly used to examine the effects of extreme temperatures on rocket motors and to meet specification requirements (Radian, 1986). Concrete slabs are present at the former locations of the 2 northern conditioning chambers. A T-shaped earthen berm and revetments (referred to as the "T-Revetment") is present further to the south. Nine conditioning chambers were reportedly present in the T-Revetment area (Radian, 1986; Tetra Tech, 2009a). The berms, revetments, and concrete pads within the revetted areas remain intact.

One possible well (Unknown #2) was formerly located in Area K. Unknown #2 was destroyed in accordance with California well standards and permits issued by the RCDEH in November 2007 (Tetra Tech, 2009b).

1.2.2.1.3 Historical Operational Area L – Propellant Burn Area

Area L is located immediately south of Area K. According to Radian (1986), large slabs of solid propellant were reportedly transported to Area L and placed on the ground surface for incineration. Diesel fuel was reportedly used to initiate combustion, and once ignited, the propellant would burn rapidly. Reportedly, no pits or trenches were dug as part of the burning process.

No obvious man made structures, such as concrete pads, regularly shaped depressions, berms, or other features which may indicate where propellant incineration could have taken place are present within Area L, and historical aerial photographs reviewed by Tetra Tech (2009a) showed no evidence of brush clearing or other activities consistent with propellant incineration within Area L. Furthermore, site investigation work conducted by Tetra Tech (Tetra Tech, 2005 and 2009d) has not found evidence of burning or significant contamination in Area L. It is possible that propellant incineration activities at the Site may have been conducted in the WDA (Section 1.2.2.1.5 below) rather than Area L.

Two former groundwater production wells (W2-1 and W2-3) and one possible well (Unknown #1) were associated with Area L. Well W2-1 was reportedly located in a side canyon off of Laborde Canyon, but was not found during Site investigations. Wells W2-3 and Unknown #1 were destroyed in accordance with California well standards and permits issued by the RCDEH in December and November 2007, respectively (Tetra Tech, 2009b).

1.2.2.1.4 Historical Operational Area M – Garbage Disposal Area

Area M is located in Disposal Site Canyon, a major side canyon located south of Area L on the eastern side of Laborde Canyon. Materials disposed in Area M by LPC reportedly included scrap metal, paper, wood, and concrete. According to Radian (1986), hazardous materials, including explosives and propellants, were never disposed of at the disposal site by LPC. The Area M disposal site was also used by Ogden Labs, a company that that tested valves and explosive items. Reportedly, Ogden Labs disposed of hazardous materials at the disposal site. In 1972, a Lockheed Safety Technician was exposed to unsymmetrical dimethylhydrazine (UDMH) vapors from a pressurized gas container located within the disposal site. Based on potential exposure risks to site personnel, LPC's safety group required Ogden Labs to take measures to remove any potentially hazardous materials from the disposal site. Shortly thereafter, a disposal company was reportedly contracted by Ogden to clean up the disposal site (Radian, 1986). Radian (1986; 1993) reported that surficial debris at the Area M disposal site included concrete debris, scrap wood, metal pipes, several junked cars, and metal drums labeled "non contaminated."

In 1993, a removal action was conducted at the Area M disposal site with oversight from the California Department of Toxic Substances Control (DTSC) (Radian, 1993). As part of the removal action, the

surficial debris was removed and a total of 816.45 tons of non hazardous waste materials were excavated and disposed off site. A Report of Completion of Removal Action for the disposal site was subsequently issued by the DTSC on April 30, 1993 (DTSC, 1993).

Features remaining at Area M include 2 mounds of soil referred to by Radian (1993) as the "North Mound" and "South Mound." The mounds mark the approximate northeastern and southwestern limits of the former disposal area, and according to Radian (1993), consist of soil excavated from the original disposal trench.

1.2.2.1.5 Waste Discharge Area

In 2007, LMC discovered the existence of Santa Ana River Basin Regional Water Pollution Control Board (SARWPCB) Resolution 62-24, issued to LPC on September 14, 1962 (SARWPCB, 1962). Resolution 62-24 prescribed requirements for the "discharge of industrial wastes (rocket fuel residuum) to excavated pits." The discharge area was described as 2 shallow basins protected by 2 foot berms, located in a small canyon on the western side of Laborde Canyon, in the SW ¼ of the NW ¼ of Section 19, Township 3 South, Range 1 West, San Bernardino Baseline and Meridian. Resolution 62-24 further described the wastes to be discharged as "residue remaining after the manufacturing refuse is burned," and indicated that amount of material to be discharged was "approximately 5,000 gallons per year."

The exact nature of the waste proposed for discharge is not clear from the language of Resolution 62-24. The description of the waste material suggests that the area may have been used for propellant incineration; but the use of volume units to describe the quantity of material to be discharged suggests that the waste may have been liquid rather than solid. A 1961 aerial photograph shows the WDA as a large cleared area with roads leading to 2 circular structures, suggesting that the WDA was in use by 1961 (Tetra Tech, 2009a). The brush clearing is consistent with use of the area for propellant incineration rather than disposal of liquids. Investigation of this area (Tetra Tech, 2007; 2009c) found perchlorate and chlorinated solvent impacts in both soil and groundwater.

Features remaining at the WDA include two roughly circular depressions surrounded by earthen berms, at the approximate locations of the circular structures identified in the 1961 aerial photograph (Tetra Tech, 2009a).

1.2.3 Findings of Previous Investigations

Compounds detected in soil at Site 2 include perchlorate, TCE, and methylene chloride. Compounds detected in groundwater at concentrations exceeding California MCLs include perchlorate, TCE, methylene chloride, Royal demolition explosive (RDX), and 1,4-dioxane.

1.2.3.1 Nature and Extent of Soil Impacts

Perchlorate

The extent of perchlorate impacted soil at the Site is shown in Figure 1-7. Two major areas of perchlorate-impacted soil have been identified at the Site: in southern Test Bay Canyon, near Test Bays 1, 2, and 3; and at the WDA. Minor areas of perchlorate impacted soil have also been identified in northern Test Bay Canyon and in Area M.

The perchlorate impacted soil in southern Test Bay Canyon includes a relatively large area of near surface impacts mainly restricted to depths of 15 feet or less, and three areas of deeper impacts which extend to groundwater. The deeper impacts are located near Test Bays 1, 2, and 3. Near the water table, a thin "tongue" of impacted soil extends across the canyon and downgradient from Test Bay 3. The maximum perchlorate concentration detected in soil at Test Bays 1 and 2 is 1,700 µg/kg; the maximum perchlorate concentration at Test Bay 3 is greater than 100,000 µg/kg. Test Bay 3 is considered to be primary perchlorate source area in southern Test Bay Canyon.

Perchlorate impacted soil in the WDA is confined to a small side canyon located on the western side of Laborde Canyon. The maximum perchlorate concentration detected in soil in the WDA is greater than 100,000 µg/kg.

Four relatively small areas of impacted soil are present in northern Test Bay Canyon, the largest of which (0.1 acres in area) is located in Test Bay 4. The highest perchlorate concentration detected in northern Test Bay Canyon is 690 µg/kg, in Test Bay 4. The perchlorate impacted soil in Area M has an area of approximately 0.1 acres, and the maximum detected perchlorate concentration is 3,100 µg/kg.

TCE

The extent of TCE impacted soil at the Site is shown in Figure 1-8. TCE was detected in soil from borings TT-MW2-21, TT-MW2-22, SB4, and SB5, all of which are located in the WDA. TCE was not detected in any other borings. The maximum detected TCE concentration was 680 µg/kg, in boring TT-MW2-22. Based on these results, the extent of TCE impacted soil appears to be localized to the WDA.

Methylene Chloride

The extent of methylene chloride impacted soil at the Site is shown in Figure 1-9. Methylene chloride was detected in soil from borings TT-MW2-21, TT-MW2-22, TT-MW2-23, and SB4, all of which are located in the WDA. Methylene chloride was not detected in any other borings. The maximum detected methylene chloride concentration was 21,000 µg/kg, in boring TT-MW2-22. Based on these results, the extent of methylene chloride impacted soil is coincident with but smaller than the TCE impacted soil, and appears to be localized to the WDA.

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Historical Operational Area J
Final Assembly

TT-MW2-2
TT-MW2-16
TT-MW2-29A/B/C
Centrifuge
Test Bay 4
Large Bunker
TT-MW2-36A/B/C
Test Bay 1
Prism
TT- MW2-40A/B/C
TT-MW2-17S/D
Test Bay 2
TT-MW2-3
100,000
TT-MW2-39
TT- MW2-33A/B/C
TT-MW2-38A/B/C
Test Bay 3
TT-MW2-14
Small Bunker
TT- MW2-30A/B/C
TT-MW2-34A/B/C
Conditioning Chambers
TT-MW2-13
Conditioning Chambers
Historical Operational Area K
Test Bays & Misc. Facilities
TT-MW2-31A/B
TT-MW2-18
TT-MW2-1
T-Revetment
Conditioning Chambers
1,000
100
10
6
TT-MW2-12
100
6
10
Disposal Site
TT- MW2-35A/B
TT-MW2-32
TT-MW2-10
TT-MW2-11
TT-MW2-4S/D
TT-MW2-28
Historical Operational Area M
Garbage Disposal Area
Historical Operational Area L
Propellant Burn Area
TT-MW2-24
Waste Discharge Area
TT-MW2-21
TT-MW2-26
TT-MW2-23
100,000
10,000
TT-MW2-22
TT- MW2-37B
TT-MW2-37A
TT-MW2-27
TT-MW2-9D
TT-MW2-9S
TT- MW2-25
1,000
TT-MW2-5
TT-MW2-6S/D
6
10
100
TT-PZ2-1
TT-MW2-7D
TT-MW2-8
TT-MW2-7

LEGEND

Perchlorate in Groundwater
- 6 µg/L
- 10 µg/L
- 100 µg/L
- 1,000 µg/L
- 10,000 µg/L
- 100,000 µg/L

Perchlorate Soil Source >µg/kg

Monitoring Well Location

Ground Surface Elevation Contour
(10-foot interval - feet msl)

Historic Operational Area Boundary

Note:
µg/L - Micrograms per liter.

N

0 300 600 Feet

Beaumont Site 2

Figure 1-7
Site 2
Perchlorate Source Areas and Groundwater Impacts

TETRA TECH

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Historical Operational Area J
Final Assembly

TT-MW2-2
TT-MW2-16
TT-MW2-29A/B/C
Centrifuge
Test Bay 4
Large Bunker
TT-MW2-36A/B/C
Test Bay 1
Prism
TT- MW2-40A/B/C
TT-MW2-17S/D
Test Bay 2
TT-MW2-3
TT-MW2-39
TT- MW2-33A/B/C
TT-MW2-38A/B/C
Test Bay 3
TT-MW2-14
Small Bunker
TT- MW2-30A/B/C
TT-MW2-34A/B/C
Conditioning Chambers
TT-MW2-13
Conditioning Chambers
Historical Operational Area K
Test Bays & Misc. Facilities
TT-MW2-31A/B
TT-MW2-18
TT-MW2-1
T-Revetment
Conditioning Chambers
TT-MW2-12
TT-MW2-32
TT-MW2-11
Disposal Site
TT- MW2-35A/B
TT-MW2-10
TT-MW2-4S/D
TT-MW2-28
Extent of TCE in Groundwater
Historical Operational Area M
Garbage Disposal Area
Waste Discharge Area
TCE Soil Source
TT-MW2-24
TT-MW2-21
TT-MW2-26
TT-MW2-23
TT-MW2-37A/B
TT-MW2-22
TT-MW2-9D
Extent of TCE in Groundwater
TT-MW2-27
TT-MW2-9S
TT- MW2-25
Historical Operational Area L
Propellant Burn Area
TT-MW2-5
TT-MW2-6S/D
TT-PZ2-1
TT-MW2-7D
TT-MW2-8
TT-MW2-7

LEGEND

- Monitoring Well Location
- TCE Soil Source
- TCE in Groundwater
- Ground Surface Elevation Contour (10-foot interval - feet msl)
- Historic Operational Area Boundary

N

0 300 600 Feet

Beaumont Site 2

Figure 1-8
Site 1
TCE Source Areas and Groundwater Impacts

TETRA TECH

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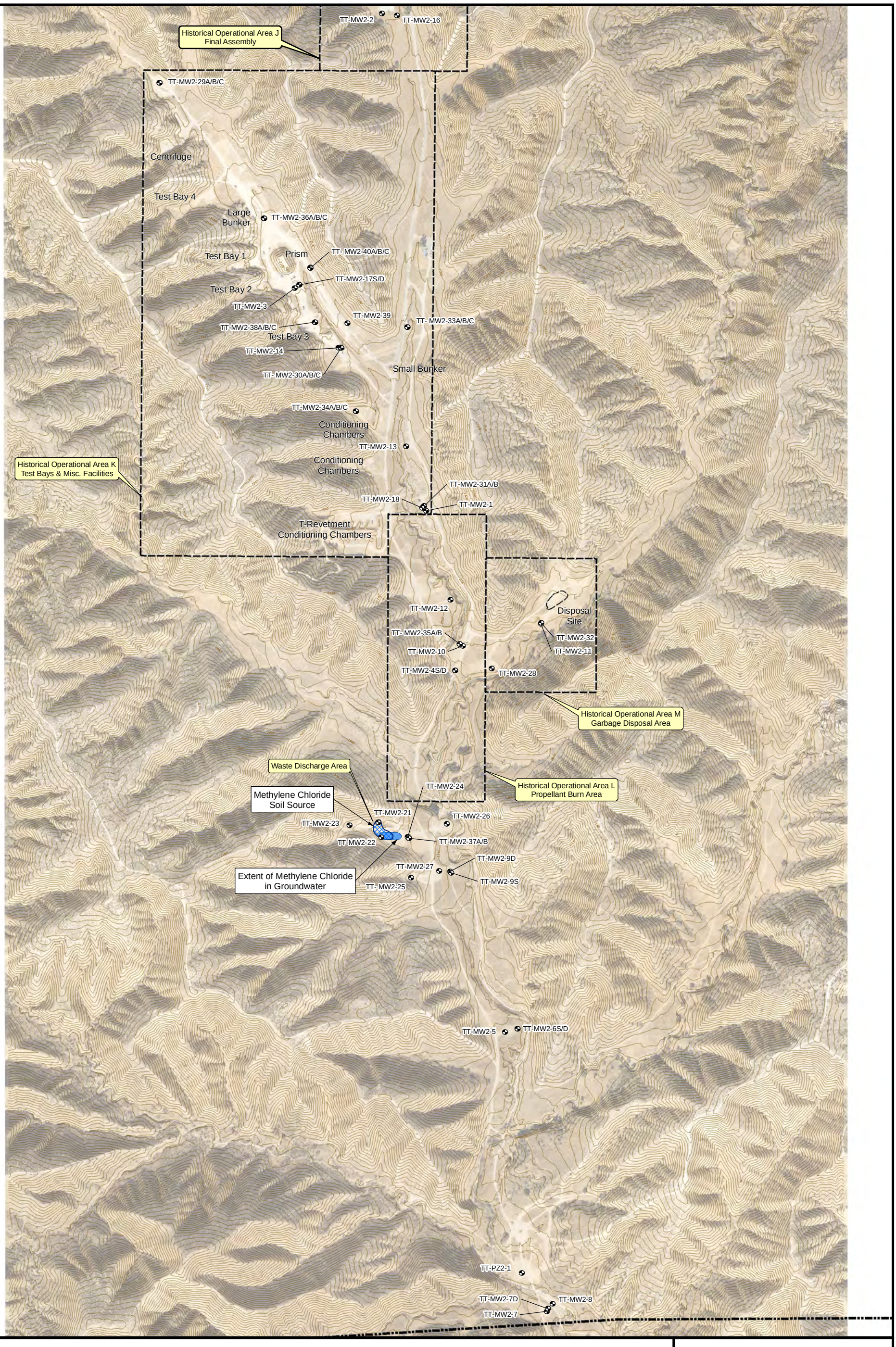

LEGEND

- Monitoring Well Location
- Methylene Chloride Soil Source
- Methylene Chloride in Groundwater
- Ground Surface Elevation Contour (10-foot interval - feet msl)
- Historic Operational Area Boundary

N

0 300 600 Feet

Beaumont Site 2

Figure 1-9

Site 2
Methylene Chloride Source Areas and Groundwater Impacts

TETRA TECH

1.2.3.2 Nature and Extent of Groundwater Impacts

Perchlorate

The extent of perchlorate in groundwater is shown in Figure 1-7. Two major perchlorate plumes have been identified at the Site: one related to soil impacts in southern Test Bay Canyon (Test Bay Canyon plume), and one related to soil impacts in the WDA (WDA plume). Minor perchlorate plumes are also present in the Centrifuge area in northern Test Bay Canyon, and in Area M.

The Test Bay Canyon groundwater plume extends approximately 2,100 feet downgradient from the source area near Test Bay 3, terminating to the north of well TT-MW2-12 in Laborde Canyon. Perchlorate concentrations in groundwater at the source area exceed 100,000 µg/L. Perchlorate concentrations gradually attenuate to approximately 13,000 µg/L at well TT-MW2-18, and then rapidly attenuate to non detectable concentrations at well TT-MW2-12, located approximately 625 feet downgradient of TT-MW2-18.

The WDA groundwater plume extends at least 3,700 feet downgradient from the source area in the WDA to beyond the southern boundary of the Site. Maximum perchlorate concentrations in groundwater at the source area exceed 100,000 µg/L. Perchlorate concentrations gradually attenuate to approximately 500 µg/L at the southern property boundary. In May 2008, perchlorate was not detected in off Site wells TT-MW2-19S and D, located approximately 4,200 feet south of the southern property boundary, indicating that the WDA plume is less than approximately 7,900 feet long.

The perchlorate impacted groundwater at the Centrifuge area appears to be limited to a perched groundwater zone. The maximum perchlorate concentration in groundwater is 230 µg/L, and based on the apparently limited occurrence of perched groundwater at the Site, is likely to be relatively small in lateral extent. The Area M groundwater plume extends approximately 900 feet downgradient from the soil source area in Disposal Site Canyon. The maximum detected perchlorate concentration in groundwater at the source area is 560 µg/L, and gradually attenuates to 28 µg/L at downgradient well TT-MW2-28.

TCE

The extent of TCE in groundwater at the Site is shown in Figure 1-8. In May 2008, TCE was detected at concentrations exceeding the MCL of 5 µg/L in three monitoring wells: TT-MW2-11, located in Area M, and TT-MW2-22 and TT-MW2-24, both of which are located in the WDA.

The TCE concentration in well TT-MW2-11 in May 2008 was 8.6 µg/L. TCE was detected at a concentration of 0.24 µg/L in deep monitoring well TT-MW2-32, which is located adjacent to TT-MW2-11. TCE concentrations in wells TT-MW2-22 and TT-MW2-24 in May 2008 were 84 µg/L and

110 µg/L, respectively. The extent of TCE appears to be shallow and localized in the WDA. As shown in Figure 1-8, a soil source for the TCE in groundwater has been identified in the vicinity of wells TT-MW2-21 and TT-MW2-22.

Methylene Chloride

The approximate extent of methylene chloride in groundwater is shown in Figure 1-9. Methylene chloride has been detected at concentrations exceeding the MCL of 5 µg/L in monitoring well TT-MW2-22, located in the WDA. In May 2008, methylene chloride was detected at a concentration of 220 µg/L. The extent of methylene chloride in the WDA appears to be localized in the area of well TT-MW2-22. As shown in Figure 1-9, a soil source for the methylene chloride in groundwater has been identified in the vicinity of wells TT-MW2-21 and TT-MW2-22.

RDX

The approximate extent of RDX in groundwater is shown in Figure 1-10. RDX has been detected at concentrations exceeding the DWNL of 0.5 µg/L in wells TT-MW2-13, TT-MW2-1, both of which are located in Laborde Canyon, and in well TT-MW2-24, located in the WDA. In May 2008, RDX was detected in well TT-MW2-13 at a concentration of 0.57 µg/L, and was not detected in well TT-MW2-1. The extent of RDX in groundwater in Laborde Canyon south of Test Bay Canyon appears to be localized in the area of well TT-MW2-13. A soil source for the RDX in groundwater has not been identified in this area.

RDX was detected well TT-MW2-24 at a concentration of 4.7 µg/L. RDX was not detected in other wells in the WDA. The extent of RDX appears to be localized to the area of TT-MW2-24.

1,4-Dioxane

The approximate extent of 1,4-dioxane in groundwater is shown in Figure 1-11. 1,4-dioxane has been detected in groundwater monitoring wells located within and downgradient from the WDA, and has not been detected in monitoring wells TT-MW2-7S and TT-MW2-8, located near the southern property boundary. The maximum detected 1,4-dioxane concentration is 250 µg/L in well TT-MW2-24, located in the WDA.

1.3 PROJECT ORGANIZATION AND RESPONSIBILITY

The following section describes the responsibilities and qualifications of the key personnel that will be utilized to complete this project. Figure 1-12 shows the project management organization chart proposed for this project. The organization, functional responsibilities of key staff, and levels of authority among key participants are described below.

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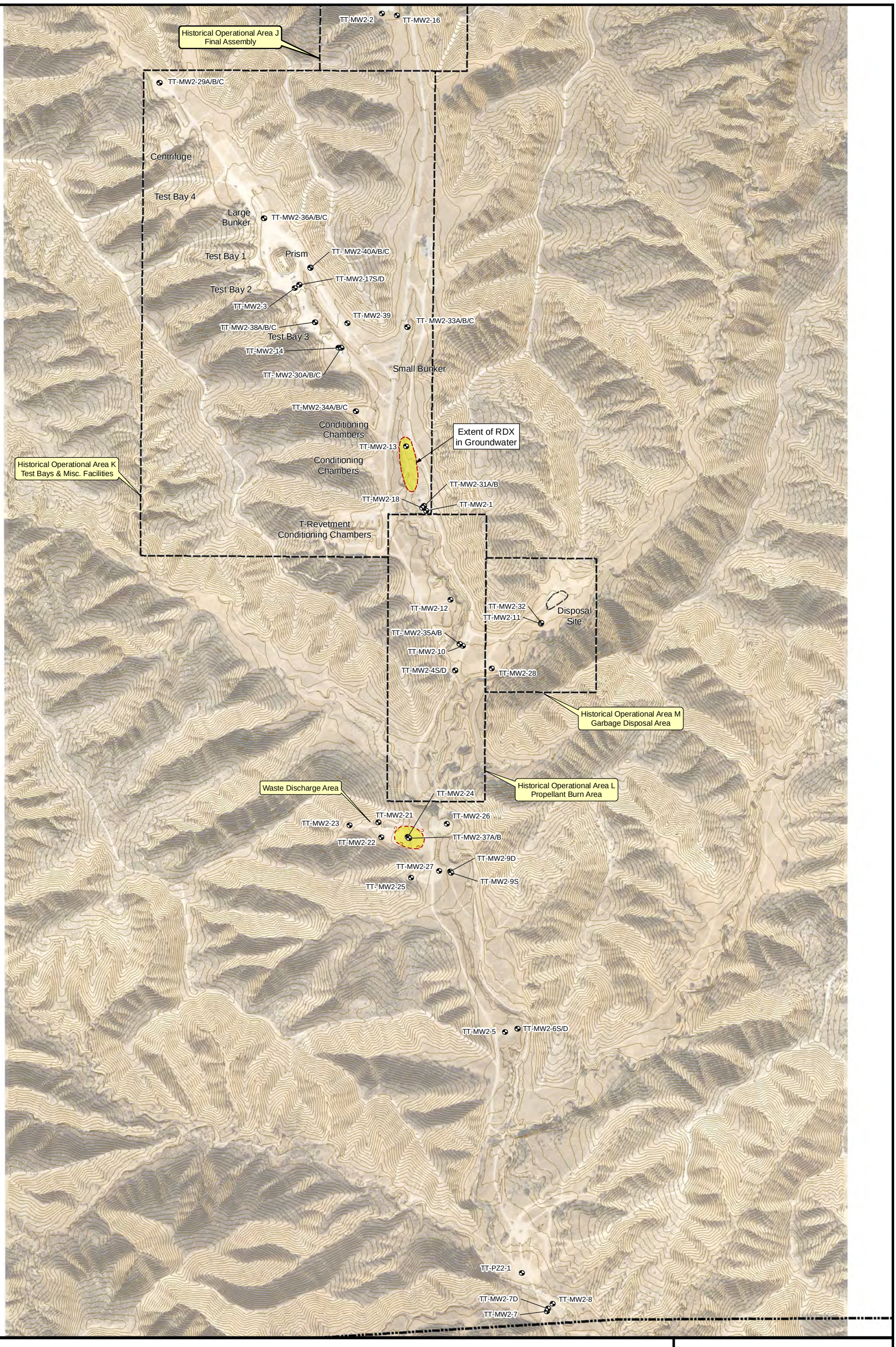

LEGEND

- Monitoring Well Location
- RDX in Groundwater
- Historic Operational Area Boundary
- Ground Surface Elevation Contour (10-foot interval - feet msl)

N

0 300 600 Feet

Beaumont Site 2

Figure 1-10

Site 2
RDX Groundwater Impacts

TETRA TECH

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TT-MW2-2
TT-MW2-16
Historical Operational Area J
Final Assembly
TT-MW2-29A/B/C
Centrifuge
Test Bay 4
Large
Bunker
TT-MW2-36A/B/C
Test Bay 1
Prism
TT- MW2-40A/B/C
TT-MW2-17S/D
Test Bay 2
TT-MW2-3
TT-MW2-39
TT- MW2-33A/B/C
TT-MW2-38A/B/C
Test Bay 3
TT-MW2-14
Small Bunker
TT- MW2-30A/B/C
TT-MW2-34A/B/C
Conditioning
Chambers
TT-MW2-13
Conditioning
Chambers
Historical Operational Area K
Test Bays & Misc. Facilities
TT-MW2-31A/B
TT-MW2-18
TT-MW2-1
T-Revetment
Conditioning Chambers
TT-MW2-12
Disposal
Site
TT- MW2-35A/B
TT-MW2-32
TT-MW2-10
TT-MW2-11
TT-MW2-4S/D
TT-MW2-28
Historical Operational Area M
Garbage Disposal Area
Waste Discharge Area
TT-MW2-24
TT-MW2-37A/B
Historical Operational Area L
Propellant Burn Area
TT-MW2-21
TT-MW2-26
TT-MW2-23
TT-MW2-22
10
100
1
TT-MW2-9D
TT-MW2-27
TT-MW2-9S
TT- MW2-25
TT-MW2-5
TT-MW2-6S/D
TT-PZ2-1
TT-MW2-7D
TT-MW2-8
TT-MW2-7

LEGEND

- Monitoring Well Location
- 1,4-Dioxane Concentration in Groundwater
- Ground Surface Elevation Contour (10-foot interval - feet msl)
- Historic Operational Area Boundary

N

0 300 600 Feet

Beaumont Site 2

Figure 1-11
Site 2
1,4-Dioxane
Groundwater Impacts

TETRA TECH

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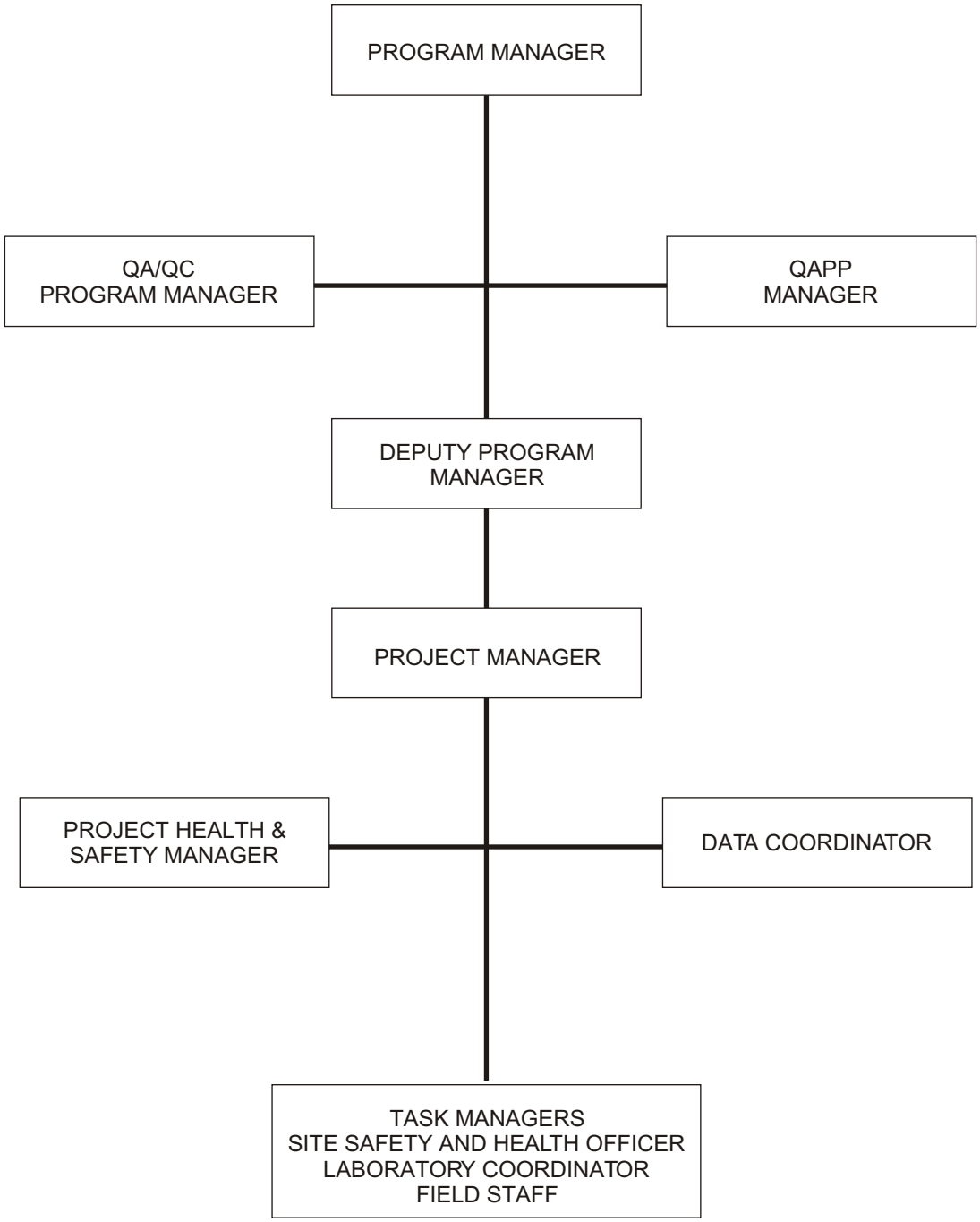


TETRA TECH

Beaumont Sites 1 & 2

Project Management Organization Chart

Figure **1-12**

The program organization diagram shown on Figure 1-12 includes open lines of communications between all functional roles. Open lines of communication will facilitate quick identification and communication of relevant issues to appropriate parties, so that appropriate personnel may address the issue without undue delay. As technical issues arise, the client point of contact (POC) shall be kept informed so that they may identify appropriate personnel to consult with during the decision making process. Subcontractor analytical laboratories must contact the Performing Contractor Program Manager as soon as technical problems arise which cannot be solved at the laboratory level. The Performing Contractor will work with the subcontractor laboratory to resolve technical problems related to data quality and should include client personnel, as appropriate.

1.3.1 Beaumont Site 1 and 2

The Performing Contractor has overall contract management responsibility for Sites 1 & 2 as described in this SAP.

1.3.1.1 Lockheed Martin Corporation, Point of Contact

The LMC POC provides Site-specific technical guidance and assistance to the Performing Contractor, including obtaining permits, facility access, maps, and drawings required for successful fulfillment of the contract.

1.3.2 Performing Contractor Responsibilities

The following Performing Contractor responsibilities are shown on the organizational chart (Figure 1-12).

1.3.2.1 Management Structure

The Quality Assurance/Quality Control (QA/QC) Manager and Project Manager roles are designed to support the Program Manager by directing the field team. The SAP, therefore, must describe the project organization for implementing field operations. In preparing site-specific FSP or QAPP Addenda, the Performing Contractor shall: (1) describe the project organization and key personnel responsibilities, (2) provide a project organizational chart identifying task managers and individuals responsible for performance of the project, (3) provide a list of names of all key participants, including organization names and telephone numbers for project, field, and laboratory QA officers, (4) include a description of the authority given to each key participant with an emphasis on the authority of the key individuals to initiate and approve corrective actions, and (5) describe the role of regulatory representatives. In addition, the Performing Contractor shall identify all subcontractors and define the scope of their performance in the project. Subcontractors proposed to provide backup services shall also be identified.

1.3.2.2 Project Personnel

Project personnel will be selected to provide specific technical and management capabilities and qualifications as required.

Program Manager

The Program Manager is responsible for the overall management of the Sites 1 & 2 program, including the direction, supervision, and coordination of Performing Contractor personnel; regulatory agency interaction; and communications with LMC associated with ongoing activities at both sites.

Deputy Program Manager

The Deputy Program Manager responsible for the day-to-day management of the Sites 1 & 2 program, and for ensuring that appropriate resources and project personnel are available to implement the requirements set forth in this plan. The Deputy Program Manager also assists the Program Manager with agency and client contacts.

QA/QC Program Manager

The QA/QC Program Manager is responsible for the overall development of QA/QC for all fieldwork encompassing this program. The QA/QC Manager oversees all field activities, review deliverables containing validated data, and prepare field audit reports.

QAPP Manager

The Project QAPP Manager is responsible for project-related laboratory QA/QC elements, including data interpretation and the application of QA/QC to environmental analytical chemistry and laboratory operations. The review of deliverables containing validated data, the practice of data validation, and the preparation of final laboratory and field audit reports will be under QAPP Manager direction.

Project Manager

The Project Manager is responsible for management of an individual project within the Sites 1 & 2 program. The Project Manager is responsible for coordinating and scheduling fieldwork, coordinating with subcontractors, and for providing technical oversight of the project. The Project Manager will be a California-licensed Professional Geologist or Civil Engineer.

Data Coordinator

The Data Coordinator reviews the entire definitive data report package and applies the final data qualifiers. Verification of data reports includes a review of flags applied by the subcontractor laboratory for accuracy. The Data Coordinator uses various checklists during the verification process to document the verification activities. Changes to the data or flags are explained in a QA summary section of

technical reports. The Data Coordinator may utilize computer programs suitable for validation of laboratory data, which review and assess all analytical data, analytical methods, and protocols in accordance with this document and applicable addenda to this document. The Data Coordinator is responsible for preparing and maintaining electronic databases, and coordinates with the Program Manager and Subcontractor Laboratory Project Manager (LPM) to develop the electronic data deliverable (EDD) database.

Project Health and Safety Manager

The Project Health and Safety Manager (PHSM) is responsible for developing and revising the Health and Safety Plan (HASP). The PHSM will update and change the HASP, if warranted by changed conditions, and shall have the only authorization to effect such changes with input from the Program Manager. The PHSM will also conduct annual audits of the field work.

Task Managers and Support Staff

Task managers coordinate, facilitate, and implement tasks associated with different phases of a project. The support staff performs tasks on a day to day basis to assist with field activities, regulatory agency coordination, project requirements (i.e., permits, plans, etc.) and other aspects of the project required to implement field tasks.

One support staff member will be designated at the Site Safety and Health Officer (SSHO). The SSHO is responsible for field implementation of the HASP, including communicating site requirements to all personnel. Responsibilities of the SSHO include:

- enforcing the provisions of the HASP;
- conducting and documenting Tailgate Safety Meetings and Visitor Logs at beginning of each work day or shift;
- stopping work as required to ensure personal safety and protection of property or in the case of noncompliance with safety requirements;
- taking prompt corrective measures to eliminate existing and predictable hazards;
- taking the lead in emergency situation and arranging for emergency transportation to medical facilities;
- examine work party members for symptoms of exposure or stress;
- performing air monitoring as specified in the HASP; and
- maintaining health and safety files and training records in the Site field office.

One or more support staff members may be designated as Laboratory Coordinators. The Laboratory Coordinator's responsibilities include coordinating sample submission and project completion dates with the subcontractor laboratory. The Laboratory Coordinators communicate problems and project changes to the project management team and appropriate subcontractor laboratory staff; and reviews project data for

completeness and compliance with project requirements. The Laboratory Coordinator submits analytical results to the project management team.

1.3.3 Subcontractor Responsibilities

Identification of analytical laboratories, subcontractors, and their tasks are discussed in Section 3.2.3 of the QAPP.

1.4 SAMPLING AND ANALYSIS PLAN ORGANIZATION

The remainder of this document serves as a supplemental planning document to each project-specific Work Plan and describes the sampling, QA/QC, and analytical procedures that will be used for this project. The remainder of this section provides a brief overview of this document, organized as follows:

Section 2 – Field Sampling Plan: The FSP describes the field operations, environmental sampling procedures, field measurements, field QA/QC, record keeping requirements, and site management.

Section 3 – Quality Assurance Project Plan: The QAPP describes the project-specific analytical procedures, methods, and criteria that will be utilized for this program.

Section 4 – References: A list of documents cited in this SAP.

Section 5 – Acronyms: A list of acronyms and abbreviations used in this SAP.

2.0 FIELD SAMPLING PLAN

This FSP describes field operations, environmental sampling, field measurements, field QA/QC, record keeping requirements, and site management for multiple site activities at Sites 1 & 2. This FSP has been prepared to comply with the United States Environmental Protection Agency (EPA) document entitled "Guidance for the Data Quality Objectives Process" (EPA, 2000), herein referred to as EPA QA/G-4.

2.1 VARIANCES

The Performing Contractor, along with its subcontractors, shall perform their services in accordance with the requirements specified in this FSP. An approved variance is required for any exception to or deviation from the requirements in this FSP. An approved variance is also required if additional analytical methods or field sampling techniques are required to support a project but are not part of this FSP. The sampling and/or analytical method must be included in a FSP addendum with all the accompanying quality control requirements, i.e., reporting limits, calibration requirements, quality control measures, corrective action, data validation, and reporting requirements.

2.1.1 Procedure for Obtaining a Variance

Variance requests will be submitted in a letter to the Performing Contractor Program Manager. In the letter, specific variances from the FSP shall be identified by chapter, subtitle, paragraph, page, and line, with supporting justification for the change. When a subcontractor laboratory requests a variance, the Performing Contractor will evaluate the laboratory variance and make recommendations to either accept or reject it. Variances must be approved in writing by the Program Manager. The variance request and proposed course of action will be communicated to the LMC POC for approval.

2.1.2 Variance Documentation

Requests for variances and corresponding written approvals from LMC will be part of the project record. Once approved, a FSP addendum will be submitted to LMC. Only the variances approved by the LMC shall be included in the final version of the FSP addendum.

2.2 PURPOSE AND SCOPE

The FSP outlines field procedures and technical information for field programs conducted at Sites 1 & 2. All field activities performed by contractors or subcontractors at Sites 1 & 2 shall be conducted in accordance with the requirements specified in this FSP. This FSP is designed to be used in concert with the QAPP, and is compliant with EPA protocol and procedures. Each project-specific FSP Addendum shall briefly describe and discuss the purpose, scope, use, and compliance of the Addendum with the corresponding statement of work.

2.2.1 Objectives

The objectives of this FSP are to:

- provide guidance for field sampling activities performed onsite and offsite;
- establish and describe consistent field sampling procedures;
- establish data gathering, handling, and documentation methods; and
- define field QA/QC measures to ensure consistency and confidence in the data obtained.

The remaining sections of this FSP address the following topics:

- Project Activities (Section 2.3);
- Permitting and Utility Clearance (Section 2.4);
- Field Operations (Section 2.5);
  - Geologic Standards (Section 2.5.1);
  - Site Reconnaissance, Preparation, and Restoration Procedures (Section 2.5.2);
  - Geophysical Surveys (Section 2.5.3);
  - Drilling Operations (Section 2.5.4);
  - Well Installation (Section 2.5.5);
  - Well Development (Section 2.5.6);
  - Well Destruction (Section 2.5.7);
  - Soil Gas Surveys (Section 2.5.8);
  - Surveying (Section 2.5.9);
  - Water Level Measurement (Section 2.5.10);
  - Aquifer Testing (Section 2.5.11);
  - Surface Water (Section 2.5.12);
  - Equipment Decontamination (Section 2.5.13);
  - Investigation-Derived Waste Handling (Section 2.5.14);
  - Asbestos Surveys and Sampling (Section 2.5.15);
- Environmental Sampling (Section 2.6);
  - Soil Sampling (Section 2.6.1);
  - Sediment Sampling (Section 2.6.2);
  - Groundwater Sampling (Section 2.6.3);
  - Surface Water Sampling (Section 2.6.4);
  - Soil Gas Sampling (Section 2.6.5);
  - Sample Handling (Section 2.6.6);
  - Sample Custody (Section 2.6.7);
  - Fixed Laboratory Quality Control (Section 2.6.8);
  - Field Quality Control Samples (Section 2.6.9);
- Field Measurements (Section 2.7);
  - Health and Safety Monitoring (Section 2.7.1);
  - Environmental Monitoring (Section 2.7.2);

  - Equipment Calibration (Section 2.7.3);
  - Equipment Maintenance (Section 2.7.4);
- Field QC Program (Section 2.8);
  - Control Parameters (Section 2.8.1);
  - Control Limits and Corrective Action (Section 2.8.2);
  - Field Performance and System Audits (Section 2.8.3);
- Record Keeping (Section 2.9);
  - Field Logbooks (Section 2.9.1);
  - Data Sheets (Section 2.9.2);
  - Photographs (Section 2.9.3);
- Validity of Sampling Program (Section 2.10); and
- Site Management (Section 2.11).

2.2.2 Data Quality Objectives

The data quality objective (DQO) process is briefly discussed in Section 3.3.4 and is detailed in EPA QA/G-4. The DQO process shall be utilized in designing sampling and analytical programs for Sites 1 & 2. Each site-specific FSP Addendum shall discuss and summarize the DQOs for the project, justify the number, location, and types of samples and analyses, identify the data quality categories (e.g., screening versus definitive data), and describe the intended use of the data acquired.

2.3 PROJECT ACTIVITIES

Project activities that may be conducted include the following:

- remedial investigations/feasibility studies (RI/FS);
- remedial treatability studies;
- remediation system pilot studies; and
- groundwater monitoring, including monitoring well, production well, and surface water sampling.

Routine sampling conducted as part of operation and maintenance of remediation systems that may be constructed at Sites 1 & 2 in the future is not described in this FSP. Remediation system operation and maintenance sampling will be described in Operation and Maintenance manuals for the individual systems.

2.4 PERMITTING AND UTILITY CLEARANCE

Prior to conducting intrusive fieldwork, the LMC POC will be consulted to determine if there are any known utilities located within or near the proposed investigation areas. Prior to beginning any field activities, the proposed investigation area shall be visually inspected to identify any above ground obstructions or other items of concern.

Underground Service Alert (USA) shall be contacted at least two working days prior to commencing any subsurface investigation for marking of underground utilities. USA notifies utility companies who in turn will go to the site within two working days and mark utilities that they are responsible for maintaining. In some cases, only the utilities within public rights-of-way are marked and the property owner is responsible for identifying utilities on private property. According to USA, the gas and water companies will typically identify their lines up to the meter; the sewer company will identify their lines up to the main; and the telephone and electrical companies vary depending on local jurisdiction.

If groundwater wells are to be installed, a Well Permit Application shall be submitted to the Riverside County Department of Environmental Health. Drilling activities shall not commence until an approved Well Permit has been issued.

2.5 FIELD OPERATIONS

The following sections provide descriptions and specifications for conducting field operations at Sites 1 & 2. The procedures presented are designed to ensure that:

- All sampling and field measurements are consistent with project objectives;
- Samples are identified, preserved, and transported in a manner that does not compromise the integrity and validity of samples; and
- Field measurements are collected and recorded in a manner that will allow comparison and provide an adequate database for achieving the objectives of this investigation.

All drilling, well installation, well development, well purging, sampling methods, and related field activities will conform to State and other applicable regulatory agency requirements. Soil boring logs and well construction forms will be filed with the California Department of Water Resources (DWR) by the drilling subcontractor. For proposed work that is not described within this FSP, the subcontractor shall provide detailed descriptions and applicable specifications for conducting the work in a site-specific FSP Addendum.

2.5.1 Geologic Standards

Lithologic descriptions for unconsolidated materials (soils or other unconsolidated surficial deposits) shall follow the Unified Soil Classification System (USCS; American Society for Testing and Materials [ASTM] Standard D2487-06 [ASTM, 2008] and D2488-06 [ASTM, 2006]). Color descriptions shall be designated by the Munsell Color System.

Lithologic descriptions for consolidated materials (igneous, metamorphic, and sedimentary rocks) shall follow conventional geologic nomenclature (e.g., Compton, 1985). Special attention shall be given to

describing fractures, vugs, solution cavities and their fillings or coatings, and any other characteristics affecting permeability. Colors shall be designated by the Munsell Color System.

The scales for maps, cross sections, or other diagrams illustrating geologic or hydrogeologic features shall be selected in accordance with the geologic and hydrologic complexity of the area. Standard engineering scales shall be utilized whenever practicable. When geophysical logs are superimposed on geologic logs, cross sections, or 3-D diagrams, the scales shall be the same. If defining geological conditions require other scales, additional logs at those scales shall be provided.

Maps shall be oriented with north toward the top of the drawing, unless the shape of the area dictates otherwise. Orientation will be indicated with a north arrow. Maps will include a descriptive legend with symbols, as appropriate, and a visual (bar-type) scale.

2.5.2 Site Reconnaissance, Preparation, and Restoration Procedures

2.5.2.1 Site Reconnaissance

The locations of all activities will be marked prior to the field investigations using stakes and/or white paint. The Program Manager or Deputy Program Manager will approve all drilling locations before drilling commences. USA will be contacted at least two working days prior to field work to mark the locations of underground utilities.

In addition to the utility clearance, upon commencement of intrusive field activities, all borings shall be hand augered to a depth of 5 feet bgs in order to determine the presence or absence of any unknown utilities or other obstructions prior to drilling. If any obstruction is encountered during hand augering, the boring will be relocated by the onsite field staff, and the hand-auger process will be repeated at the new location. If no utilities or other obstructions are encountered during the hand auger process, the boring operation may commence at the planned location.

2.5.2.2 Equipment Staging and Decontamination Area

A staging area located near the work area will be designated for storing equipment and supplies, including a decontamination area and a storage area for solid and liquid wastes generated during the field activities. Drilling equipment, including all down-hole tools and equipment, will be decontaminated according to the procedures outlined in Section 2.5.13 of this FSP. The portion of the area designated as the equipment decontamination area will be large enough to accommodate a drilling rig and associated equipment. Fluids generated during decontamination activities will be contained within the area, and temporarily stored in holding tanks. Solid wastes generated from equipment decontamination will be stored in bulk storage bins, 55 gallon drums, or other appropriate containers.

Smaller decontamination areas for personnel and portable equipment shall be provided as necessary. These locations shall include buckets, basins, or tubs to capture decontamination fluids, which shall be transferred to holding tanks, as necessary. Personnel decontamination procedures are described in the HASP.

2.5.2.3 Potable Water and Electricity Supply

Potable water is not available at Sites 1 & 2. Depending on project-specific requirements, potable water shall be obtained at a designated off-site location and transported to the Site. Small quantities of potable water may be brought to the site in carboys or similar containers. Larger quantities of potable water may be brought to the site in a tank mounted on a drill rig or support vehicle, or may be brought in by water truck and stored on-site in a storage tank. Water tanks shall be placed in the equipment staging area.

Electric power is not available at Site 2, and is available at only one location at Site 1. Portable generators must be provided by the contractor or subcontractor for equipment requiring electric power. Generators shall be maintained in good operating condition. Generator fueling shall be conducted in a manner which minimizes the potential for spills. Secondary containment shall be provided in areas where fueling is conducted.

2.5.2.4 Site Security

Trespassers have been observed at Sites 1 & 2, and vandalism has been reported at both sites in the past. Site security for subcontractor equipment remaining onsite during field work shall be the sole responsibility of the subcontractor. At their discretion, subcontractors may choose to hire a private security service to provide security for equipment left on-site overnight or on weekends. Subcontractors shall be responsible for contracting directly with the security service. If a private security service is used, the following conditions will apply:

- Absolutely no driving is permitted at Sites 1 & 2 at night. To enforce this restriction, the security guard will be met at the upper gate of the Site by a representative designated by the Performing Contractor Program Manager and escorted to the work area. After arrival at the work area, the odometer reading of the guard's vehicle will be recorded. In the morning, a representative designated by the Program Manager will meet the guard at the work area, record the odometer reading of the guard's vehicle, and escort the guard to the upper gate of the Site.
- Absolutely no nighttime shift changes will be permitted.
- Absolutely no dogs or guns will be permitted at either site.
- Many areas at Sites 1 & 2 are accessible only by poorly graded dirt roads. If security personnel are utilized, it is recommended that they use a pickup truck, preferably 4-wheel drive.
- Under no circumstances will LMC or the Performing Contractor be liable for loss or damage to subcontractor equipment left onsite.

2.5.2.5 Emergency Equipment and Supplies

Emergency equipment (e.g., fire extinguishers, first-aid kits, personnel safety equipment) will be kept in plain view at each site where work is being conducted. Each work crew will be trained and equipped with a mobile phone to quickly alert the appropriate emergency service should assistance be required. Emergency phone numbers and egress routes will be posted on the dashboard of all work vehicles. Emergency response procedures are outlined in HASP.

2.5.2.6 Site Restoration

Each work site or sampling location shall be restored to its original condition when possible. Efforts shall be made to minimize impacts to work sites and sampling locations, particularly those in or near sensitive habitat. One of the objectives of restoration is to leave the area of investigation essentially as it was originally, except for the physical addition of monitoring wells, if required. Soil cuttings, unused well construction materials, and stakes/flagging will be removed from each site upon the conclusion of work. Following the completion of work at a site, all drums, trash, and other waste shall be removed. Decontamination and/or purge water and soil cuttings shall be transported to the designated staging area.

2.5.3 Geophysical Surveys

2.5.3.1 General Requirements for Geophysical Surveys

The Performing Contractor shall have a California-licensed geologist, geophysicist, or civil engineer supervise geophysical work. The locations of boreholes logged with geophysical instruments, surface geophysical grid system layouts, and/or areas analyzed with surface geophysical techniques shall be shown on a site map. Final results shall be presented in plan views with contours and/or cross sections, as appropriate. The interpretation of results shall discuss positive and negative results as well as limitations of the method and data, and the interpretation of the data shall be incorporated into the conceptual site model.

2.5.3.2 Surface Geophysical Surveys

Surface geophysical techniques include, but are not limited to, ground penetrating radar (GPR), magnetometry, electromagnetic, and seismic techniques. Use of any of these techniques is dictated by the project DQOs specified in the project-specific Work Plan. Surface geophysical survey objectives will be included in the project-specific Work Plan. The areas to be surveyed will be described and shown on site maps in the project-specific Work Plan.

Surface geophysical surveys are conducted along transect lines or within predetermined grids defined by transect lines crossing each site or area of interest. Grid spacing is determined from the approximate dimensions of the features to be located.

Location and elevation information sufficient to map and assess the survey results shall be recorded. Depending on the level of accuracy and detail required, northing and easting from a surveyed reference point, depth bgs, and/or professionally surveyed points and transects may be included. Location data, instrument numbers, calibration information, geophysical interpretation, and maps for all geophysical surveys shall be stored in project files.

For all surveys using a geophysical survey grid, at least two points on the grid will be surveyed. Distance will be measured in feet from the referenced location, which is tied to the State Plane Coordinate System. The Performing Contractor shall correlate surface survey data (profiles and soundings) with at least one soil boring, well bore, or outcrop at the same site as the survey.

2.5.3.2.1 Ground Penetrating Radar

GPR is a geophysical survey technique that provides a continuous real-time measurement of subsurface layering. The instrumentation for this type of investigation consists of a radar control unit, signal processing and conditioning circuitry, and a graphical recorder. This unit is connected to an antenna by an electrical umbilical cable. The antenna is towed along a traverse and transmits radar impulses into the ground. Interfaces between soil layers mark changes in physical properties in the subsurface; as these are encountered, the radar impulse typically undergoes a change in velocity, causing some of the radar energy to be reflected back to the antenna. The time required for the radar signal to travel from the antenna to a reflecting soil interface and back is proportional to the interface depth. The maximum depth of penetration will vary with subsurface soil conditions.

Recording these depth-dependent impulses on a scanning, time-based graphic chart recorder creates a cross-section of the areal distribution of subsurface layers and other features. The survey area shall be large enough to identify the natural distribution of layers.

2.5.3.2.2 Magnetometry

Magnetometer surveys measure variations in the earth's magnetic field. Measurements of the magnetic gradient can be used to locate buried ferrous objects such as tanks, pipelines, and metallic debris. Magnetometer surveys are conducted using a magnetometer/gradiometer or equivalent equipment. The magnetometer typically has two sensors and an electronics package. The magnetometer can collect both total field data and vertical gradient data and can discriminate to 0.2 gammas in a total field of 40,000 to

60,000 gammas. Magnetic readings are stored in memory with the time of day, station numbers, and line numbers of the readings. A base station for magnetic readings is established at the start of each day's measurements. Magnetic readings are collected and recorded at the base station in the morning, at noon, and at the end of day to evaluate instrument drift.

2.5.3.2.3 Electromagnetic Methods

Electromagnetic (EM) surveys measure the electrical conductivity of a subsurface volume, which is a function of the soil or rock type, porosity/permeability, fluid content, and fluid chemistry. The measured values, referred to as terrain conductivity, are obtained without direct ground contact through EM induction. Data collected during an EM survey can be used to map the location of buried utilities; depth or thickness determinations cannot be made solely by this method. Under some conditions, the EM technique can also detect chemicals or contaminant plumes (e.g., hydrocarbons in high concentrations or other conductive or resistive chemicals).

A ground conductivity meter (e.g., Geonics Ltd. EM-31DL or EM-34) is used to obtain terrain conductivity data. The transmitting and receiving coils on this instrument are mounted at the ends of 4-foot tubes that project horizontally from either end of the instrument console. The 8-foot coil separation results in a depth of penetration of approximately 15 to 18 feet. A data logger records quadrature and in-phase data at each measuring station.

EM data will be recorded in both digital and analog format along survey transects. Transect spacing will depend upon site-specific observations made during reconnaissance. The date, time, survey line number, and stationing information will be marked on the analog strip chart record as the EM data are collected. The locations of the EM transects will be plotted on a site map.

2.5.3.2.4 Seismic Surveys

Seismic refraction/reflection methods use seismic waves to determine the thickness and extent of lithologic units or to identify subsurface geologic structures, such as faults. Seismic surveys are conducted by generating seismic waves at the surface by striking a steel plate with a hammer or dropping a heavy object on the ground. To improve the signal-to-noise-ratio, multiple hammer blows or weight drops may stacked together to form a final data record for each location where data is collected. The seismic waves are refracted or reflected at interfaces between materials with different seismic velocities, and are then sensed with geophones placed firmly on the ground surface. The geophone signals are input to a seismograph, which records the data electronically for later processing and interpretation. Analysis of the seismic data can provide information on seismic velocity, the depth to various interfaces in the

subsurface, faulting, and other features. The depth of the seismic survey and types of information collected are determined by the survey design, which will be discussed in a site-specific work plan.

Seismic data is collected along transects which are oriented at approximate right angles to the features being investigated. Survey design information (i.e., the number of geophones used and geophone spacing) will be recorded. The date, time, and location of each data collection point will be entered in the seismograph records during data collection. The endpoints of each transect will be surveyed and plotted on a site map.

2.5.3.3 Subsurface Geophysical Surveys

2.5.3.3.1 Borehole Geophysics

Borehole geophysics is a family of methods which utilize geophysical instruments within a borehole. Borehole geophysical logging is typically performed by a specialty subcontractor. Various logging tools are lowered into the borehole using a wireline; data is then collected electronically as the tools are withdrawn. A wide variety of geophysical logging data can be collected, including resistivity, spontaneous potential, natural gamma, gamma-gamma, neutron, acoustic, temperature, flowmeter, caliper, and video logs. Some methods, such as resistivity, require that the borehole be uncased and filled with fluid. Other methods, including natural gamma, gamma-gamma, and neutron logging can be conducted in a cased borehole and do not require the presence of a fluid. Borehole geophysics is most commonly used to log borings drilled using rotary methods.

Because of the wide variety of methods available and types of information that can be obtained, the specific methods that may be used at Sites 1 & 2 and their limitations will be discussed in a project-specific work plan.

2.5.3.3.2 Downhole Seismic Surveys

Downhole seismic surveys are performed to determine vertical seismic velocity profiles. The survey consists of placing a geophone at a specified depth in a well or borehole, then generating seismic waves near the well by striking a steel plate with a hammer or dropping a heavy object on the ground. The data is used to measure the travel time from the wave source to the geophone. The geophone is then lowered 3 to 5 feet deeper into the well or boring, and the process repeated to the bottom of the well or borehole. The resulting data can be used to correlate seismic velocities with soil or rock units noted on soil boring logs.

Survey design information (i.e., geophone depths and distance between the wave source and the well or boring) will be recorded. The date, time, and location where data is collected will be entered in the seismograph records during data collection.

2.5.4 Drilling Operations

Two primary factors influence the selection of drilling methods: (1) the need to minimize the introduction of foreign materials that may influence the results of chemical analyses, and (2) the need to penetrate diverse geologic materials. The following drilling methods may be used at Sites 1 & 2:

- hand auger;
- direct-push (DP), including Geoprobe and cone penetrometer testing (CPT);
- hollow-stem auger (HSA);
- sonic;
- rotary methods (air rotary, air rotary-casing hammer (ARCH), and mud rotary);
- percussion (dual wall reverse-circulation); and
- bucket auger.

Drilling fluids used may include addition of air, potable water, and drilling mud (used only with mud rotary, which will consist of potable water and National Sanitary Foundation [NSF]-certified bentonite gel). General drilling procedures and descriptions of the drilling methods are provided in the following subsections.

2.5.4.1 General Drilling Procedures

All field activities (drilling, soil boring, geophysical surveys, lithologic sampling, and monitor well construction) will be supervised by a California-licensed Professional Geologist (P.G.) or Professional Engineer (P.E.). All field activities will be conducted by qualified field staff. A detailed log of the drilling activities and materials encountered will be maintained by the onsite field staff. The Performing Contractor and their subcontractors shall obtain and pay for all permits, applications, and other documents required by state and local authorities. All drilling, well installation, and abandonment activities shall conform with state and local regulations.

Drilling and sampling methods will generally follow the procedures described in the RCRA (Resource Conservation and Recovery Act) Groundwater Monitoring Technical Enforcement Guidance Document (EPA, 1986) and Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells (EPA, 1991). Well installation and destruction methods will follow procedures described in the Water Well Standards: State of California Bulletin 74-81 (DWR, 1990) and California Well Standards, Water Wells, Monitoring Wells, Cathodic Protection Wells, Bulletin 74-90 (DWR, 1991). The DWR has responsibility for developing these standards under California Water Code Section 231.

When drilling boreholes through more than one water bearing zone or aquifer, the Performing Contractor and its subcontractors shall take measures to prevent cross-connection or cross-contamination of the zones or aquifers. The Performing Contractor and its subcontractors will describe all procedures to avoid cross-connection and/or cross-contamination of aquifers in the project-specific work plan. Specific details will depend on geologic conditions. However, in most cases a drilling method which involves advancing a casing or drill pipe with the same diameter as the borehole will be used to prevent cross-contamination. Alternatively, a conductor casing may be installed to prevent cross-contamination. If used, the conductor casing will be installed past the first water-bearing zone, and several feet into the confining zone. Care shall be taken not to drill through the confining zone. Once the confining layer has been reached, the casing will be left at that depth and grouted in place, and drilling will resume through the conductor casing using a smaller diameter casing to proceed down hole.

The drill rig shall be cleaned and decontaminated in accordance with the procedure in Section 2.5.13. The drill rig shall not leak any fluids that may enter the borehole or contaminate equipment placed in the hole.

Drilling fluids shall consist of air, water, or mud. If air is used, it shall be filtered to remove organic vapors, and filters shall be changed daily. The effectiveness of the air filter shall be checked at least every 4 hours using a photoionization detector (PID) or flame ionization detector (FID). If organic vapors are detected in air passing through the downstream end of the air line or drill stem, their source (i.e., filter, contaminated line) shall be decontaminated or replaced. Only water from a pre-approved source shall be used as a drilling fluid. Drilling mud, if used, shall consist of 100 percent sodium bentonite and shall be approved by the Program Manager. The Performing Contractor shall provide the client with the chemical analyses of any drilling mud additive or substitute proposed for use prior to the start of drilling. The additives or substitutes shall be analyzed for all analytes of concern at the site.

Lubricants shall not introduce or mask contaminants. The driller shall provide chemical analyses of all lubricants proposed for downhole use. Chemical detection limits shall be equivalent to those used for analyzing project groundwater samples. Lubricants with constituents that are toxic or that increase, decrease, or mask the target chemical species of the investigation shall not be permitted.

A log of drilling activities shall be kept in a field notebook. Information in the log book shall include location, time on site, personnel and equipment present, down time, materials used, samples collected, measurements taken, and any other observations or information that would be necessary to reconstruct field activities at a later date. At the end of each day of drilling, the field staff supervising drilling shall complete a Daily Drilling Log. In addition to the recordkeeping requirements stated in Section 2.9, additional information will be recorded, such as:

- purpose of boring;
- boring identification number;
- location relative to nearby landmarks;
- name of drilling subcontractor;
- drilling method;
- depth at which saturated conditions were first encountered;
- lithologic descriptions and depths of lithologic boundaries;
- sampling depths;
- zones of caving or heaving;
- drilling rate; and
- drilling rig observations, such as chatter, rod drops, and bouncing.

The drilling subcontractor shall dispose of all trash, waste grout, cuttings, and drilling fluids in an appropriate manner.

2.5.4.2 Hand Auger Drilling

The hand auger is typically used for shallow borings and for clearance of utilities before drilling with other methods. This method entails the use of a hand auger with a 2- to 4-inch diameter bucket. The hand auger is turned by hand and retrieved to the surface, where cuttings are manually removed from the auger bucket. Disturbed soil samples may be collected directly from soil contained in the hand auger bucket; relatively undisturbed samples may be collected from the boring using a solid-barrel sampler driven with a hand-operated slide hammer.

For the purposes of utility clearance, hand auger borings are typically drilled to 5 feet bgs. Hand auger borings can be drilled to depths of 10 feet bgs or greater with the use of extension rods, if tight soils and/or rocks do not impede progress.

2.5.4.3 Direct-Push Drilling

DP drilling involves advancing a string of hollow drill rods into the subsurface by hammering or by pushing with a hydraulic ram system. This method does not use any drilling fluids or lubricants, thus minimizing the potential for cross-contamination or infiltration of foreign materials into the formation. In addition, this method does not generate soil cuttings, with the exception of core samples, greatly reducing the amount of waste generated.

2.5.4.3.1 Geoprobe System

The Geoprobe system consists of a hydraulically-powered percussion hammer mounted on a truck or van. The drilling rods are advanced by hammering and by application of weight to the rods. Relatively undisturbed soil samples may be collected with a variety of sampling tools. The most common type of

soil sampling tool is a piston sampler, consisting of a solid-barrel sampler with a lockable piston system, which is lined with acetate, brass, or stainless steel sleeves. The sampler is initially advanced to the top of the desired sampling interval with the piston locked in the closed position. The piston prevents soil from entering the sampler as it is advanced. The piston is then unlocked, which allows it to retract as the sampler is advanced. A soil sample is then collected by advancing the sampler to the bottom of the desired interval. The soil sample is then retrieved by tripping the entire tool string out of the hole. The sample liners are then extracted from the sampler for logging by field staff. If conditions allow, continuous cores can be collected using the direct push method by using 4- to 5-foot long samplers.

Soil samples may also be collected using a dual-tube system. This method uses larger-diameter rods with a drive shoe at the bottom. An acetate liner is placed inside the larger diameter rods, and held in place by a string of light-weight drill rods. The entire assembly is then advanced as a unit. When the liner is filled with soil, it is retrieved to the surface, leaving the larger diameter rods in place to act as a casing. A fresh liner is then placed in the large-diameter rods, and the entire assembly is again advanced. The dual-tube system is particularly useful for collecting continuous cores, and in situations where soil conditions require a cased borehole.

The Geoprobe system is best suited for sampling unconsolidated soils at depths of up to 60 feet bgs, depending on lithology. In addition to soil sampling, Geoprobe tools are available to collect soil gas and groundwater samples.

Alternative systems comparable to the Geoprobe include Strataprobe, Powerprobe, and various custom-built systems.

2.5.4.3.2 Cone Penetrometer Testing

CPT is a rapid and cost-effective method to determine soil characteristics based on resistance to penetration (tip resistance), lateral friction, and instantaneous fluid pore pressure measured during penetration. Real-time measurements are recorded as the tool is pushed into the ground. CPT measurements can be used for soil type determinations based on established correlations between these properties and USCS soil types.

A CPT rig consists of a truck or van ballasted to weigh 25 to 30 tons. Under favorable conditions, a 30-ton rig is capable of penetrating soils to depths of up to approximately 150 feet. To conduct a CPT, an instrumented cone mounted on a series of hollow rods is smoothly advanced into the subsurface using a hydraulic ram system. Tip resistance, lateral friction, and instantaneous fluid pore pressure are measured with pressure transducers at approximate 2-centimeter (cm) intervals during penetration. These data are

transmitted by means of a cable strung through the rods and collected at the surface with a computer data acquisition and display system at the surface.

Before initiation of testing, the field staff and selected subcontractor will conduct a CPT adjacent to a new or existing boring to check and compare the penetrometer sensor response to the site-specific lithology. This calibration will consist of comparing the instrumental log generated by the CPT with conventional soil boring logs. This comparison provides control for the CPT data so an accurate evaluation of the subsurface can be made.

CPT is best suited for sampling unconsolidated soils at depths of up to 150 feet bgs, depending on lithology. In addition to soil sampling, Geoprobe tools are available to collect soil gas and groundwater samples. In addition to determining subsurface geology, the CPT rig can be used for collection of soil, soil vapor, and groundwater samples using special sampling tools. Exploration for water-bearing zones can be facilitated by conducting pore pressure dissipation tests during probe advancement.

2.5.4.4 Hollow-Stem Auger Drilling

HSA drilling is most suitable for drilling in unconsolidated or poorly consolidated materials, and is the preferred method for drilling borings in unconsolidated or poorly-consolidated materials to depths of up to 100 feet bgs or greater at Sites 1 & 2. If this method proves ineffective, alternative methods will be proposed to the Program Manager for approval.

The HSA technique involves simultaneously rotating and advancing a string of continuous-flight hollow stem augers into the subsurface. The auger string acts as casing to stabilize the borehole as the augers are advanced. A pilot bit inserted into the hollow stem is used to plug the bottom of the auger string during drilling. The pilot bit and teeth on the auger bit cut into the soil and direct the cuttings to the auger flights. As the augers are rotated, the soil cuttings are brought to the surface along the auger flights on the outside of the hollow stem. The HSA technique is commonly used for both vertical and slant soil boring investigations. No drilling fluids or lubricants are used, minimizing the potential for cross-contamination or infiltration of materials into the formation. However, unusually difficult drilling conditions may require the addition of small amounts of potable water to cool and lubricate the bit. If flowing (heaving) sands are encountered, potable water may be added to the borehole to equalize head pressure between the formation and the inside of the hollow stem.

Soil sampling is most often conducted using a split barrel-type sampler, which is lowered inside the hollow drill stem and driven ahead of the augers using a 140-pound hammer dropped a distance of 30 inches. Samplers may include the 2-inch outside diameter (O.D.) standard penetration test (SPT) sampler,

or larger diameter samplers, including the 2.5-inch O.D. modified California sampler and the 3-inch O.D. California sampler. A thin-wall Shelby-tube sampler, which is advanced using the weight of the drill rig, may be used to sample unconsolidated fine-grained soils. If conditions allow, continuous cores can be collected by driving back-to-back samples split barrel samples, or by driving a 5-foot core barrel in front of the auger bit as the boring is advanced.

2.5.4.5 Sonic Drilling

The sonic drilling method uses a combination of rotation and high frequency vibrations generated at the drill head to advance a drill pipe into the subsurface. Sonic drilling is suitable for a wide variety of subsurface conditions, including drilling in both unconsolidated and consolidated materials.

Drilling is initiated by advancing a core barrel (which is typically one-inch smaller in diameter than the boring diameter) approximately 10 feet into the subsurface. The core barrel is then retrieved to the surface and vibrated to expel the soil or rock core sample into a plastic sheath. As each 2-foot section of core is expelled, the end of the sheath is knotted to form a sample bag. After the entire core sample is expelled and bagged, the core barrel is returned to the borehole, advanced another 10 feet, and retrieved to the surface. Once the core barrel had been advanced to approximately 20 feet bgs, flush-threaded steel drill casing is advanced to a depth of approximately 10 feet bgs. Slough generated by advancing the drill casing is then removed from the borehole by performing a cleanout run with the core barrel. Drilling then proceeds by advancing the core barrel 10 additional feet, advancing the casing 10 additional feet, and performing a cleanout run. Some amount of open hole (10 feet in this example) is typically maintained during drilling to avoid bridging the core barrel inside the drill casing. Once the boring is cored to total depth, the drill casing is advanced to the bottom of the boring, and a final cleanout run is performed.

Whenever possible, sonic drilling shall be conducted without adding water to the borehole. In some instances, however, it is necessary to introduce small amounts of water to cool and lubricate the drill bit when difficult conditions are encountered. Any water added to the borehole shall be clean potable water. Added water is typically contained within the core barrel during drilling, and is removed with the next core run. Any excess water may be removed by bailing, if necessary.

When monitoring wells are to be constructed in sonic borings, it may be necessary to enlarge the borehole (for example, to provide sufficient annular space for installation of a large diameter well casing, or to provide additional space annular space for the installation of nested wells). Sonic borings may be enlarged by “overwashing” the drill casing with larger diameter casing, typically one to two inches larger in diameter than the drill casing. Initially, a surface casing approximately four inches larger in diameter than the drill casing is advanced to a depth of approximately 10 to 20 feet. The casing to be overwashed is then

advanced between the surface casing and the drill casing. Cuttings are flushed out of the annular space with potable water. Water added during the overwashing process is typically contained at the surface in a plastic tub or other containment structure placed over the drill string.

2.5.4.6 Direct Rotary Drilling

Direct rotary drilling is a family of methods which include the air rotary, ARCH, and mud rotary techniques. All of these methods involve the simultaneous rotation and advancement of a drill bit mounted on a hollow drill pipe. A drilling fluid, consisting or air or drilling mud, is used to remove cuttings from the borehole. In the direct-rotary methods, the drilling fluid is circulated downward through the drill pipe and returned to the surface through the annular space between the drill pipe and the borehole. The drilling fluid cools and lubricates the drill bit, and (in the case of mud rotary drilling) stabilizes the borehole.

Drill cuttings should be used as an aid to lithologic logging of boreholes drilled with rotary methods; however, cuttings should not be the primary means of logging, due to uncertainties in sample origin, potential mixing, and washout of fine-grained materials. Coring and/or geophysical logging is recommended as the primary tool for logging rotary borings.

2.5.4.6.1 Air Rotary Drilling

Air rotary drilling uses compressed air as a drilling fluid. Air and cuttings returned to the surface are blown out of the borehole and collect at the surface around the borehole. Advantages of air rotary drilling include the rapid removal of cuttings from the borehole, and high penetration rates in resistant rocks. Depths of up to 1,000 feet can be attained under favorable conditions. However, air rotary drilling is mainly restricted to use in semiconsolidated to consolidated materials.

Air from compressors may contain small amounts of hydrocarbon contaminants from the compressor fluid and lubricants. Compressed air shall be filtered to remove organic vapors, and filters shall be changed daily. The effectiveness of the air filter shall be checked at least every 4 hours using a PID or FID. If organic vapors are detected in air passing through the downstream end of the air line or drill stem, their source (i.e., filter, contaminated line, etc.) shall be decontaminated or replaced.

2.5.4.6.2 Air Rotary Casing Hammer Drilling

In unconsolidated formations and materials which are subject to caving, such as sand-cobble-boulder layers or heaving sands, the ARCH method can be used instead of traditional air rotary drilling. The ARCH system consists of a non-rotating, flush-threaded steel casing which driven with a pneumatic or hydraulic drill-through casing in conjunction with a conventional air rotary drill string. Air and cuttings

are typically diverted through an eductor pipe to a cyclone separator. In addition to limiting caving problems, the casing can be used to seal off the borehole and prevent cross-contamination between hydrogeologic units. Upon completion of drilling, the drill rod and bit are extracted through the casing, and the casing is removed using a casing puller.

Air from compressors may contain small amounts of hydrocarbon contaminants from the compressor fluid and lubricants. Compressed air shall be filtered to remove organic vapors, and filters shall be changed daily. The effectiveness of the air filter shall be checked at least every 4 hours using a PID or FID. If organic vapors are detected in air passing through the downstream end of the air line or drill stem, their source (i.e., filter, contaminated line, etc.) shall be decontaminated or replaced.

2.5.4.6.3 Mud Rotary Drilling

Mud rotary drilling uses a drilling mud comprised of bentonite gel, water, and various additives as a drilling fluid. The drilling mud stabilizes the borehole during drilling, which allows this technique to be used in both unconsolidated and consolidated formation. The drilling mud also forms a cake on the borehole walls, which help stabilize the borehole and control fluid loss to the formation. At the surface, the drilling mud and cuttings are directed to a mud pit, where the cuttings are separated from the drilling mud. The drilling mud is then recirculated into the borehole. Mud rotary drilling can be used to drill extremely deep boreholes, and with judicious choice of mud additives, can be used to drill through most materials. However, the use of drilling mud creates a high potential for affecting groundwater characteristics and quality. In addition, it is difficult to remove the mud cake from the borehole walls during well development.

Drilling mud used should not affect the chemistry of soil or groundwater samples or adversely impact the operation of monitoring wells. Only potable water from a pre-approved source shall be used for mixing drilling mud. Drilling mud shall be mixed using 100 percent sodium bentonite and shall be approved by the Program Manager. The Program Manager shall provide the LMC with the chemical analyses of any drilling mud additive or substitute proposed for use prior to the start of drilling. The additives or substitutes shall be analyzed for all analytes of concern at the site.

2.5.4.7 Dual-Wall Reverse-Circulation Air Percussion Drilling

The dual-wall reverse-circulation air percussion method involves advancing a double-walled drill pipe into the subsurface by driving with a diesel-powered pile hammer, which pulverizes the rock or soil at the bit face. Compressed air is circulated downward through the annular space between the inner and outer drill pipe. Cuttings are brought to the surface through the central pipe, where they are directed through an eductor to a cyclone separator. The cuttings are separated from the circulating air at the cyclone.

Reverse-circulation air percussion drilling is suitable for a variety of difficult drilling conditions, including drilling through coarse-grained materials ranging in size from gravel to boulders. In addition, the drill pipe acts as a casing to support the borehole wall and can be used to seal off the borehole and prevent cross-contamination between hydrogeologic units. It is less suitable for drilling through soft, compressible fine-grained materials such as clays.

Air from compressors may contain small amounts of hydrocarbon contaminants from the compressor fluid and lubricants. Compressed air shall be filtered to remove organic vapors, and filters shall be changed daily. The effectiveness of the air filter shall be checked at least every 4 hours using a PID or FID. If organic vapors are detected in air passing through the downstream end of the air line or drill stem, their source (i.e., filter, contaminated line, etc.) shall be decontaminated or replaced.

2.5.4.8 Bucket Auger Drilling

Bucket auger rigs are used to drill large-diameter boreholes in unconsolidated material. Drilling involves rotating and advancing a steel drum with hinged cutter plates attached to a telescoping Kelly drive bar into the subsurface. Cuttings collect inside the drum during drilling. When the drum becomes filled with cuttings, it is hoisted out of the borehole and moved to one side, where the cuttings are discharged by releasing the cutter plates. The cutter plates are then locked back into place, and the bucket is returned to the borehole to continue drilling.

Bucket auger borings can range in size from approximately 1 foot to as much as 8 feet in diameter, although 3 to 4 feet are more typical maximum sizes. Overreamer arms attached to the bucket can be used to increase borehole diameter by as much as 2 feet. Depth is limited by the length of the telescoping Kelly bar and the presence of saturated sands, boulders, or hard-to-penetrate materials such as caliche or competent rock.

Bucket auger rigs are most frequently used for drilling caisson holes for foundations. They are also commonly used to drill exploratory holes for geotechnical investigations. Environmental applications of this drilling methodolology include deep remedial excavations, which are conducted by drilling overlapping large-diameter boreholes in a regular pattern.

2.5.4.9 Sampling and Lithologic Logging

The lithology in all boreholes shall be logged using the systems described in Section 2.5.1 (Geologic Standards) of this FSP, with the exception of CPT borings, which are logged instrumentally. A boring log form shall be used for recording the lithologic logging information. A copy of a typical boring log form is provided in Appendix A. Information recorded on the boring log form includes the borehole location,

drilling information, sampling information such as sample intervals, recovery, and blow counts, sample description information, and borehole completion information.

Samples of unconsolidated materials shall be obtained at each change in lithology or every 5-foot interval, whichever is less, or as specifically stated in the project-specific work plan. Descriptive information to be recorded in the field shall include: (1) the predominant particle sizes and range of particle sizes; (2) percent of gravel, sand, and silt or clay (fines); (3) description of grading of coarse particles; (4) particle angularity and shape; (5) maximum particle size or dimension of coarse particles; (6) color using Munsell Color System; (7) moisture content; and (8) consistency of fine-grained soils, and (9) other relevant information, such as mineralogical composition, cementation, etc.

Samples of consolidated materials shall be obtained at each change in lithology or every 5-foot interval, whichever is less, or as specifically stated in the project-specific work plan. Descriptive information to be recorded in the field shall include: (1) the predominant particle sizes and range of particle sizes; (2) percent of gravel, sand, and silt or clay (fines); (3) description of sorting of coarse particles; (4) particle angularity and shape; (5) maximum particle size or dimension of coarse particles; (6) color using Munsell Color System; (7) moisture content, (8) degree of induration; and (9) other relevant information, such as mineralogical composition, cementation, etc.

In addition, to the soil and/or rock descriptions, the USCS group symbol or rock type symbol shall be identified for each lithologic unit observed. In addition, depth to the water table, caving or sloughing of the borehole, changes in drilling rate or methodology, depths and collection times/dates of lithologic and laboratory samples, presence of organic materials and significant odor or staining, organic vapor analyzer (OVA) readings, presence of fractures or voids in consolidated materials, and other noteworthy observations or conditions, such as the locations of geologic boundaries, shall be recorded. The information recorded on the boring logs will also include name of drilling subcontractor, name of onsite field staff, method of drilling, bit size, total depth drilled, location, and coordinates and elevation if known.

All samples shall be monitored for organic vapors using an OVA (e.g., PID, FID). The samples shall be handled in such a way as to minimize the loss of volatiles. Soil cuttings shall be examined for their hazardous characteristics. Materials suspected to be hazardous because of abnormal color, odor, or organic vapor monitor readings shall be containerized in conformance with the RCRA and with state and local requirements. If necessary, rock cores may be stored in standard core boxes, and missing sections of core replaced with spacers.

2.5.4.10 Ambient Air Monitoring

Ambient air will be monitored during all drilling and sampling activities. An OVA (e.g., PID, FID) will be used to monitor concentrations of total volatile organic vapors in the breathing space at worker chest-level, from the drill cuttings coming up outside of the drill string, and from samples collected for lithologic logging. Air monitoring concentrations will be recorded in the remarks column on the boring logs. If ambient or borehole air concentrations exceed those specified in the site-specific HASP, drilling will be stopped and appropriate action taken according to the established guidelines.

2.5.4.11 Borehole Abandonment

Boreholes are typically abandoned by backfilling with hydrated bentonite chips or a cement-bentonite slurry from the bottom to the top of the borehole. Borings less than 20 feet deep may be backfilled with either hydrated bentonite chips or cement-bentonite slurry. Borings greater than 20 feet deep shall be backfilled using cement-bentonite slurry emplaced from the bottom up with a tremie pipe. Cement/bentonite mixtures should consist of Portland cement with the addition of 6% by weight pure bentonite gel or grout.

All backfilled boreholes shall be checked 24 to 48 hours after grout emplacement to determine whether curing is occurring properly. If settling has occurred, a sufficient amount of slurry/grout shall or hydrated bentonite chips shall be added to fill the hole to the ground surface. These curing checks and any addition of bentonite or slurry shall be recorded in the field log.

2.5.5 Well Installation

Wells will be installed according to the project-specific work plan and based on data collected during drilling. Wells will be designed by the onsite field staff and the supervising P.G. or P.E. Any changes to the proposed well design, based upon site conditions or subsurface conditions, will be documented in the field logbook. Well installation records will be kept in the field logbook and on the borehole logs. Storage and disposal of drill cuttings will be handled as described in Section 2.5.14.

2.5.5.1 Monitoring Well Construction

This section includes a summary of groundwater monitoring well construction requirements. Drilling and sampling methods will generally follow the procedures described in the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (EPA, 1986) and Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells (EPA, 1991). Well installation and destruction methods will follow procedures described in the Water Well Standards: State of California Bulletin 74-81 (DWR, 1990) and California Well Standards, Water Wells, Monitoring Wells, Cathodic Protection Wells,

Bulletin 74-90 (DWR, 1991). The DWR has responsibility for developing these standards under California Water Code Section 231. In addition, specifications for all of the components of the monitoring well are included in the following subsections.

2.5.5.1.1 General Monitoring Well Construction Procedures

Groundwater monitoring wells will generally be completed using 2-inch, 3-inch, 4-inch, or 6-inch internal diameter (I.D.) casing and screened sections. The blank casing will be flush-threaded Schedule 40 or Schedule 80 polyvinyl chloride (PVC). All well screened sections will be machine-slotted Schedule 40 or Schedule 80 PVC, or wire-wrap stainless steel (type 304 or 316). Well screens will have a slot size of 0.020 inches, unless the formation grain size requires a different slot size.

Screen and casing sections that have not already been cleaned and wrapped in plastic will be steam cleaned onsite according to decontamination procedures outlined in Section 2.5.13, wrapped in plastic for transportation to the well location (if required), and assembled at the ground surface. The casing sections will be covered and kept on a plastic ground cover until they are lowered down the borehole in order to avoid possible contamination.

Depths of monitoring wells will be determined based on lithology and the depth of hydrostratigraphic units. When there is a possibility that floating products [i.e., light non-aqueous phase liquids (LNAPLs)] may be encountered, shallow monitor wells shall be screened across the water table. The length of the screen shall be such that seasonal water table fluctuations shall not cause water levels to rise above or fall below the screened interval. Water table groundwater monitoring wells will be screened in a 20 foot interval within the unconsolidated alluvial sediment with the top of the screen approximately five to ten feet above static water level to allow for seasonal groundwater fluctuations. If dense products (i.e., dense non-aqueous phase liquids [DNAPLs]) may be encountered, monitor wells shall be screened at the bottom of the hydrostratigraphic zone to capture the DNAPL. Deep groundwater monitoring wells will be screened appropriately across the hydrostratigraphic zone being targeted. Blank well casing will be placed from the top of the well screen to the ground surface.

To maintain stability of the borehole, drill casing or auger flights will remain in the ground while the well is being constructed. With the HSA drilling method, the auger will be used to center the well string within the borehole during well construction, thus centralizers do not need to be used. The well screen and casing will be assembled at the surface and lowered into the borehole. The well string will be suspended from the surface during construction, and not allowed to rest on the bottom of the borehole. Once the well casing and screen is installed, a filter pack consisting of #2/16 washed sand (unless the formation grain size requires a different sand size) will be slowly introduced into the annulus between the well screen and

the borehole wall. As the filter pack is placed, the drill casing or auger flights will be withdrawn in increments ahead of the sand to prevent bridging of the drill casing or auger. The filter pack sand will be furnished in unopened sacks and be clean and free of oil, acid, organics, or other deleterious material. The primary filter pack will be placed opposite the screened intervals from the bottom of the screen to a minimum of 2 feet above the top of the well screen. The volume of filter pack material used will be recorded in the field logbook during well construction. The filter pack depth will be periodically sounded to monitor the depth, and the volume of sand used will be compared to the calculated volume of annulus filled each time a section of auger or drill casing is pulled up and removed. This is intended to locate any points of bridging between the well casing and the borehole wall. If a significant discrepancy arises between the volume of sand used versus the estimated annulus volume, the source of this error will be identified and mitigated.

After the filter pack is emplaced, the well will be surged with a surge block for at least 10 minutes. The top of the sand pack will then be sounded to verify depth. If the filter pack has settled, additional filter pack will be placed as needed to return the level of the pack to the original depth. This process will be repeated until no further settlement of the filter pack is observed.

Transition sand, consisting of #0/30 sand or similar, will then be placed in a minimum 0.5 foot layer above the primary filter pack. The purpose of the transition filter pack is to impede the movement of grout into the primary filter pack. The transition filter pack material will be slowly introduced into the annulus between the well casing and borehole wall. The volume of transition sand used will be recorded in the field logbook during well construction.

A minimum 2-foot, pure sodium bentonite seal, consisting of medium bentonite chips, will be introduced down the annulus above the transition filter pack sand. The bentonite will be free of additives that may affect water quality. The bentonite will be saturated with potable water and allowed to hydrate for approximately 1 hour. After the bentonite seal has hydrated, the remaining annulus will be grouted using a cement/bentonite slurry. The slurry will consist of approximately 6 pounds of powdered bentonite and 8 each sack of Type I or II Portland cement. The slurry will be pumped into the borehole using the tremie method and allowed to settle, thus ensuring the integrity of the seal.

2.5.5.1.2 Borehole Specifications

Borehole diameters shall be at least 4 inches larger than the O.D. of the casing and well screen to provide sufficient annular space for placement of a filter pack. For wells constructed in cased boreholes, the appropriate minimum borehole diameter would be 6 inches for a 2-inch O.D. well, and 8 inches for a

4-inch O.D. well. For wells installed in HSA borings, an appropriate minimum borehole diameter would be 8 inches for a 2-inch diameter well, and 10 inches for a 4-inch diameter well.

A completed monitoring well shall be straight and plumb. The monitor well shall be sufficiently straight to allow passage of pumps or sampling devices. The monitor well shall be plumb within 1 degree of vertical where the water level is greater than 30 feet below land surface unless otherwise approved the appropriate regulatory agency. The regulatory agency may waive a plumbness requirement. Monitoring wells not meeting straightness or plumbness specifications shall be redrilled and/or reconstructed.

All soil borings used for monitoring well installation will be drilled and documented as described in Section 2.5.4 (Drilling Operations) of this FSP.

2.5.5.1.3 Casing Specifications

All well casing shall be new and unused. Screen and casing sections that have not already been cleaned and wrapped in plastic shall be decontaminated according to the specifications in Section 2.5.13. Glue shall not be used to join casings, and casings shall be joined only with compatible welds or couplings that shall not interfere with the planned use of the well. All PVC shall conform to the ASTM Standard F-480-88A or the National Sanitation Foundation Standard 14 (Plastic Pipe System). All metal casing shall be seamless stainless steel casing. The casing shall be straight and plumb within the tolerance stated for the borehole. Finally, the driller shall cut a notch in the top north side of the casing to be used as a measuring point for water levels.

2.5.5.1.4 Well Screen Specifications

All requirements that apply to casing shall also apply to well screen, except for strength requirements. Monitoring wells shall not be screened across more than one water bearing unit. Screens shall be factory slotted or wrapped, and screen slots shall be sized to prevent 90 percent of the filter pack from entering the well. For wells where no filter pack is used, the screen slot size shall be selected to retain 60 to 70 percent of the formation materials opposite the screen. In situations where heaving sands may be an issue, use of pre-pack screen may be appropriate. Finally, the bottom of the well screen is to be capped and the cap shall be joined to the screen by threads.

Contractors may propose open-hole wells in bedrock where cave-in is unlikely. Prior approval for such wells shall be obtained, in writing, from the appropriate regulatory agency. In addition, recent developments in alternative well screen strategies are available for selected applications that may be proposed in lieu of conventional well screen on a case-by-case basis, pending written approval by the appropriate regulatory agency. One example is continuous multi-chamber tubing that allows sampling of

multiple isolated screened intervals in one installation. Since such applications also entail careful control of grouting, proposed applications shall be detailed in project-specific FSP Addenda.

2.5.5.1.5 Annular Space Specifications

The annular space between the casing string and the borehole wall shall be filled with a filter pack, a bentonite seal, and grout backfill. Any drilling fluids shall be thinned with potable water of known acceptable quality to a density less than 1.2 grams per cubic centimeter (10 pounds per gallon) before the annular space is filled. As the annular space is being filled, the well string shall be centered and suspended such that it does not rest on the bottom of the borehole.

2.5.5.1.6 Filter Pack Specifications

The filter pack shall consist of washed sand or gravel and shall extend from the bottom of the hole to at least 2 feet above the top of the well screen. The filter pack material shall be clean, inert, and well rounded and shall contain less than 2 percent flat particles. The sand or gravel shall be certified free of contaminants by the vendor or subcontractor. If decontamination is necessary, the methods shall be approved in writing by appropriate regulatory agency.

After the filter pack is emplaced, the well shall be surged with a surge block for at least 10 minutes. The top of the sand pack shall be sounded to verify its depth during placement. Additional filter pack shall be placed as required to return the level of the pack to 2 feet above the screen, and the well should again be surged to set the filter pack. Additional filter pack should be placed as required to bring its level to 2 feet above the screen. Transition filter pack sand, consisting of #0/30 washed sand or similar, will then be placed in a minimum 0.5 foot layer above the primary filter pack. If gravel filter pack is used, 6 inches of coarse sand shall be placed on top of the gravel.

The filter pack shall have a grain size distribution and uniformity coefficient compatible with the formation materials and the screen, as described in Chapter 12 of Ground Water and Wells (Driscoll, 1986). The filter pack sand must be sized so that at least 90 percent of the filter pack does not pass through the screen casing. For a screen slot size of 0.020-inch, No. 3, #2/12, and #2/16 sand are appropriately sized such that the filter pack does not pass through the screen. If the slot size is changed, the sand will be resized. The filter pack shall not extend across more than one water bearing unit. The augers or drill casing will be raised periodically as the filter pack is emplaced to allow the sand to fill the annular space between the well casing and the borehole wall. The height of the filter pack will be confirmed by sounding with a weighted tape.

For unusually complex completions, such as nested wells, the filter pack may be emplaced using a tremie pipe. Potable water may be used as an aid in emplacing the filter pack, so long as no contaminants are introduced.

The Performing Contractor shall record the volume of the filter pack emplaced in the well. Formation materials may be used as a filter pack when they are compatible with the slot size of the screen.

2.5.5.1.7 Bentonite Seal Specifications

The bentonite seals shall consist of at least 2 feet of bentonite placed between the filter pack and the grout backfill. For installation of the bentonite seal above the water table surface, the bentonite material will typically be in pellet or chip form, and will be emplaced in 6-inch lifts and hydrated with potable water between each lift. For installation below the water table, coated bentonite pellets, which hydrate at a slower rate, may also be used. The bentonite seal shall be emplaced using a tremie pipe whenever the seal will be below the water level in the well. Potable water may be used as an aid in emplacing the seal, so long as no contaminants are introduced. Powdered bentonite may also be used for the seal. Where powdered bentonite is used, it shall be hydrated prior to installation, and shall be emplaced by pumping through a tremie pipe. Only 100% pure sodium bentonite shall be used. The bentonite seal will be sounded with a weighted tape following its installation. The Performing Contractor shall record the volume of the seal material emplaced in the well.

For wells less than 15-feet in depth, alternate sealing methods may be proposed. Prior approval for any alternate method shall be obtained from the local regulatory agencies before well construction begins.

2.5.5.1.8 Grout Specifications

The grout backfill shall extend from the top of the bentonite seal to ground surface. The grout shall be mixed in the following proportions: 94 pounds of neat Type I Portland or American Petroleum Institute (API) Class A cement, not more than 6 pounds of 100 percent sodium bentonite powder, and not more than 8 gallons of potable water. All grout shall be pumped through a tremie pipe, and pumping shall continue until the grout has returned to the surface to ensure that the borehole is completely grouted and surface contaminants will not enter the annulus. Note that for methods such as HSA, the drill casing may be used as a tremie pipe. In wells where the bentonite seal is visible and within 30 feet of the land surface, return of grout is not necessary, as long as the tremie pipe is pulled back as the grout is emplaced. Excess grout shall be removed and cleaned from the site prior to installing the surface completion.

All newly-installed wells shall be checked 24 to 48 hours after grout emplacement to determine whether curing is occurring properly. If settling has occurred, a sufficient amount of grout or hydrated bentonite

chips shall be added to fill the hole to the ground surface. These curing checks and any addition of bentonite or slurry shall be recorded in the field log.

2.5.5.1.9 Surface Completion Specifications

The wells will be completed either flush with the ground surface or above the ground surface, depending on site conditions and future use of the well. To allow gas to escape from aboveground surface completions only, a small diameter (e.g., ¼-inch) vent hole may be placed in the well casing, or a ventilated well cap may be used.

If wells are to be completed in high traffic areas or other locations where above-ground completions are not practical, they will be completed flush with the ground surface. For flush-mount completions, the well casing will be cut 3 to 4 inches below the ground surface, and a water-tight, cast-iron traffic-rated well box with a protective lid will be centered over the well casing. A 3-foot by 3-foot concrete pad sloped away from the well box (to avoid surface accumulation of water) will then be constructed around the well box. A minimum 4-inch clearance will be maintained between the top of the well casing and the bottom of the well box cover. A locking well cap with an expandable seal will be placed on the well casing. The well number will be clearly marked on the well box cover or concrete pad, and on the well casing. The highest point on the casing or the northern side of the top of the well casing will be notched for use as a water level measurement reference point.

If an above ground surface completion is used, the well casing will be extended 2 to 3 feet above the ground surface. An 8-inch to 10-inch diameter steel guard pipe with a hinged lockable steel cover will be placed over the well casing and seated in a 2-foot by 2-foot by 4-inch thick concrete surface pad. The pad will be sloped away from the well casing. A locking well cap with an expandable seal will be placed on the well casing. The well casing will be notched on the highest point on the casing or the north side for use as a water level measurement reference point. Three-inch diameter pipe bollards may be installed around the well, if such protection is necessary. The bollards will be approximately 5 feet in length and will be recessed 2 feet into the ground and set in concrete. The posts will not be set into the concrete pad placed at the well base. Each well will be clearly marked using paint and/or impact lettering.

All wells shall be secured as soon as possible after drilling. Corrosion-resistant locks shall be provided for both flush mounted and above ground surface completions. The locks must either have identical keys or be keyed for opening with one master key.

2.5.5.2 Remedial Well Construction

This section addresses general design issues associated with wells installed and constructed specifically for the purpose of remediation. The guidelines presented in the previous section generally also apply to remediation wells, with exceptions noted below. The types of remediation wells discussed herein are categorized as either extraction wells or injection wells.

2.5.5.2.1 Extraction Wells

Remediation extraction wells include wells designed to extract fluids entirely from the saturated zone (i.e., groundwater extraction or pumping wells), entirely from the vadose zone (i.e., soil vapor extraction [SVE] wells), or from both the saturated and unsaturated zones (i.e., dual-phase extraction [DPE] wells).

Remediation extraction wells are designed with the goal of focused removal of fluids across the screened interval(s). Since remediation extraction wells typically target the zone(s) of highest contaminant concentrations, the screen interval selection criteria may be weighted based on laboratory chemical data. If multiple screened intervals are planned for a single well, the permeability of each screened zone should be considered to allow for balanced extraction rates from the zones.

For groundwater extraction wells, well diameter, filter pack size, and screen slot size are often selected to maximize the radius of influence of the well. Standard water well industry methodologies, such as those described by Driscoll (1986), may be used for well screen and filter pack design. In this methodology, the filter pack is designed based on sieve analysis of the formation material encountered during drilling. Typically, the 70% retained size of the formation (or a selected portion of the formation) is multiplied by a factor between 4 and 10, and result used as the 70% retained size for the filter pack. A smooth curve with a uniformity coefficient of 2.5 or less is then drawn through the filter pack 70% retained size, and a commercial filter pack closely matching this curve is selected for the well. The well screen slot size is then selected to retain about 90 percent of the filter pack material.

Requirements restricting the use of glue to join well casing may not apply to connections with piping used for extraction when the extracted fluid is treated prior to release. Casing selection should consider the presence and concentrations of chemicals and anticipated forces during remedial system operation in the vicinity of the well. Surface completions for extraction wells often include traffic-rated, water-resistant utility boxes or vaults to accommodate multiple, subsurface pipes for fluid conveyance. In addition, wellhead completion considerations often include providing necessary access to ports and instruments attached to the wellhead or piping laterals for remedial process monitoring.

SVE wells and vapor monitoring wells are screened above the water table, and often have long screened sections, in order to best capture soil vapors based on the depth of soil contamination.

2.5.5.2.2 Injection Wells

Remediation injection wells include those designed for injection within the unsaturated zone, saturated zone, or both. Examples of such injection strategies may include wells designed to deliver oxidizing agents (e.g., ozone, permanganate, or Fenton's reagent), reducing agents or substrates to support microbial degradation (e.g., emulsified soybean oil, molasses, cheese whey, microbial inoculations), or to introduce other fluids (e.g., permeable reactive barrier injection wells).

Because injection wells are often operated at higher pressures than extraction wells, well casing diameter may be smaller, and the casing may be constructed from materials other than PVC. In addition, because of the higher operating pressures of injection wells, the well seal(s) may be thicker than for monitoring wells. Well screen length may be highly variable depending on the intended well use: screens of 6 inches or less may be used for air sparging wells designed to introduce air at the base of an aquifer; while screen lengths of 60 feet or more may be used for infiltration wells. In addition, well screen slot size and filter pack size may be increased to improve the efficiency of injection (less pressure loss) into the targeted aquifer, and to afford some flexibility to accommodate biofouling or chemical buildup around the well screen.

Surface completions for injection wells often include traffic-rated water resistant utility boxes or vaults to accommodate multiple subsurface pipes for conveyance of subsurface fluids. In addition, wellhead completion considerations often include providing necessary access to ports and instruments attached to the wellhead or laterals for remedial process monitoring.

2.5.5.3 Well Completion Diagrams

Well completion diagrams will be prepared for all wells or piezometers installed. A diagram showing well construction details will be completed in the field by the onsite field staff supervising the well installation. The diagram will include the following information:

- well identification;
- drilling method;
- installation date(s);
- total boring depth;
- boring diameter(s);
- length and descriptions of materials used to partially backfill the boring prior to casing installation;
- lengths and descriptions of the screen and casing;

- lengths and descriptions of the filter pack, bentonite seal, grout backfill, and any other material placed in the annular space;
- depth to groundwater; and
- description of the surface completion.

The well construction diagram may be incorporated into the boring log, or may be recorded on a separate well construction log form. An example of a well construction log form is provided in Appendix A. In the case of nested wells or piezometers, the well construction diagram will include details associated with each screened interval.

In addition, well construction activities will be summarized in the field logbook and any changes from the planned well construction will be noted. The well construction diagrams will be submitted in the final report, and completion details will be forwarded to permitting agencies by the drilling subcontractors.

2.5.6 Well Development

Each newly installed well will be developed no sooner than 24 hours and no later than 30 days following well completion. The wells will be developed using a combination of the surge-and-bail and pumping techniques. Initially, each well will be bailed until most of the settled solids have been removed from the well casing and the bottom of the well can be sounded. The well will then be swabbed using a surge block to flush fine-grained materials from the filter pack and adjacent formation. After surging, the fine-grained materials drawn into the well casing will be bailed from the well until most of the settleable solids have been removed. After two or more bailing periods, a submersible pump will be placed in the well and purging will begin. If the pump used for purging is not equipped with a check valve, the pump will be turned off several times after the purge water is relatively clear and free of suspended solids, a procedure referred to as "rawhiding." Rawhiding surges the filter pack by allowing water from the pump hose to rapidly flow back into the well, which mobilizes any fine-grained sediments still trapped within the filter pack and set the filter pack sand in a gradational pattern that will allow for flow of formation water through the screen. During purging, groundwater parameters, including pH, temperature, electrical conductivity (EC), dissolved oxygen (DO), and turbidity will be monitored and recorded at regular intervals on a well development field data sheet. A copy of a typical well development field data sheet is provided in Appendix A.

Water level measurements and pumping rates will also be periodically recorded during development. Pumping rates will be measured using either the bucket/stopwatch method or an in-line flow meter. The bucket/stopwatch method will consist of pumping the well discharge into a container of known volume, usually a calibrated 5-gallon bucket. A stopwatch is started when flow begins entering the container and is stopped when the container is full. This will give the time needed to discharge the known volume of

water from the well. This value number will be converted to gallons per minute (gpm) and recorded on the field logging sheets. This procedure will be repeated several times to establish an average pumping rate. The volume of water pumped during development will be calculated based on the average pumping rate and the total time the well is pumped. The water level drawdown achieved at the end of the purging, divided by the total gallons pumped, will be recorded on the logging sheet. Water level drawdown and pumping rates measured during development may be used to estimate the hydraulic conductivity of the formation as described in Section 2.5.11.2.

After all suspended solids have been removed and groundwater parameters have stabilized for a minimum of three consecutive readings (i.e., pH ± 0.1 units, EC ± 5%, temperature ± 1 degrees Celsius [°C], DO ± 0.3 parts per million [ppm], and turbidity is stable or ≤ 5 nephelometric turbidity units [NTUs]), well development will be considered complete. The submersible pump will be turned off and removed from the well. Well development purge water will be handled as described in Section 2.5.14. Equipment used for well development will be decontaminated as described in Section 2.5.13.

For small-diameter wells that cannot accommodate a conventional submersible pump, airlift systems may be used for well development. Only double tube-type airlift systems, consisting of an air line enclosed in an eductor pipe, may be used for well development. To avoid introducing air into the formation, the airlift system intake must be maintained at least ten feet above the screened interval of the well at all times. DO readings shall not be used to evaluate groundwater parameter stabilization when airlift pumping is used for well development. The Program Manager shall approve the use of airlift systems for well development on a case-by-case basis.

Some monitoring wells at Sites 1 & 2 are installed in very low-yielding formations (i.e., wells do not recover to within 80% of the prepurging water level within 24 hours). Development of these wells is problematic, because they are typically bailed or pumped dry before groundwater parameters have stabilized. Development of low-yielding wells will be continued until three well volumes of groundwater have been removed and the well casing is substantially free of accumulated sediment. Prior experience at Sites 1 & 2 has shown that groundwater samples with acceptable turbidity can be collected from low-yielding wells using low-flow purging methods with dedicated pumps, as described in Section 2.6.3.6.1.

2.5.7 Well Destruction

Monitoring, extraction, and/or injection wells that become damaged or are no longer needed will be properly destroyed in accordance with state and local regulations. Well destruction permits will be obtained prior to well destruction. In general, well destruction will consist of removing the surface

completion, and then either overdrilling and removing the well casing, screen, and annular materials, and backfilling the boring with grout; or pressure grouting the well in place. If pressure grouting is used for well destruction, the well casing and/or screen may be perforated prior to grouting, if required by the local regulatory agency. Cement/bentonite grout will be used for well abandonment, unless the local regulatory agency requires the use of another grout formulation. Grout shall be placed from the bottom to the top of the boring or well using a tremie pipe.

All destroyed wells shall be checked 24 to 48 hours after grout emplacement to determine whether curing is occurring properly. More specific curing specifications or quality assurance checks may be recommended by the manufacturer and shall be followed. Additionally, if significant settling has occurred, a sufficient amount of mud/solid bentonite shall be added to attain its initial level. These slurry/solid bentonite curing checks and any addition of mud/solid bentonite shall be recorded in the field logs.

2.5.8 Soil Gas Surveys

2.5.8.1 General Soil Gas Survey Procedures

The primary function of a soil gas survey is to assist in identifying potential source areas for soil and groundwater contamination. Soil gas may also be used in small source areas to help target soil boring, monitoring well, and indoor air sampling locations. Soil gas sampling networks will be designed to obtain all necessary information with a minimal expenditure of time and resources. The development of the sampling network will be based on background information, properties of the vadose zone, and hydrogeologic properties of the area. Soil gas sampling procedures are discussed in Section 2.6.5.

Common sampling schemes include grids, transect lines, biased, random, and combinations of sampling schemes. Grids consist of sampling points on perpendicular lines at equal distances along the lines. The size of the grid will be dependent upon site characteristics and sampling objectives. The transect line sampling network is typically used to find a source area of contamination. Sampling points are placed along a line between the area of impact and the suspected source area. In a biased sampling network, sample points are placed near the suspected source of contamination to locate "hot spots" and further delineate the extent of contamination. This sampling network will not be used for unknown conditions. Random sampling networks use a numbered grid system and the sample points are selected by a random number generator. This network is typically used in areas where little information is available or no contamination is suspected. The combination-sampling network consists of several of the above-referenced networks. The interval between sampling points will be dependent on the objectives of the investigation.

The selection of sampling schemes will be described in each project-specific work plan. The type(s) of sampling schemes selected will be dependent on site conditions and the data quality objectives for the project. Soil gas sampling will be used when groundwater sampling indicates contamination or when vadose zone contamination is suspected. Where DQOs require soil gas data of high quality (e.g., risk assessment data use), the standard for implementing soil gas surveys will be the most recent update jointly developed by DTSC and Regional Water Quality Control Board (RWQCB), Los Angeles Region, *Advisory – Active Soil Gas Investigations* (DTSC, 2003). This standard has received approval by state regulators, and yields a high degree of data quality. For investigation programs where a screening level soil gas survey approach with lower DQOs may be appropriate, the Performing Contractor and its subcontractors shall use the above standard as a general guide, and shall specify deviations from the standard in a project-specific FSP Addendum.

In certain instances use of passive, rather than active, soil gas survey techniques may be practical. In these cases, the grid spacing, depth of insertion, and brand of passive sorbent device must be provided, in addition to a description of the field and laboratory program, in a project-specific FSP Addendum. In most cases, adherence to manufacturer's guidelines with appropriate analytical QA/QC is sufficient to produce a quality result.

2.5.8.2 Soil Gas Probe Construction

Soil gas probes may be constructed in hand auger, DP, or HSA borings, depending on subsurface conditions and probe installation depth. Soil gas probes installed using DP methods typically involve advancing a 1-inch steel drill rod with a drop-off point on the lead end to total depth. Soil gas probes installed using HSA typically involve drilling a 6-inch diameter boring to total depth. The soil vapor probes will be completed with stainless steel mesh screens or plastic filters and ¼-inch Nylaflow or Teflon tubing. The screens are set in a filter pack consisting of 1 foot of washed sand (No. 3, #2/12, or #2/16 sand). As the drill rod or auger is removed, the borings will be sealed with hydrated granular bentonite. This process may be repeated if multi-depth probes are being installed. The remainder of the boring will then be backfilled with hydrated granular bentonite slurry to the ground surface. For multi-depth soil gas probes, the probe depth will be indicated by the length of tubing at the surface, with longer lengths used for deeper completions, or by using color-coded tubing. A petcock valve and a protective surface completion, consisting of a flush-mount well box or a length of 2-inch PVC pipe with a slip cap, will be installed at the surface. Newly-installed soil gas probes will be allowed to equilibrate prior to sampling for a minimum of 30 minutes if installed in DP borings, or for 48 hours if installed in HSA borings. However, longer equilibration times (2 days for DP borings and 2 weeks for HSA borings) are often used to ensure that the formation has completely equilibrated prior to sampling.

A leak test shall be performed when sampling soil gas probes. Immediately before sampling, a leak check compound should be placed at locations where ambient air could enter the sampling system or where cross-contamination may occur. Locations of potential ambient air intrusion include surface bentonite seals and sampling system connections. The leak test should include analysis of the leak check compound in all samples. If the leak check compound is detected in the soil gas samples, leakage should be confirmed by resampling with a different leak check compound. If leakage cannot be corrected, the soil gas probe should be destroyed and a replacement probe should be installed at least 5 feet from the original probe location.

2.5.9 Surveying

All wells will be referenced to standard horizontal and vertical control (third order) by a California-licensed Professional Land Surveyor. For monitoring wells, elevations will be surveyed at the reference point at the top of the well casing and at the ground surface adjacent to the well. The reference point will be clearly and permanently marked on the highest point on the casing or the north side of the inside well casing for future water level measurements. The elevation of the well casing will be surveyed to the nearest 0.01-foot and the elevation of the ground surface will be measured to the nearest 0.1-foot, referenced to mean sea level (MSL). The horizontal location of each well and borehole center point will be surveyed to the nearest 0.1-foot.

Other sampling locations, such as soil borings, surface soil and water sampling locations, and soil gas sampling locations will be measured to an accuracy appropriate to the DQOs of the project using a hand-held global positioning system (GPS) unit. The accuracy of the GPS is variable, and generally does not meet the requirements of plus or minus 0.1 foot in the horizontal plane and plus or minus 0.01-foot in the vertical direction. Therefore, the hand-held GPS will only be used for surveying locations where there is no 0.1-foot/0.01-foot requirement (e.g., soil borings, surface soil and surface water sampling locations, and soil gas sampling locations). If a field program will likely entail the need to resample a boring or surface sample location, precise surveying may be appropriate, and should be stated in the project-specific work plan addendum. For locations where groundwater elevations are to be measured, the 0.1-foot/0.01-foot requirement shall be achieved.

Surveyed locations shall be measured as the distance in feet from a survey reference location (i.e., control point) that is tied to the state plane system. An X-Y coordinate system shall be used to identify locations. The X-coordinate shall be the east-west axis; the Y-coordinate shall be the north-south axis. The reference location is the origin. All surveyed locations shall be reported in feet using the state plane coordinate system. The horizontal datum will be North American Datum (NAD) 83 and the vertical datum will be

North American Vertical Datum (NAVD) 88. The surveyed control information for all data collection points shall be recorded and displayed in a table. The table shall give the X and Y coordinates in state plane coordinate values, the ground elevation, and the measuring point elevation if the location is a groundwater monitor well. The locations of survey reference monuments will be identified on the plot map for each survey program. Survey reference monuments will be maintained for each site and will be periodically checked by licensed surveyors using GPS instrumentation to ensure the integrity and to track subtle changes over time in future surveys.

2.5.10 Groundwater Level Measurements

2.5.10.1 General Procedures for Water Level Measurement

Water levels will be measured in all newly installed groundwater monitoring wells, prior to sampling existing or newly-installed monitoring wells, and as specified in project-specific work plans. Groundwater levels will be measured using an electric sounder or pressure transducer. The following protocols will be employed while collecting water-level measurements.

The calibrated water level probes, i.e., electric sounders and interface probes, will be decontaminated before use in each well. Decontamination procedures will follow those for the water sampling equipment as described in Section 2.5.13. Measurements will be recorded as feet below the measuring point elevation (usually top of casing) to the nearest 0.01 foot and will be referenced to MSL. Measurements will be taken after wells have been developed and prior to any well purging activities. The measurements will be taken within as short a time period as practical so that water levels are representative of a given period. The water level measurements shall be recorded on a water level measurement field data sheet. An example of a water level measurement field data sheet is provided in Appendix A. Groundwater contour maps of the Site will be developed based on water level elevations recorded.

Monitoring air above the wellhead using an OVA will indicate toxic potential for workers. Appropriate action levels for compounds detected in the breathing zone are listed in the HASP. Air monitoring may also indicate the presence of immiscible layers. If there is an immiscible layer, an interface probe will be lowered down the well to measure both the static water level and light or dense immiscible layers. The interface probe will first measure the air/floating product interface and next the floating product/water interface to establish the thickness of the floating product layer. If air monitoring indicates the possible presence of an immiscible layer and the interface probe does not detect a layer, an acrylic bailer will be lowered into the well to evaluate the presence of a floating layer too thin to be detected by the interface probe. The bailer can then be lowered to the bottom of the well to register the presence of free phase

dense non-aqueous liquids. If fuel or other floating hydrocarbons are detected, water levels will be corrected to account for the presence of the floating hydrocarbons using the following equation:

$$PE = MP - WL + SG (WL - FL)$$

where:

PE = piezometric elevation, in feet
MP = measuring point elevation, in feet
WL = depth to water, in feet below MP
FL = depth to floating product, in feet below MP
SG = specific gravity of the fuel (fuel density/water density)

True product thickness will be estimated from the boring logs by noting the first appearance of soil contamination and the depth to groundwater.

2.5.10.2 Procedure for Measuring Groundwater Levels with an Electric Sounder

- A battery-powered electric sounder (Heron, Solinst or equivalent) or an interface probe may be used for water-level measurements. The sounder will have firmly affixed or permanent marks on the sounder line at regular intervals of 1-foot or less. Water level measurements will be recorded with a precision of 0.01 foot.
- All portions of the sounder cable that are lowered into the groundwater will be decontaminated according to the procedures described in Section 2.5.13.
- Sounders and interface probes will be maintained in a clean and functional condition.
- Conditions affecting water-level readings will be recorded in the field log.
- Remove the locking and protective caps.
- Sample the air in the breathing zone for the presence of organic vapors using an OVA and proceed as indicated in the HASP.
- Sample the air in the well head for the presence of organic vapors using an OVA (and an explosivity meter, if required by elevated OVA readings). Assess the presence of light (floater) and/or denser (sinker) immiscible layer(s) using an interface probe, if applicable. If immiscible layers are present, measure the depth of the water and the thickness of the immiscible layer(s).
- If there are no immiscible layers, determine the static water level depth from the top of the well casing (surveyed measuring point) to the nearest 0.01 foot using an electric sounder.
- Measure the total depth of the well from the top of the well casing (surveyed measuring point) to the nearest 0.01 foot using an electric sounder. If a dedicated sampling pump is present in the well, the well depth does not need to be measured.
- Calculate the corrected water level if free product is observed.

2.5.10.3 Procedure for Measuring Water Levels with Pressure Transducers

- Electronic or pneumatic pressure transducers may be used during single-well or multiple-well aquifer testing. Pressure transducers may also be used for continuous monitoring of water levels over periods of several weeks or months.
- The operation, calibration, maintenance, and storage of the pressure transducers will be in accordance with the manufacturer's specifications. A copy of the manufacturer's recommended

calibration procedures will be available for inspection. The pressure transducer calibration log will be available in the project files.

- Barometric pressure should be monitored at the beginning and at least at the end of the test, or throughout the monitoring period, to evaluate potential impacts from barometric pressure on the test.
- Enter the required information into the electronic data logger in accordance with the manufacturer's instructions. Note: It is important to consult the Operations Manual for the proper data entry sequence as different models require different data entry procedures.
- Store all data internally, and also on appropriate portable electronic media (CD, DVD, etc.).
- Transfer the information directly to the appropriate computer for analysis as soon as practical after the test is completed. Maintain a computer printout of the data in the project files as documentation.
- The exact depth to the sensing tip of the transducer and the water level at time of placement will be measured and recorded.
- Conditions that could affect transducer operations will be noted and recorded in the field log book.
- During aquifer or pumping tests where pressure transducers are being used, water levels will be periodically checked using an electrical sounder. The distance from the marked measuring point on each well to the reference point on each transducer will be recorded for each measurement.
- If pressure transducers are used for continuous water-level monitoring over extended periods of time, the calibration of the transducer will be checked at least weekly by measuring the water level with an electric sounder. Measurements will also be made using an electric sounder on the day of transducer installation and immediately before removing the transducer from the well.

2.5.11 Aquifer Testing

2.5.11.1 General

Equipment shall be decontaminated as specified in Section 2.5.13. The Performing Contractor shall demonstrate that the assumptions of the selected analytical methods for deriving the hydraulic properties match the hydrogeological conceptual site model and meet the DQOs in the project specific work plan.

2.5.11.2 Specific Capacity Tests

Water level drawdown and pumping rates measured during well development may be used to estimate the hydraulic conductivity of the formation, using the equations from Driscoll (1986), derived from Cooper and Jacob's (1946) approximation of the Theis solution:

$T = 200\ Q/s$ (for unconfined aquifers)
$T = 267\ Q/s$ (for confined aquifers)

where:

T = well transmissivity (feet^2/day)
Q = discharge (gallons/minute)
s = drawdown (feet)

The average hydraulic conductivity (K) for the screened interval of the well is then calculated by dividing the estimated transmissivity by the wetted screen length in feet;

$$K = T/b$$

where:

K = hydraulic conductivity (feet/day)
b = wetted screen length of the well (feet).

2.5.11.3 Slug Tests

2.5.11.3.1 General Procedures for Conducting Slug Tests

The slug test measures the rate of water level recovery in a well over time in response to the injection or withdrawal of a mass (slug) beneath the groundwater surface. The slug can be a quantity of water or a solid of known volume. Hydraulic conductivity in the immediate vicinity of the well can be determined by measuring water level versus time data after the slug is added or removed.

First, a slug is inserted to a level beneath the groundwater surface and the water level is allowed to reach equilibrium. Then the slug is removed and the rise in water level is measured with time. Alternatively, a slug of water may be withdrawn and water level response monitored. Tests shall be performed by inserting or removing a solid slug or by withdrawing water from the well; no fluid shall be put in the well. The primary advantages and disadvantages of using slug tests to estimate conductivities are:

- estimates can be made in situ and the errors incurred in the laboratory testing of disturbed samples can be avoided;
- tests can be performed quickly at relatively low costs because a pumping well and observation wells are not required;
- the hydraulic conductivity of small, discrete portions of a saturated medium can be estimated (e.g., sand layers in a clay);
- certain assumptions are made in the analysis process (i.e., if the assumptions are inappropriate for the geologic conditions at the site, the slug test data are invalid);
- the storage coefficient, S, usually cannot be determined; and
- data sufficient for analysis may not be collected if the hydraulic conductivity is relatively high.

The time required for a slug test is a function of the volume of the slug, the hydraulic conductivity of the formation, and the type of well completion. The slug volume should be large enough that a sufficient number of water level measurements can be made before the water level returns to equilibrium conditions. The length of the test may range from less than a minute to several days.

If the well is used for groundwater monitoring, precautions should be taken so contamination is not introduced by equipment placed in the well. All slugs, bailers, and measuring devices shall be decontaminated as specified in Section 2.5.13.

Conduct slug tests on relatively undisturbed wells. If a test is conducted on a well that has recently been pumped for water sampling purposes, the measured water level must be within 0.1 ft of the static water level at the well. The exact dimensions of the borehole, casing, and filter must be recorded for accurate analysis of the slug test data

2.5.11.3.2 Procedure for Conducting Slug Tests using Pressure Transducers

- Barometric pressure should be monitored at the beginning and at least at the end of the test to evaluate potential impacts from barometric pressure on the test.
- Enter the required information into the electronic data logger in accordance with the manufacturer's instructions. Note: It is important to consult the Operations Manual for the proper data entry sequence as different models require different data entry procedures.
- Store all data internally, and also on appropriate portable electronic media (CD, DVD, etc.).
- Transfer the information directly to the appropriate computer for analysis as soon as practical after the test is completed. Maintain a computer printout of the data in the project files as documentation.
- Determine the static water level in the well with an electric sounder, and continue to measure the depth to water periodically for several minutes to several hours, and take the average of the readings.
- Record information in the field logbook.
- Install the transducer in the well below the estimated target drawdown depth. Ensure that the depth of submergence is within the design range stamped on the transducer.
- Attach the transducer cable to the well to hold the transducer at a constant depth.
- If the tranducer does not have an internal datalogger: connect the transducer cable to the electronic data logger, enter the initial water level and transducer design range into the recording device according to the manufacturer's operating instructions, and record the initial water level on the recording device.
- Smoothly lower the slug into the well or withdraw the slug from the well.
- Observe the transducer readout to detect where the slug contacts the water, or measure groundwater levels with an electric sounder.
- Allow the water level to stabilize (within 0.1 ft) and insert or remove the slug or volume as quickly and smoothly as possible because the analysis assumes that an instantaneous change in volume is created in the well.
- Continue measuring and recording depth/time measurements until the water level returns to equilibrium conditions or a sufficient number of readings have been made to clearly show a trend on a plot of water level recovery versus the logarithm of time.
- Stop the datalogging sequence, download the data to a computer, print the data and file them on appropriate portable electronic media (CD, DVD, etc.) at the end of the test.

2.5.11.4 Pumping Tests

Pumping tests will be performed to evaluate specific capacity, hydraulic conductivity, transmissivity, specific yields for unconfined aquifers, and storage coefficient for confined aquifers. The pumping test involves pumping one well and simultaneously recording the drawdown in the extraction and nearby observation wells. Monitoring wells shall be used as observation wells when possible. The number and spacing of observation wells and other aspects of the pumping test design are site-specific, and will be specified in the project-specific Work Plan.

The pumping rate shall be determined by conducting step tests prior to the pumping test. The well shall be pumped at predetermined rates in order to determine the optimum pumping rate. If a lower pumping rate is preferable because of factors such as nearby supply wells, areas with floating product, disposal costs, or limited storage facilities, the lower rate shall be approved by the Program Manager. The constant rate (steady state) discharge test involves continued pumping at a constant rate from an extraction well until water levels in nearby observation wells reach equilibrium. The procedures that will be used include the following:

- Barometric pressure should be monitored at the beginning and at least at the end of the test to evaluate potential impacts from barometric pressure on the test.
- Where possible, at least three observation wells at different distances from the pumping well will be used to determine drawdown effects.
- The test shall not begin until water levels in all wells have completely recovered from previous disturbances due to sampling or the step test.
- The discharge valve shall be monitored and regulated for either a constant-discharge or constant-head test.
- The discharge rate shall be measured at least 10 times during the first 100 minutes of the test and at least every time water levels are measured thereafter.
- All pumping equipment will be decontaminated prior to use according the procedures described in Section 2.5.13.
- Water levels shall be measured at least 10 times per log cycle for the first 100 minutes of the test and at least once every hour thereafter.
- The pumped water shall be disposed of so as not to recharge the portion of the aquifer being tested or otherwise affect the validity of the test. If the discharge water is suspected of being contaminated it will be containerized for proper disposal.
- Time-drawdown or distance-drawdown data shall be analyzed during the test.
- The test shall be terminated when collection of additional data shall not affect results (e.g., when water levels are essentially at equilibrium, or when a well in low hydraulic conductivity sediment or rock does not yield sufficient water to continue). Test durations may range from two hours to a week or more. Common test periods are 24 to 72 hours.
- Field conditions such as diurnal fluctuations of surficial aquifers, barometric/tidal effects, rainfall, and irrigation will be assessed during field data analysis.
- Analysis of the pumping test data may be aided by computer software.

2.5.11.5 Air Permeability/Radius of Influence Tests

Air permeability testing provides data about soil permeabilities to support the design and installation of SVE or bioventilation systems for cleanup of impacted soils. The tests are done by extracting air through an existing soil vapor extraction well and measuring the induced vacuum in surrounding monitoring wells (vapor piezometers). The extraction system equipment will vary depending on the specific system used for each test, and the sampling equipment will vary depending on the required analyses and sampling methods. These details are to be specified in the project-specific work plan and FSP Addendum. Air permeability and radius of influence testing are to be conducted in accordance with the *Bioventing Principles and Practices, Vols. 1 and 2* (EPA, 1995).

2.5.11.6 Bioventilation Tests

Bioventilation is the process of aerating subsurface soils to enhance in situ biological activity and promote aerobic biodegradation. Bioventilation is accomplished by injecting air (or other gas containing oxygen) into vent wells such that it is forced into surrounding impacted soils. The number, sizes, and spacing of vent wells are site-specific and will be specified in the project-specific work plan. Specific tests to be conducted during a bioventilation test may include an in-situ respiration test and an air permeability test. The in-situ respiration test provides a measurement of in-situ biodegradation rates by measuring the decline of oxygen concentrations over a period of time following its introduction into a targeted soil zone at a known concentration. Procedures will follow those outlined in EPA (1995) protocol.

2.5.11.7 Other Test Methods

Aquifer hydraulic parameters can be estimated from an extraction well's specific capacity and from step-drawdown tests. For rocks with low hydraulic conductivity, ASTM methods D-4630 or D-4631 are applicable (ASTM, 1993). For clay, ASTM methods D-1587 and D-2434 are applicable (ASTM, 1993).

2.5.12 Surface Water

2.5.12.1 Stream Discharge Measurements

Stream discharge shall be estimated using the float method. In this method, two cross-sections at least 10 feet apart, and preferably at least 20 feet apart, are selected along a reach of channel. The reach should be relatively uniform and free of debris pools, debris piles, and overhanging vegetation. A floating object is then released upstream of the first cross-section. A stopwatch is started when the float passes the first cross-section, and is stopped when the float passes the second cross-section. A travel time of at least 20 seconds is recommended, but shorter times are acceptable for small streams with high velocities. Care

should be taken that the float is not affected by wind. A stream depth measurement is then made where the float passes the second cross-section.

The stream velocity is calculated by dividing the distance between the two cross-sections by the time needed for the float to pass between the cross-sections. The cross-sectional area of the stream is calculated by multiplying the width of the stream at the second cross-section by the measured stream depth. Discharge is then calculated by multiplying the stream velocity by the cross-sectional area of the stream.

$$v = l \times t$$
$$A = w \times d$$
$$D = v \times A$$

where:

l = distance between cross-sections (feet)
t = time needed for float to pass between cross-sections(seconds)
v = stream velocity (feet/second)
w = stream width at second cross-section (feet)
d = stream depth at point where float passes second cross-section line (feet)
A = cross-sectional area of stream ($feet^2$)
D = stream discharge (cubic feet per second)

Where multiple channels are present, as in braided streams, discharge is measured in each channel and the results added together to obtain the total stream discharge.

2.5.12.2 Surface Water Sampling

Surface water samples will be collected using the direct method. This method shall not be used for sampling lagoons or other impoundments where contact with contaminants is a concern. Using adequate protective clothing and in accordance with the site-specific HASP, the designated sampling location should be accessed by appropriate means. For shallow streams or stormwater runoff sampling, samples are collected by placing the sample container under the water surface while pointing the container upstream. Where water depths are extremely shallow, it may be necessary to create a small depression to allow the container opening to be submerged the below the water surface. If this is necessary, care should be exercised to avoid collecting turbid samples. In all cases, the container must be upstream of the collector to avoid collecting turbid samples, and efforts should be taken to avoid disturbing the substrate. When using the direct method, prepreserved sample bottles should not be used for sample collection, as the collection method may dilute the concentration of preservative necessary for proper sample preservation.

2.5.13 Equipment Decontamination

As previously indicated, an equipment decontamination area located onsite will be used for drilling equipment decontamination. A temporary decontamination pad may be constructed at the site, if necessary.

All equipment that may directly or indirectly contact samples shall be decontaminated prior to and after each use in a designated decontamination area. This includes casing, drill bits, auger flights, the portions of drill rigs that stand above boreholes, sampling devices, and instruments, such as slugs and sounders. In addition, the subcontractor shall take care to prevent samples from coming into contact with potentially contaminating substances, such as tape, oil, engine exhaust, corroded surfaces, and dirt. The drill rig used for this work effort must be equipped with a self-contained decontamination station to provide for day-to-day decontamination requirements. Drilling equipment will be decontaminated before and after use, and between each distinct sampling location (e.g., borehole, well). The following procedure shall be used to decontaminate large pieces of equipment 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:

- rinse with high-pressure/hot water cleaner;
- wash external surfaces of the drilling equipment with high-pressure/hot water and laboratory grade detergent (i.e. Alconox or Liquinox), and scrub if necessary to remove dirt, grime, grease, and oil;
- wash internal surfaces of casing, drill rod, and auger flights as described above;
- rinse with high pressure/hot water cleaner;
- rinse with potable water until all rinsate water appears clear; and
- drain decontamination materials (solids and fluids) to a collection container and dispose in accordance with applicable regulations, following proper chemical characterization and evaluation of disposal options.

.The following procedure shall be used to decontaminate sampling and drilling devices, such as split spoons, bailers, and augers that can be hand-manipulated. Any water sampling equipment which may directly contact groundwater (e.g., lifting lines and re-usable bailers) will be decontaminated prior to collection of the sample following the sequential steps below.

- scrub the equipment with a solution of potable water and Alconox, Liquinox, or equivalent laboratory-grade detergent to remove visible soil or other visible potential contaminants;
- rinse the equipment with copious quantities of potable water until rinsate appears clean;
- double rinse with distilled or deionized water; and
- dispose of rinse solutions in a designated 55-gallon drum or bulk fluid storage container properly marked for its contents.

Purge equipment, including pumps and discharge lines, will be decontaminated by flushing/pumping a Liquinox or equivalent solution, potable water, then deionized water through the components. Lifting lines will be washed with a Liquinox or equivalent solution and rinsed with potable and deionized water. Measuring equipment, such as thermometers or conductivity probes, will be thoroughly rinsed with deionized water prior to each use and between sampling points.

Distilled or deionized water shall be purchased, stored, and dispensed only in approved containers. It is the subcontractor's responsibility to assure these materials remain free of contaminants. If any question of purity exists, new materials shall be used.

Discarded materials, including paper towels and decontamination fluids, will be stored in 55-gallon drums for disposal in accordance with applicable regulations, following chemical characterization and evaluation of disposal options.

2.5.14 Investigation Derived Waste Management

Investigation-derived waste (IDW) may include soil cuttings, liquid drilling fluids, groundwater from development of newly constructed wells, groundwater from purging, decontamination fluids, and disposable personal protective equipment (PPE). The IDW shall be segregated at the site according to matrix (solid or liquid) and derivation (e.g., soil cuttings, decontamination fluids, purged groundwater, etc.). Each container shall be properly labeled with site identification, sampling point, generation date, matrix, constituents of concern, and other pertinent information for handling. Waste characterization will consist of collecting and analyzing soil cuttings and decontamination/purge water per waste profiling requirements set by the appropriate disposal facility. General procedures to be employed for containerizing, temporarily storing, sampling and evaluating analytical results, and transporting/disposing of IDW are discussed below.

All IDW will be kept in containers until analytical results are obtained to determine if IDW is hazardous or nonhazardous. The number of containers shall be estimated on an as-needed basis. Acceptable containers shall be sealed, U.S. Department of Transportation (DOT)-approved plastic or steel 55-gallon drums or roll-off bins with lids. The containers shall be transported in a manner that prevents spillage or particulate loss to the atmosphere.

2.5.14.1.1 Soil Cuttings

Soil cuttings are generated during the course of drilling boreholes and wells. Field screening, consisting of monitoring using an OVA and visual inspection, will be conducted on cuttings for an initial indication of contamination. Soils with elevated OVA readings (>50 ppm above background) or obvious staining or

discoloration will be considered potentially contaminated. Cuttings with obvious indications of contamination will be containerized separately in drums or roll-off bins and labeled as "potentially contaminated." All containers will be periodically moved to the waste storage area or disposed of after waste characterization has been completed.

2.5.14.1.2 Purge Water

Groundwater purged from monitoring wells during well development and sampling will be placed in labeled 55-gallon drums, or for larger volumes, transported to bulk fluid storage tanks at the designated IDW storage area.

2.5.14.1.3 Disposable PPE

IDW may include disposable PPE such as chemical protective suits, gloves, rags used to wipe equipment, and plastic sheeting. All disposable protective clothing and supplies will be placed in labeled 55-gallon drums and stored at the IDW storage area at the Site until fieldwork is completed. Soil and groundwater analytical data will be used to determine if IDW materials are hazardous or non-hazardous waste. At the end of the field program, these materials will be disposed of accordingly, depending on the analytical data.

2.5.15 Asbestos Surveys and Sampling

Asbestos surveys will follow the AHERA (40 Code of Federal Regulations [CFR] Part 763) sampling requirements. All suspect materials will be divided into groups/areas with similar characteristics (homogeneous materials) from which the required number of samples will be collected. Suspect materials include, but are not limited to, the following: surfacing materials (sprayed or troweled on structural members, ceilings and walls, such as fireproofing, thermal insulation, acoustic or decorative materials); thermal system insulation (pipe, boiler, tank, equipment, duct or other HVAC insulation materials); and miscellaneous materials (construction materials for roofs, ceilings, floors and walls, such as tiles/panels, sheeting, wallboard/joint compound, paints, coatings and roofing materials). Each homogeneous material will be classified as a surfacing material, thermal system insulation (TSI), or miscellaneous material. Surfacing material such as plaster, joint compound, or fireproofing will fall under the 3-5-7 rule where a minimum of 3 samples will be collected of material with a total quantity less than 1,000 square feet; 5 samples up to 4,999 square feet; and 7 samples thereafter. TSI will have 3-samples collected of each homogeneous material. Only 1 sample of each miscellaneous material is required to be collected. However, three samples of each material are usually collected to ensure the statistical validity of sample results. The Performing Contractor's personnel will determine in the field using professional judgment

whether one sample is sufficient or if three samples should be collected. The following table provides a generalized sampling approach used in asbestos surveys:

Types of Materials	***Number of Samples***
Surfacing Materials:	
Fireproofing	3-5-7 rule
Plaster	3-5-7 rule
Drywall / joint compound	3-5-7 rule
Wall/ceiling texture compound	3-5-7 rule
Thermal System Insulation (TSI):	
HVAC duct insulation	3 samples of each homogeneous material
Boiler/vessel insulation	3 samples of each homogeneous material
Pipe run/fitting/valve insulation	3 samples of each homogeneous material
Other TSI insulation	3 samples of each homogeneous material
Miscellaneous Materials:	
Fire doors insulation	1 sample of each type required (3 samples usually taken)
Ceiling panels/tiles	1 sample of each type required (3 samples usually taken)
Ceiling tile adhesives	1 sample of each type required (3 samples usually taken)
Wall tile/panel and adhesives	1 sample of each type required (3 samples usually taken)
Thermal system insulation	1 sample of each type required (3 samples usually taken)
Baseboard/adhesive	1 sample of each type required (3 samples usually taken)
Vinyl Flooring & Adhesives	1 sample of each type required (3 samples usually taken)
Ceramic tiles grout and underlayment	1 sample of each type required (3 samples usually taken)
Exterior stucco or wall texture material	1 sample of each type required (3 samples usually taken)
Interior/Exterior caulking, sealants, mastics, putty	1 sample of each type required (3 samples usually taken)
Miscellaneous debris above ceilings	3 samples of each type
Other miscellaneous materials	1 sample of each type required (3 samples usually taken)
Roofing shingles, composite roof tar/felt, roof paper, cap sheet, gravel roofing, asphalt shingles, base flashing, etc.	1 sample of each type required (3 samples usually taken)
Transite exhaust flue pipes or other transite materials	Presumed Asbestos Containing Material (PACM)- Not sampled
Roof patch and penetration mastics	Exempt if <10 square feet, otherwise 1-3 samples of each type

Each sample will be collected and placed in a plastic or metal container. The container will be sealed, labeled, and placed in a larger storage bag. Destructive inspection methods (if allowed) will be used to find concealed asbestos and ensure that all asbestos containing suspect materials are discovered and surveyed. Throughout the process, care will be taken to prevent cross-contamination of the collected samples. Sampling equipment will be cleaned after each sample is obtained. In addition, sample containers will be placed directly beneath each sample location, when feasible, to collect any materials which may become dislodged during the sampling process. Any debris generated by the sampling process will be cleaned by wet-cleaning methods. Sample locations will not be repaired but will have any exposed

surfaces sealed with flexible caulking type material or sealant or be taped over with abatement tape to minimize any potential fiber release.

Samples will be documented by entering the sample data on a bulk log, including a description of the material, sample number, location, condition, accessibility, friability, potential for damage, and quantity. The sample location will be marked on a field-drawn sketch (not to scale) or, if available, on provided engineering drawings. In addition, a photograph will be taken to further document the material sampled, its condition, and location.

2.6 ENVIRONMENTAL SAMPLING

Soil, groundwater, surface water, and vapor samples will be collected during the RI/FS, treatability and remediation pilot studies, and groundwater monitoring. The methodologies to be used in collecting these samples, including descriptions of field QC samples, are discussed in the following subsections. In addition to the sampling methods discussed below, other sampling methods may be proposed in project-specific work plans. In these instances, a FSP Addendum will be prepared describing the proposed sampling methods.

The construction material of the sampling devices (e.g., plastic, glass, PVC, or metal) discussed below shall be appropriate for the Site COPCs and shall not interfere with the chemical analyses intended for the sample.

All purging and sampling equipment shall be decontaminated according to the specifications in Section 2.5.13 prior to any sampling activities and shall be protected from contamination until ready for use.

2.6.1 Soil Sampling

Soil borings may be drilled using techniques discussed in Section 2.5.4. Unless otherwise specified in the project-specific work plan, borings will either be continuously cored or sampled at 5-foot intervals, depending on the drilling method and location. Each core/sample will be observed and logged for lithologic description using the classification systems described in Section 2.5.1. If field screening methods indicate that the soil is contaminated, additional soil samples may be collected for analysis by an off site laboratory.

Soil samples shall be collected according to project-specific work plan directives. If initial screening results indicate the presence of organic vapors, a headspace analysis shall be conducted on the soil sample from the shoe or the first soil sleeve containing representative soil, but not sealed for shipment to the laboratory. Small diameter split-spoon samples may be used with the approval of Program Manager. The additional soil in the brass or stainless steel rings will be used for lithologic description.

Additional subsurface soil sampling procedures are as follows:

- Split-spoon or ring samples will be collected at 5-foot intervals at zones of obvious contamination, and at major changes in lithologic conditions such as contacts between strata.
- Background concentrations will be determined from new and existing data. If additional background data are needed, borehole locations will be identified based upon factors such as soil and geologic similarities, proximity to the source of contamination, and history of land use.
- All sampling equipment will be kept off contaminated surfaces to prevent cross-contamination of the samples. For example, equipment will be placed on clean disposable polyethylene sheeting.
- All sampling equipment will be decontaminated between sampling locations as described in Section 2.5.13.
- Excavated soil cuttings shall be screened for hazardous properties.
- All boreholes will be surveyed as described in Section 2.5.9.
- All boreholes that are not completed as monitoring wells shall be abandoned in accordance with the state and local regulations, as described in Section 2.5.4.11.

Soil samples collected for VOC analysis shall be preserved using EPA Method SW5035A. The soil samples must be preserved with one of two preservatives prior to analysis, either in the field at the time of collection, or in the laboratory within 48 hours of collection. A sodium bisulfate preservative is added to soils anticipated to contain VOCs at concentrations less than 200 parts per billion (ppb), while a methanol preservative is used for those soils anticipated to contain VOCs at concentrations greater than 200 ppb. If the soil samples are to be preserved in the laboratory, the samples must be collected in a purge-and-trap soil sampler, an Encore sampler, or a similar type device and must then be delivered to the lab for preservation within 48 hours of sample collection. EPA Method 5035A gives a number of options for collecting soil samples that are summarized below. In all cases (i.e., EnCore sampler, field preservation with methanol, or field preservation with sodium bisulfate), an additional subsample of soil must be collected and submitted along with the primary and sent to the laboratory for moisture content determination.

2.6.1.1 Soil Sampling for VOCs

2.6.1.1.1 Soil Sampling using Encore or Equivalent Sampling Device

For volatile analysis of soil samples by EPA Method SW8260B, EnCore samplers or comparable DTSC-approved EPA Method 5035 sampling devices will be used for collection and preparation of soil samples from split-spoon or solid-barrel samplers. The Encore sampler is a disposable, EPA-approved sampling device that allows soil samples to be collected and transported to the laboratory without preservation in the field. The Encore sampler is made of an inert composite polymer, and is designed to collect, store, and deliver soil in a sealed container with no headspace. In order to collect the sample, the

Encore sampler is attached to a reusable T-handle that assists in pushing the sampler into the soil. An airtight sealing cap is then attached, creating a self-contained package for shipment to the laboratory.

The procedure for using EnCore samplers is as follows:

- Prior to taking sample, hold coring body and push plunger rod down until small o-ring rest against tabs of EnCore sampler;
- Depress the locking lever on EnCore T-handle. Place coring body, plunger end first, into open end of T-handle aligning the two slots on the coring body with the two locking pins in the T-handle. Twist coring body clockwise to lock pins in slots. Check to ensure sampler is locked in place. Sampler is now ready for use.
- Turn the T-handle with T-up and coring body down. This positions the plunger bottom flush with the bottom of the coring body (ensure that plunger bottom is in position). Using T-handle, push sampler into soil from split-spoon sampler until coring body is completely full. When full, small o-ring will be centered in T-handle viewing hole. Remove sampler from soil and wipe excess soil from coring body exterior with a clean wipe.
- Cap the coring body while it is still on T-handle. Push cap over flat area of ridge and twist to lock cap in place. Cap must be seated properly in order to seal sampler.
- Remove the capped sampler by depressing locking lever on T-handle while twisting and pulling sample from T-handle.
- Lock the plunger by rotating extended plunger rod fully counterclockwise until wings rest firmly against tabs.
- Attach a completed sample label to cap on coring body, place in sealed zipper bag and place in iced cooler.
- Three EnCore samples will be collected for each sample for VOC analysis.

2.6.1.1.2 Field Methanol Preservation for High Level Soil VOC Samples:

Field personnel shall measure and dispense a volume of soil corresponding to a weight of approximately 5 grams into a pre-weighed 40-milliliter (ml) glass vial containing 5 ml of methanol preservative. The soil shall be placed in the vial in a manner which does not result in splashing or loss of methanol as the soil is introduced into the vial. The sample must be collected and dispensed utilizing a coring device such as a syringe with the end cut off. The vial must be quickly capped after introduction of the sample to avoid loss of methanol. The sample is then labeled and shipped to the laboratory for analysis.

2.6.1.1.3 Field Sodium Bisulfate Preservation for Low Level Soil VOC Samples:

This technique is similar to the field methanol preservation procedure with the following exception: Two glass vials preserved with sodium bisulfate are collected in addition to the methanol-preserved vial. The two vials preserved with sodium bisulfate are analyzed using a closed system purge and trap procedure. In this procedure, the volatiles are liberated from the soil by agitation and purging with an inert gas into the headspace in the vial. A special instrument is used that punctures the septum on the vial, and extracts an aliquot of the gaseous layer above the sample. Consequently, only one analysis can be performed on each

vial. For this reason, a second vial must be collected in case reanalysis is necessary. Additionally, a methanol preserved vial is required for this analysis should the sample require high level sample reanalysis. In soils with high calcium carbonate content, it may be necessary to collect a low level sample without addition of sodium bisulfate (see EPA Method SW5035A).

2.6.1.2 Split-Spoon Sampling

Samples of undisturbed soil or rock may be collected by advancing a split-spoon sampler attached to the drill rods or wire-line into the soil below the drill bit or auger bit at the bottom of the borehole. When soil samples are to be submitted for laboratory analysis, they shall be collected using California-modified split-spoon samplers, or equivalent. These samplers are 18 or 24 inches in length and have an outside diameter of 3 inches to accommodate 2-inch diameter brass or stainless steel rings.

Each time a split-spoon sample is taken, a standard penetration test shall be performed in accordance with ASTM D-1586 (ASTM 1993). The sample is obtained by driving the sampler a distance of 1-foot into undisturbed soil with a 140-pound hammer free falling a distance of 30 inches. The sampler is first driven 6 inches to seat it in undisturbed soil; then the test is performed. The number of hammer blows for seating the spoon and making the test are then recorded for each 6 inches of penetration on the drill log (e.g., 5/7/8). The standard penetration test result (N) is obtained by adding the last two figures (e.g., 7 + 8 = 15 blows per foot). The sampler may then be driven an additional 6 inches to fill the remainder of the split-spoon prior to retrieval.

As soon as the split-spoon is opened, the open ends of the brass or stainless steel rings shall be monitored for organic vapors using a PID or FID. Air monitor results shall be recorded on the boring log and in the field logbook.

The number of sleeves submitted to the laboratory depends on the analytical methods required. Samples for VOC analysis shall be collected from a brass or stainless steel ring using EPA Method 5035A. Rings with large gravel or debris shall not be used. Samples collected concurrently with VOC samples to be tested for other analytical parameters shall be collected from the remaining brass or stainless steel rings immediately adjacent to the VOC sample interval. The sleeve will be capped and secured with Teflon tape. Care shall be taken not to touch the ends of the sleeves prior to capping. If soil from several brass or stainless steel rings must be composited to provide sufficient sample volume for a particular analysis, the sample shall be composited and homogenized in a stainless steel bowl using a stainless steel trowel or scoop. The composited sample will then be transferred to the appropriate container, sealed, and labeled prior to being placed in an iced cooler.

2.6.1.3 Sonic Core Barrel Samples

Soil samples may be collected during sonic drilling from bagged samples extruded from the sonic core barrel. Soil samples collected in this manner are disturbed, and may not be used for VOC analysis. Samples shall be collected from the soil sample bags. The bag is cut open, and the soil from the center of the bag is removed and placed into 4- or 8-ounce glass jars with Teflon-lined screw caps, using nitrile gloves and clean sampling tools.

2.6.1.4 Hand Auger Sampling

Hand augering is used to collect soil samples from depths up to 10 feet bgs, although the technique can sometimes be used to greater depth. Soil samples may be collected from the hand auger borehole using a manually driven sampling device lined with brass or stainless steel sleeves. The sleeve will be capped and secured with Teflon tape. Care shall be taken not to touch the ends of the sleeves prior to capping. Samples for VOC analysis shall be collected in accordance with EPA Method 5035A.

When soil samples are collected from the hand-auger, soil will be placed directly from the hand-auger into 4- or 8-ounce glass jars with Teflon-lined screw-cap lids, using nitrile gloves and clean sampling tools.

2.6.1.5 Direct Push Sampling

DP sampling involves advancing a soil sampling tool, such as a piston sampler, using direct hydraulic pressure or by using a percussion hammer. Samples may be collected continuously or at specific depths. The samples well be collected in brass, stainless steel, or acetate sleeves. The sleeve will be capped and secured with Teflon tape. Care shall be taken not to touch the ends of the sleeves prior to capping. Once the container has been filled, the appropriate information will be recorded in the field logbook. Samples for VOC analysis will be collected in accordance with EPA Method 5035A.

2.6.1.6 Surface Soil Sampling

Surface soil samples shall be collected from the ground surface to 6 inches below the surface. If chemicals that are highly adsorbed to clay surfaces were released at the site, an additional sample may be collected from the surface to the 1-inch depth. Aboveground plant parts and debris should be excluded from the sample. Surface soil samples may be collected using stainless steel trowels, or collected directly into stainless steel, glass, or Teflon sample containers. Samples for VOC analysis shall be collected in accordance with EPA Method 5035A.

Surface soil samples will be collected at the Site where past disposal practices suggest that surface contamination is likely. Samples collected for the purpose of air dispersion modeling will be analyzed for grain size and moisture content, in addition to other chemical parameters required by the project specific work plan.

In addition to the record keeping requirements outlined in Section 2.9, unusual surface conditions that may affect the chemical analyses should be recorded, such as the following: (1) asphalt chunks that may have been dispersed over the sampling area; (2) distance to roadways, aircraft runways, or taxiways; (3) obvious deposition of contaminated or clean soil at the sampling location; (4) evidence of dumping or spillage of chemicals; (5) soil discoloration; and/or (6) unusual condition of growing plants, etc.

2.6.2 Sediment Sampling

Shallow sediment samples may be collected in shallow water using a scoop, trowel, or shovel. For the purpose of this method, surface sediment is considered to range from 0 to 6 inches in depth, and shallow water is considered to range from 0 to 12 inches in depth. Although this method can be used to collect both unconsolidated and consolidated sediment, it is limited somewhat by water depth and movement. Deep and rapidly flowing water can render this method less accurate if fines are separated from the coarser sediment during sampling. However, representative samples can be readily collected using this procedure in shallow, slow moving water providing that care is demonstrated by the sampler. A stainless steel or plastic sampling implement shall be used for sample collection. Care should be exercised to avoid the use of implements that are painted or plated with chrome or other materials.

To collect a sample, the desired volume of sediment is removed from the sampling area using a decontaminated sampling implement. The sample is then transferred into a 4- or 8-ounce glass jar with a Teflon-lined screw cap lid. Surface water is decanted from the sample container prior to sealing. Care should be taken to retain the fine sediment fraction during decanting.

2.6.3 Groundwater Sampling

The following section describes the methods that will be used for collecting groundwater samples from the borings and monitoring wells after installation. Initial groundwater sampling will follow a series of procedures for proper well preparation and sample collection including well development and well purging. Well development, as described in Section 2.5.6, will precede well purging and sampling by a minimum of 24 hours, to allow the well to stabilize after the agitation and aeration caused by development activities. Purging and sampling activities will follow procedures discussed below and described in *RCRA Groundwater Monitoring Technical Enforcement Guidance Document* (EPA, 1992).

2.6.3.1 Equipment Blank Sampling

Equipment blanks (EBs) should be collected prior to sampling the first well of the day. After decontaminating the pump and discharge line, distilled water should be pumped through the system. When two hose volumes have been allowed to clear the lines, the samples can be collected. Water must not contact anything except the pump and the sample bottles. The EBs will be analyzed for the same parameters as all environmental sample(s) collected each day; therefore, the number and type of sample bottles will be the same as for the sample(s) collected at the site. For reusable sampling devices such as pumps, an EB will be collected immediately after the sampling equipment has been decontaminated. For disposable sampling equipment such as a bailer for groundwater sampling or acetate sleeve used for soil sampling, an EB is collected prior to first use by pouring distilled water through a bailer or acetate sleeve directly into the sample containers. For disposable sampling equipment, one EP per box of bailers, acetate sleeves, etc. is required since the manufacturing process, storage, and shipping conditions should be similar for the entire box. After the equipment blank has been collected, environmental sampling may commence. EBs are not required if dedicated pumps are used for groundwater purging and sampling.

2.6.3.2 Monitoring Well Sampling

Newly installed monitoring wells will be sampled at least 24 hours after well development. Depending on the lithologies encountered, hydraulic gradient, hydraulic conductivity, and other factors, some wells may need more time to equilibrate with the surrounding aquifer. An indication of well performance may be obtained from the well development field sheets.

When numerous monitoring wells are to be sampled in succession, they will be sampled in order beginning with the location of lowest expected contamination location and ending with the well of greatest expected contamination, when possible. In addition, the use of sorptive tubing, such as polyethylene, will be avoided. These practices will help reduce the potential for cross contamination between wells. All sampling activities will be recorded in the field logbook, and other appropriate forms. Additionally, all sampling data will be recorded on a groundwater sampling field data sheet. An example of a groundwater sampling field data sheet is provided in Appendix A.

Before groundwater sampling begins, wells will be inspected for signs of tampering or other damage. If tampering is suspected, (e.g., casing is damaged, lock or cap is missing) this will be recorded in the field logbook and on the purge record, and reported to the Project Manager. Wells that are suspected to have been tampered with will not be sampled until the Project Manager has discussed the matter with the Program Manager.

Standing water, if present, will be removed from within the protective housing or in the vaults around the well casing prior to venting and purging. If field equipment is to be set on the ground, plastic sheeting will first be placed on the ground surrounding the well, to provide a clean work surface.

An OVA will be used to measure organic vapor concentrations at the wellhead. If an OVA reading is above background, the field team will move upwind of the wellhead. Respirator protection for workers may be necessary based on the OVA readings in the breathing space (see Site-specific HASP). In addition, if conditions encountered during well drilling or installation suggest a possibility that explosive conditions may exist, if the location of the well is in an area consistent with methane production (i.e. wetland, landfill, fuel product plume), or if recent monitoring data suggest a change consistent with creating a potentially explosive situation, an explosimeter will also be used to record and monitor for potentially explosive conditions at the wellhead (see Site-specific HASP).

If DNAPL is suspected, a bailer will be lowered to the bottom of the well before purging. The bailer will be retrieved and its contents observed for the presence of DNAPL. If the presence of DNAPL is confirmed, a sample will be collected, if specified in the project-specific work plan, from the bottom of the well.

If the monitoring well(s) contain floating LNAPL, the LNAPL and groundwater will be sampled, if specified in the project-specific work plan, as described below.

- Apparent product thickness will be measured with an electronic interface probe. A Teflon bottom-filling bailer will be lowered into and through the product layer to the oil/water interface. Care will be taken to minimize the amount of groundwater that enters the bailer while sampling. This procedure will continue until an appropriate amount of product has been retrieved.
- If floating product is detected, the following groundwater purging and sampling method will be employed. Two-inch PVC pipe will be fitted with a bottom end slip-cap and Teflon-coated stainless steel wire will be attached to the top of the pipe. The pipe will then be lowered into the well to a depth below the floating product and held in place using a clamping device that rests on top of the well. Purging will be accomplished by lowering the pump through the pipe and knocking off the end-cap. The end-cap will be retrieved with the wire. The well will be purged at a slow rate to minimize drawdown of the floating product. Once purging has been completed, the well will be sampled, using a Teflon bailer, through the PVC pipe.

Purge pump intakes will be equipped with a positive foot check valve to prevent purged water from flowing back into the well. Purging and sampling will be performed in a manner that minimizes aeration and agitation in the well and formation. Equipment (including bailers) will not be allowed to free-fall into a well. If a submersible pump is used, it will be positioned at the wetted midpoint of the screen or at the depth of maximum drawdown.

In addition to following the recordkeeping procedures described in Section 2.9, the following information shall be recorded each time a well is purged and sampled: (1) depth to water before and after purging, (2) total depth of well and well volume calculation, (3) the condition of each well, (4) the thickness of any nonaqueous layer, if present, and (5) field parameters, such as pH, temperature, EC, DO, and turbidity.

2.6.3.3 Remediation Injection Well Sampling

Remediation wells used for injection are not routinely sampled since the introduction of agents via the well creates an expected change in the groundwater chemistry in the immediate well vicinity, rendering sampling of "representative" formation water difficult. Rather, sampling from monitoring well(s) installed at some distance from the injection well is completed in lieu of injection well sampling.

An exception will be made when a single well "push-pull" test is conducted. The test consists of the controlled injection of a prepared test solution into an aquifer followed by the recovery of the test solution/groundwater mixture from the same location. In this case, after introduction of the injectate, pumping from the point of injection is done to reverse the flow path of the injectate for collection and analysis. Standard groundwater sampling equipment (e.g., pumps, bailers) can be used for this purpose.

2.6.3.4 Extraction Well Sampling

2.6.3.4.1 Groundwater Extraction Wells.

For groundwater extraction wells, groundwater samples are collected during system operation using in-line influent and effluent spigots to purge and to collect water samples. If a groundwater extraction well has been taken offline for some time, it can be sampled using standard monitoring well purging protocol after removing the pump and/or other accessories from the well. In either case, extracted water is typically monitored for temperature, pH, EC, DO, and turbidity to document stability before sample collection. These parameter readings are noted on a groundwater sampling field data sheet (Appendix A).

2.6.3.4.2 Soil Vapor Extraction Wells.

For soil vapor extraction wells, soil vapor samples are collected either during operation or following shut-down of the vacuum blower. In the former case, ports affixed to the extraction wellhead are accessed and a vacuum in excess of the system vacuum is applied to draw soil vapor out of the well into either a portable field instrument or into an appropriate gas sample bag (Tedlar) or canister (Summa) for analysis of appropriate parameters. Sampling personnel should ensure there are no leaks at the wellhead or within the sampling system. On the well sampling field form, operational records of the system should be provided including the date and time of sample collection, times of system operation, extraction well

vacuum measurements, contaminant concentrations, and other parameters (e.g., oxygen, carbon dioxide) specific to the program.

For sampling after shut-down of the soil vapor extraction system, a period of 2 to 4 weeks is allowed to elapse to permit soil vapor the opportunity to "rebound" in response to a change in the subsurface conditions. Rebound samples are collected from wellheads by first isolating the wellhead by closing off wellhead laterals, and accessing the sampling port at the well. A vacuum pump is used to purge typically 3 to 5 static well volumes of gas prior to sample collection. Monitoring of the purge gas is conducted to document the change in gas concentration during the purge cycle, with the intent of determining the optimal number of well purge volumes that correspond to maximum well concentrations.

Following static gas purging from the wellhead, an appropriate sample container (Tedlar bag or Summa canister) is connected to the wellhead for sample collection. The Summa canister has the added advantage of eliminating the need for a vacuum sampling pump, since it is provided by the laboratory under vacuum. The Summa canisters will be equipped with dedicated, laboratory decontaminated flow regulators. At a minimum, the date, time, number of purge volumes, and wellhead identification will be recorded onto a field SVE well sampling form.

2.6.3.5 Water Level Measurement

An interface probe shall be used if a nonconductive floating product layer is suspected in the well. The interface probe shall be used to determine the presence of floating product prior to measurement of the groundwater level. The groundwater level shall then be measured to the nearest 0.01-foot using an electric water level indicator. Water levels shall be measured from the notch located at the top of the well casing and recorded on the well sampling form. If well casings are not notched, measurements shall be taken from the north edge of the top of the well casing, and a notch shall be made using a decontaminated metal file.

Following water level measurement, the total depth of the well from top of casing shall be determined using a weighted tape or electrical sounder, and recorded on the well sampling form. The water level depth shall then be subtracted from the total depth of the well to determine the height of the water column present in the well casing. All water level and total depth measuring devices shall be routinely checked to ensure measurements are precise. Measurements will be recorded on a water level measurement field data sheet (Appendix A).

2.6.3.6 Purging Prior to Sampling

Monitoring wells are purged to remove water that has been stagnant in the well and may not be representative of the aquifer. Purging may be accomplished using a pump or bailer. Pumps may be either dedicated or portable pumps. Initial installation depth of dedicated pumps will factor in the thickness of the aquifer, the wetted height of the casing, the air-water interface relative to the screened casing, and the lithologic conditions adjacent to the well screen. The intake of dedicated pumps must always be installed adjacent to screened casing. Ideally, the pump should not be closer than 3 feet from the well bottom, where silt and/or DNAPL may accumulate, or within 1-foot of the upper water table surface where organic debris and LNAPL may accumulate. Typically, an interval near the mid-point of the wetted, screened casing is appropriate, assuming that the lithology adjacent to this interval is at least as conductive as the median lithology spanned by the well screen. The overall objective of positioning the intake of a dedicated pump within a well is to select the vertical interval that provides an optimal balance of obtaining clear, representative samples of groundwater from the targeted portion of the aquifer that is conducting groundwater flow.

If a portable pump is being used for purging, if the water column is less than 5 feet, consider lowering the pump to the bottom of the well, as complete drawdown of the water within the well is possible. If the water column is more than 5 feet, the pump should be placed at the top of the water column at the beginning of purging. Periodically lower the pump at approximately 2-foot intervals to completely purge the well's water zones and remove all stagnant water. Ideally, the final purging will be performed with the pump at least 2 feet above the bottom of the well.

The water level, temperature, pH, EC, DO, and turbidity will be measured and recorded periodically (in three to five-minute intervals for a minimum of six readings) during purging on a groundwater sampling field data sheet (Appendix A) to document stabilization of parameters. Criteria for determining stabilization are a minimum of three successive measurements of:

- drawdown within 0.1 feet;
- temperature within $\pm$1 degrees Celsius (°C);
- pH within $\pm$0.1 units;
- EC within $\pm$5 %; and
- turbidity stable or $\leq$5 NTUs.

When possible, sampling will not begin until the turbidity is less than 5 NTUs. If stabilization of parameters is unobtainable or turbidity remains above 5 NTUs, the well will be sampled after five well volumes are purged, or after the well is purged dry and allowed to recover. The exception to this is noted in the following subsections.

At sites where monitored natural attenuation is being evaluated as a remedial alternative, field measurements of oxidation-reduction potential (ORP), DO, and ferrous iron (Fe^{2+}) will be collected in addition to the standard measurements of pH, EC, temperature, and turbidity. Field data will be recorded on a groundwater sampling field data sheet (Appendix A).

Water removed from the well during purging will be placed in appropriate containers. Purged groundwater volume shall be measured using orifice meters, containers of known volume, in-line meters, flumes, or weirs. More information concerning IDW is presented in Section 2.5.14.

2.6.3.6.1 Low Flow Purging using Dedicated Blatypus Pumps

Purging at low flow rates (e.g., micropurge) is a method that induces laminar (non-turbulent) flow in the immediate vicinity of the sampling pump intake, thus drawing groundwater directly from the aquifer into the sampling device. Low-flow pumping rates associated with micropurge equipment are approximately 0.01 to 2.0 liters per minute. These low flow rates are designed to minimize disturbance in the screened aquifer, resulting in: (1) minimal production of artificial turbidity and oxidation, (2) minimal mixing of chemically distinct zones, (3) minimal loss of volatile organic compounds, and (4) collection of representative samples while minimizing purge volume.

Dedicated pumps designed for low-flow purging (Blatypus pumps) have been installed in wells used for groundwater monitoring at Sites 1 & 2. The procedure for low-flow purging and sampling with Blatypus pumps is as follows:

- The Blatypus pump should already be suspended in the well to the desired depth and the suspension cap should not need to be lifted or removed for normal groundwater sampling.
- Attach an air line from a secured nitrogen gas tank with regulator, or from an oilless air compressor, to the pump control box fitting labeled “Gas In.” If using the QED MP-10 control box, gas from nitrogen tanks or compressors should not exceed 100 pounds per square inch (psi) into the “Gas In” fitting.
- Attach a second air line from the fitting labeled “Gas Out” on the pump control box. Attach the airline from the “Gas Out” fitting to the fitting designated as the gas pressure fitting on the top of the suspension cap. This is typically the fitting on the left when the fittings are facing you, and it should have a brass protective cap.
- Attach the dedicated sample discharge tubing to the “Sample Discharge” fitting on the top of the suspension cap, and connect the end of the sample discharge tubing to the bottom connection of the flow-through cell. Attach a discharge tube to the top fitting of the flow-through cell and place the other end in a bucket or other receptacle.
- Before pressurizing the system, set the initial cycle rate and the recharge and discharge phase rates on the pump control box.
- If previous control box settings are known, set the control box for these settings. If this is a new pump, or if water level has changed significantly, set the pump to 2 cycles per minute (CPM) with recharge phase set for 20 seconds, and discharge phase for 10 seconds.

- Calculate the minimum lift pressure (MLP) using the equation:

  [(Depth from Ground Surface to Pump in feet) / (2.31 feet/PSI)] x 1.1

  A quick check should show that MLP is slightly less than 1/2 of the depth of the pump.
- Open the main valve on the nitrogen tank, or turn on the compressor. Adjust the pressure on the control box to 5 to10 PSI lower than the MLP.
- Start the pump. If water is not flowing after 2-3 complete cycles, slowly raise the output pressure until the MLP is reached.
- Depending on depth of water level below ground surface, water should be produced within a few minutes.
- Once water reaches the surface, the output pressure and the recharge and discharge phase times can be adjusted to minimize water level drawdown.
- There should be no "sputtering" or bubbles in the discharge water and the flow should be non-turbulent. Output pressure can be adjusted up or down in increments of 3 to 5 PSI to obtain these results. Allow 2-3 complete cycles between adjustments.
- If the well exhibits excessive drawdown (greater than 0.33 feet), the flow rate should be reduced by increasing the recharge phase time (decreasing the discharge phase time) or by reducing the cycle rate. The water level drawdown should be limited to less than 0.33 feet.
- If the water level exhibits little or no drawdown, the purge rate may be increased gradually to a maximum of 500 ml/min by increasing the discharge phase time (decreasing the recharge phase time) or by increasing the cycle rate.
- After the flow rate has stabilized, measure the volume of purge water produced during one complete discharge/recharge cycle, and multiply this amount by the CPM setting. This is the flow rate in milliliters per minute.
- Purge one complete system volume prior to collecting the first set of water quality readings. To calculate the complete system volume, calculate the volume of water in the air line, [(tubing volume) x (depth of pump – water level)], the volume of water in the discharge line, [(tubing volume) x (depth of pump)], and the volume of water in the pump chamber, 200 ml. The sum of these three sections is one complete system volume.

  Thin wall 1/4" tubing (1/4" x 3/16") volume is approximately 5.4 ml per foot;
  System Volume = 5.4 x [(2 x depth of pump) – water level] + 200

  Thick wall 1/4" tubing (1/4" x 1/8") volume is approximately 2.4 ml per foot;
  System Volume = 2.4 x [(2 x depth of pump) – water level] + 200

- After the first set of readings have been collected, collect additional readings every 3-5 minutes until all parameters have stabilized.
- Stabilization is defined as three successive readings within the following criteria: pH ± 0.1, conductivity ± 3%, dissolved oxygen ± 0.3 mg/L, oxidation reduction potential ± 10 mv, turbidity ± 10% or <10 NTUs, water level ± 0.1 foot
- When all parameters have stabilized sample collection can begin. Disconnect the sample discharge tubing from the flow through cell and fill sample containers directly through this tubing.
- When sampling is complete, turn off the pump and close the main valve on the nitrogen tank or turn off the compressor. Carefully disconnect the air and sample discharge lines from the suspension cap and replace the protective caps on to their respective fittings. Empty the flow-through cell into the bucket containing the purge water, replace and lock the well monument cover, and secure the sampling equipment for travel to the next location.

2.6.3.6.2 Low Flow Purging using Portable Bladder Pump

Dedicated pumps may not be installed in wells at the time of initial sampling. If a Blatypus pump is not installed, a non-dedicated (portable) bladder pump will be used for purging and sampling. The procedure for low-flow purging and sampling with a portable bladder pump is as follows:

- The portable bladder pump should be suspended in the well at the approximate midpoint of the screened interval.
- Attach an air line from a secured nitrogen gas tank with regulator, or from an oilless air compressor, to the pump control box fitting labeled "Gas In." If using the QED MP-10 control box, gas from nitrogen tanks or compressors should not exceed 100 pounds per square inch (psi) into the "Gas In" fitting.
- Attach a second air line from the fitting labeled "Gas Out" on the pump control box. Attach the airline from the "Gas Out" fitting to the air line on the portable bladder pump.
- Connect the sample discharge tubing on the portable bladder pump to the bottom connection of the flow-through cell. Attach a discharge tube to the top fitting of the flow-through cell and place the other end in a bucket or other receptacle.
- Before pressurizing the system, set the initial cycle rate and the recharge and discharge phase rates on the pump control box.
- If previous control box settings are known, set the control box for these settings. If this is a new pump, or if water level has changed significantly, set the pump to 2 cycles per minute (CPM) with recharge phase set for 20 seconds, and discharge phase for 10 seconds.
- Calculate the minimum lift pressure (MLP) using the equation:

  [(Depth from Ground Surface to Pump in feet) / (2.31 feet/PSI)] x 1.1

  A quick check should show that MLP is slightly less than 1/2 of the depth of the pump.
- Open the main valve on the nitrogen tank, or turn on the compressor. Adjust the pressure on the control box to 5 to10 PSI lower than the MLP.
- Start the pump. If water is not flowing after 2-3 complete cycles, slowly raise the output pressure until the MLP is reached.
- Depending on depth of water level below ground surface, water should be produced within a few minutes.
- Once water reaches the surface, the output pressure and the recharge and discharge phase times can be adjusted to minimize water level drawdown.
- There should be no "sputtering" or bubbles in the discharge water and the flow should be non-turbulent. Output pressure can be adjusted up or down in increments of 3 to 5 PSI to obtain these results. Allow 2-3 complete cycles between adjustments.
- If the well exhibits excessive drawdown (greater than 0.33 feet), the flow rate should be reduced by increasing the recharge phase time (decreasing the discharge phase time) or by reducing the cycle rate. The water level drawdown should be limited to less than 0.33 feet.
- If the water level exhibits little or no drawdown, the purge rate may be increased gradually to a maximum of 500 ml/min by increasing the discharge phase time (decreasing the recharge phase time) or by increasing the cycle rate.
- After the flow rate has stabilized, measure the volume of purge water produced during one complete discharge/recharge cycle, and multiply this amount by the CPM setting. This is the flow rate in milliliters per minute.

- Purge one complete system volume prior to collecting the first set of water quality readings. To calculate the complete system volume, calculate the volume of water in the sample discharge line [(tubing volume) x (depth of pump)] and the volume of the bladder in ml (V_p; provided by pump manufacturer). The sum of these two sections is one complete system volume.

  Thin wall 1/4" tubing (1/4" x 3/16") volume is approximately 5.4 ml per foot;
  System Volume = 5.4 x (length of sample discharge line) + V_p

  Thick wall 1/4" tubing (1/4" x 1/8") volume is approximately 2.4 ml per foot;
  System Volume = 2.4 x (length of sample discharge line) + V_p

  3/8" tubing volume is approximately 9.5 ml/ft
  System Volume = 9.5(length of sample discharge line) + V_p

- After the first set of readings have been collected, collect additional readings every 3-5 minutes until all parameters have stabilized.
- Stabilization is defined as three successive readings within the following criteria: pH ± 0.1, conductivity ± 3%, dissolved oxygen ± 0.3 mg/L, oxidation reduction potential ± 10 mv, turbidity ± 10% or <10 NTUs, water level ± 0.1 foot
- When all parameters have stabilized sample collection can begin. Disconnect the sample discharge tubing from the flow through cell and fill sample containers directly through this tubing.
- When sampling is complete, turn off the pump and close the main valve on the nitrogen tank or turn off the compressor. Carefully disconnect the air and sample discharge lines. Empty the flow-through cell into the bucket containing the purge water, replace and lock the well monument cover, and secure the sampling equipment for travel to the next location.

After purging and sampling has been completed, the portable bladder pump and tubing is decontaminated as described in Section 2.5.13.

2.6.3.6.3 Standard Bailer or Pump Purging

For wells being purged using the standard bailer or pump method, sampling will be conducted after at least three well volumes of water have been purged and groundwater parameters have stabilized, unless the well is purged dry and recharge rates are less than approximately 0.25 gallons per minute. Parameters monitored during purging will include, at a minimum, temperature, pH, EC, and turbidity. Criteria for determining stabilization are three successive measurements of temperature within ± 1 °C, pH within ± 0.1 units, and conductivity within ± 5%. When possible, sampling will not begin until the turbidity is less than or equal to 5 NTUs. If stabilization of parameters is unobtainable or turbidity remains above 5 NTUs, the well will be sampled after five well volumes are purged, or the well is purged dry and allowed to recover, and the anomalous parameters will be brought to the Task Manager's attention. If a well is purged dry, it may be sampled when the well has recharged to the point where a sample can be collected.

A well volume is the volume inside the submerged casing and screen. One well volume can be calculated using the following equation (Ohio EPA, 1993):

$$V = H \times F$$

where:

V = one well volume
H = the difference between the total depth of the well and the depth to water (feet); and
F = factor for volume of 1-foot section of casing (gallons) from the following table:

Diameter of Casing (inches)	F Factor (gallons/foot)
1.5	0.09
2	0.16
3	0.37
4	0.65
6	1.47

F can also be calculated from the formula:

$$F = \pi\left(\frac{D}{2}\right)^2 * 7.48 \frac{gallons}{ft^3}$$

where:

π = 3.14, and
D = the inside diameter of the well casing (feet)

Sampling from a well that was purged using the standard pump or bailer method is generally performed using a disposable bailer, by discharging the contents of the disposable bailer directly into the appropriate sample containers.

2.6.3.7 Grab Groundwater Sampling

Grab groundwater samples may be collected during drilling operations to provide additional information on groundwater conditions. Grab groundwater samples are not directly comparable to monitoring well samples because they are collected under disturbed conditions.

2.6.3.7.1 Borehole Grab Sampling

Borehole grab samples are collected by drilling a soil boring to first groundwater, allowing groundwater to enter the hollow-stem augers or drill casing, and collecting a groundwater sample with a disposable bailer. Two additional variations on this method may also be used. A temporary well may be used to collect a groundwater grab sample. With this method, a small-diameter well screen and casing is placed in an open borehole. Groundwater is allowed to enter the temporary well, which is then sampled with a 1-inch diameter bailer or peristaltic pump, depending on depth. Groundwater samples may be collected

below the water table from cased boreholes using the "case-and-bail" method. In this method, the drill casing is used to seal shallow groundwater zones, allowing deeper zones to be sampled. Prior to sampling a deeper water-bearing zone, the drill casing is purged with a bailer or submersible pump to remove groundwater which may have been carried down during drilling. Groundwater is then allowed to enter the casing, and a groundwater sample is collected with a disposable bailer.

2.6.3.7.2 Direct Push and Hydropunch Sampling

Direct-push groundwater sampling involves advancing a sampling tool to the point below the water table where the sample is desired. The probe can be advanced by direct hydraulic pressure or by using a percussion hammer. When the probe is at the proper depth, sampling ports on the probe are opened and the sample is collected using a bailer, by vacuum pressure, or using the natural pressure of the formation. Samples collected for VOC analysis should not be drawn by vacuum pressure.

Discrete-depth groundwater samples may also be collected during drilling to determine the water quality of any major hydrostratigraphic units as they are penetrated. Discrete-depth groundwater samples will be collected using a temporary well point device such as a Hydropunch groundwater sampling tool which allows the collection of water samples from precise depths without installing a well. The Hydropunch tool will be advanced approximately 2-4 feet below the bit inside the drill string when groundwater is encountered. Groundwater samples may be collected beneath the water table to evaluate the vertical extent of groundwater contamination if necessary.

Alternate techniques or variations of those described above shall be detailed in Site-specific FSP addenda.

2.6.3.8 Production Well Sampling

Permission for sampling shall be obtained from the well owner by the Performing Contractor prior to conducting any sampling activities.

Prior to sampling, the production well shall be inspected to determine the location of a suitable sampling port. Samples can be collected from discharge pipes, faucets, or petcocks. It is desirable to have the sampling port located between the pump and the storage tank, and before any water treatment systems, such as chlorinators or water softeners. The well and pump system should be examined carefully to understand the direction of flow and determine which potential sample ports are located before the tank or treatment systems.

Purging is required prior to collecting any samples. For sampling ports located before the storage tank, the well casing is purged by running the pump for a minimum of 10 minutes. For irrigation or industrial wells, the well owner may be able to manually switch the pump on. Alternatively, a pump may be forced

to run by opening faucets around the house or business, with the permission of the owner. In addition to purging the pump, the sampling port should be flushed for at least one minute prior to sampling.

Groundwater parameters, including temperature, pH, and EC will be measured and recorded periodically during purging and recorded on a groundwater sampling field data sheet (Appendix A) to document stabilization of parameters. Criteria for determining stabilization are a minimum of three successive measurements of:

- temperature within ±1 °C;
- pH within ±0.1 units; and
- EC within ±5 %.

After the well has been purged, groundwater samples are collected as described in Section 2.6.3.9.

2.6.3.9 Groundwater Sample Collection

Samples will not be collected within 24 hours of monitoring well development. Before collecting groundwater samples, the sampler will put on clean, phthalate-free, protective gloves (i.e. nitrile or latex). Required sample containers, preservation methods, volumes and holding times are given in Section 3.4.2.1 and Tables 3-2, 3-3, and 3-4 of the QAPP. Sampling equipment will be decontaminated in accordance with Section 2.5.13 upon completion of sampling activities at each well.

For wells in which a submersible pump is used for purging and sampling, samples will be collected after the water level has recovered to 80 percent of its static level or 16 hours after completion of purging, whichever occurs first. If a monitoring well is bailed or pumped dry before the standard three well volumes are removed, the sample will be collected when a sufficient volume of water has accumulated within the well to allow for sample collection. Samples to be analyzed for volatile or gaseous constituents will not be withdrawn with pumps that exert a vacuum on the sample (e.g., centrifugal and peristaltic), or may cause aeration of changes in temperature (submersible pump). For this reason, samples for volatile constituents will always be collected using a low flow sampling method with a submersible pump (low-flow bladder pump or variable-speed electric pump), except that in the case where the well is purged dry, a bailer will be used.

For the low-flow sampling method, groundwater sampling will begin after parameter stabilization and a minimum of one pump and tubing volume has been removed from the well. At the start of the purging process, the water level will be checked and water level drawdown and the discharge rate will be monitored every 5 minutes. During purging, groundwater drawdown in the well shall be maintained at less than 0.33 feet. If this drawdown cannot be maintained, purging will stop and the well will be allowed

to recharge before resuming purging. Samples will be collected immediately after purging is completed. Groundwater samples from submersible pumps, including volatile constituents, are collected directly from the effluent tubing attached to the pump.

VOC samples will be collected using a slow, controlled fill down the side of the tilted sample vial to minimize volatilization. The sample vial will be capped immediately after a convex meniscus is visible at the top of the vial. After capping, the vial will be inverted and gently tapped to ensure no air bubbles are present. If bubbles are observed, the vial will be discarded and the VOC sampling effort will be repeated. Refilling of vials may result in loss of chemical preservative and is not permitted. After the vials are sealed, sample degassing may occur within the vial, causing bubbles to form. These bubbles will be left in the vial. VOC samples will not be composited, homogenized, or filtered.

Prior to collection of samples, a sample aliquot may be collected for testing of Fe^{2+} by EPA Method SM3500 using the Hach field kit, or other field test method specified in the project-specific work plan. VOC samples will be collected first, before bottles for other analyses are filled. Water samples will be collected in the following order, as applicable:

1. VOCs;
2. Semivolatile organic compounds (SVOCs), including polynuclear aromatic hydrocarbons (PAHs);
3. 1,4-Dioxane;
4. Perchlorate;
5. General chemistry including pH; Alkalinity; Anions; and Sulfide;
6. Hexavalent Chromium; and
7. Dissolved metals.

Sample turbidity will be recorded during sampling for total metals. Water samples requiring filtration (e.g., for dissolved metals analysis) will be filtered through a 0.45 micrometer (µm) membrane filter. A borosilicate microfiber prefilter may be used to remove suspended particulate matter, as required. Vacuum filtration or any method that may aerate the samples shall not be used. Exposure of samples to air shall be kept to a minimum. In-line filtration and disposable filter assemblies will be used. Filters with larger pores may be used as pre-filters.

2.6.4 Surface Water Sampling

Surface water samples will be collected using the direct method. The sample container is placed under the water surface while pointing the container upstream. Where water depths are extremely shallow, it may

be necessary to create a small depression to allow the container opening to be submerged the below the water surface. If this is necessary, care should be exercised to avoid collecting turbid samples. In all cases, the container must be upstream of the collector to avoid collecting turbid samples, and efforts should be taken to avoid disturbing the substrate. When using the direct method, prepreserved sample bottles should not be used, as the collection method may dilute the concentration of preservative necessary for proper sample preservation.

Water samples will be collected in the following order, as applicable:

1. VOCs;
2. SVOCs including PAHs;
3. 1,4-Dioxane;
4. Perchlorate;
5. General chemistry including pH; Alkalinity; Anions; and Sulfide;
6. Hexavalent Chromium; and
7. Dissolved metals.

Sample turbidity will be recorded during sampling for total metals. Water samples requiring filtration (e.g., for dissolved metals analysis) will be filtered through a 0.45 micrometer (µm) membrane filter. A borosilicate microfiber prefilter may be used to remove suspended particulate matter, as required. Vacuum filtration or any method that may aerate the samples shall not be used. Exposure of samples to air shall be kept to a minimum. In-line filtration and disposable filter assemblies will be used. Filters with larger pores may be used as pre-filters.

2.6.5 Soil Gas Sampling

Soil gas sampling will be conducted in general accordance with *Advisory – Active Soil Gas Investigations* (DTSC and RWQCB Los Angeles Region, 2003), unless otherwise specified in a project-specific work plan and FSP Addendum. Soil gas may be sampled using Summa canisters, gas-tight glass syringes or bulbs, Tedlar bags, or sorbent tubes. Samples collected for off-site laboratory analysis will be collected in Summa canisters. Gas-tight syringes or bulbs may be used to collect samples for on-site laboratory analysis for VOCs. Tedlar bags may be used for off-site laboratory analysis of fixed gases. Note that Tedlar bags are not the preferred choice for data collection regarding site characterization or risk assessment. Samples collected in Tedlar bags should not be used for quantification of VOCs. A proper soil gas sampling container will be selected based upon sampling depths and analysis requirements of the project-specific work plan. Sampling procedures for each sample container are described below.

In addition to following the record keeping procedures in Section 2.9, the following information shall be recorded: (1) soil gas sample or probe depth; (2) apparent moisture content (dry, moist, saturated) of the sampled zone; (3) soil gas purge rate, sampling duration, sampling system leak rate, and pump vacuum; (4) description of sample containers (if any); (5) location of sample analysis; (6) location and grid layout of sampling stations; and (7) instrument calibration. If only qualitative data are required, only items 1 and 6 are needed.

At landfills, where methane and/or hydrogen sulfide may be of concern, these constituents should be monitored for using either handheld instrumentation (e.g., Land Tech Gas Analyzer GA-90 for methane, Jerome 631-X for hydrogen sulfide).

2.6.5.1 Summa Canister Samples

Summa canister samples will be collected for off-site laboratory analyses. Prior to sampling, the initial canister vacuum will be measured. A dedicated, laboratory-decontaminated flow regulator calibrated by the laboratory for a flow rate of 200 ml/minute or less will be installed on the Summa canister, and the canister/flow regulator assembly will be attached to a fitting on a sampling manifold ahead of the purge pump. The probe and manifold will then be purged at a flow rate of 200 ml/minute or less. After purging, the purge pump will be isolated, and the Summa canister valve opened to collect the sample. The vacuum in the Summa canister will be monitored during sampling, and will not be allowed to rise to atmospheric pressure (zero psi reading on vacuum gauge). At the completion of sampling, the canister valve will be closed and the canister removed from the sampling manifold. The sampling manifold shall be decontaminated between sampling locations by passing ambient air through the manifold using a pump for three minutes.

2.6.5.2 Syringe Samples

To collect a syringe sample, a fitting with a Teflon septum will be installed in the sampling line ahead of the purge pump. After purging the required volume, samples will be collected using a gas-tight syringe.

2.6.5.3 Bulb Samples

If the sampling container is a glass or metal bulb equipped with an entrance and exit stopcock, tubing from the sampling probe will be attached to the entrance stopcock, and a second length of tubing will run from the exit stopcock of the bulb to a portable vacuum pump. The sampling train is then purged by switching the vacuum pump on, drawing the gas contained in the interstitial spaces of the soil through the probe, tubing, and sample container. When purging is complete, the stopcock on the downstream side of

the bulb (toward the pump) is closed, followed by the stopcock on the upstream side of the bulb. The vacuum pump will then be switched off.

2.6.5.4 Tedlar Bags

Tedlar bag samples can be collected for field analysis using real-time instruments. An oil-less diaphragm pump will attached to the sampling line and a Tedlar bag will be attached to the pump exhaust. Samples will be kept out of direct light and analyzed within 24 hours of collection to minimize the potential for loss, reaction, or degradation of samples. Note that Tedlar bags are not the preferred choice for data collection regarding site characterization or risk assessment. Samples collected in Tedlar bags should not be used for quantification of VOCs.

2.6.5.5 Sorbent Tubes

Sorbent tubes may be used to collect samples for real-time field analysis (i.e., colorimetric tubes such as Draeger tubes) or for off-site laboratory analyses. The well or probe will be purged, the sorbent tube will be installed in the sampling line, and the required volume of soil gas will be drawn through the tube. Colorimetric tubes are read directly, while sorbent tubes will be capped and stored on ice (dry ice may be required) until they are shipped to the laboratory.

In addition to following the record keeping procedures in Section 2.9, the following information shall be recorded: (1) soil gas sample or probe depth; (2) apparent moisture content (dry, moist, saturated) of the sampled zone; (3) soil gas purge rate, sampling duration, sampling system leak rate, and pump vacuum; (4) description of sample containers (if any); (5) location of sample analysis; (6) location and grid layout of sampling stations; and (7) instrument calibration. If only qualitative data are required, only items 1 and 6 are needed.

At landfills, where methane and/or hydrogen sulfide may be of concern, these constituents should be monitored for using either handheld instrumentation (e.g., Land Tech Gas Analyzer GA-90 for methane, Jerome 631-X for hydrogen sulfide). Fixed gases are generally analyzed in a laboratory.

2.6.6 Sample Handling

Samples will be placed into the appropriate containers prepared for the specified analysis as described in the QAPP (Section 3.0). After filling to the top without allowing overflow, the containers will be tightly capped with the provided lids. The containers will then be labeled, wrapped with bubble wrap shipping material, and stored on ice in a thermally insulated shipping container until delivered to the analytical laboratory. Each sample within a shipping container will be listed on a Chain-of-Custody (CoC) record for that container. An example of a CoC record form is provided in Appendix A. The samples will be

packaged and transported in a manner that maintains proper sample custody, temperatures, and integrity. Sample identification systems and packaging are discussed below.

2.6.6.1 Sample Containers

Sample containers are purchased precleaned and treated according to EPA specifications for the methods. Sampling containers that are reused are decontaminated between uses by the EPA-recommended procedures (EPA, 1992). Containers are stored in clean areas to prevent exposure to fuels, solvents, and other contaminants. Amber glass bottles are used routinely where glass containers are specified in the sampling protocol.

2.6.6.2 Sample Volumes, Container Types, and Preservation Requirements

Sample volumes, container types, and preservation requirements for the analytical methods performed on samples are listed in Section 3.4.2.1 and Tables 3-2, 3-3, and 3-4 of the QAPP.

Sample holding time tracking begins with the collection of samples and continues until the analysis is complete. Holding times for methods required routinely for fieldwork are specified in Tables 3-2, 3-3, and 3-4 of the QAPP.

The Performing Contractor shall provide detailed descriptions of the required sample volumes, container types, and preservation requirements for analytical methods proposed for project work which are not listed in Tables 3-2, 3-3, or 3-4 in a QAPP Addendum.

2.6.6.3 Sample Identification

A sample identification number that uniquely identifies each sample will be assigned at the time of sample collection. However, it may be modified based on task-specific needs, as long as the naming system uniquely identifies each sample. Sample identification numbers will be designated by a two-part code. First, activity at the site is numbered consecutively, e.g., the first well would be MW1, and the second well would be MW2, etc. Activity is denoted by MW for monitoring well, SB for soil boring, CPT for CPT boring, or SG for soil gas samples. Second, the sample sequence or sample depth is numbered consecutively according to activity (i.e., 1 for the first sample from the well or 22' for the sample collected from 22 feet bgs). A dash (-) separates the sample identification, sample date, and sample sequence/ depth. No other delimiters such as slashes or colons shall be used between numbering system fields. Quality control samples such as trip blanks (TBs) and EBs are also numbered consecutively per sampling period. Sampling date and times are also recorded on field data sheets and the CoC.

An example of a groundwater sample identification is presented below:

MW3-1

where:

MW3:	The third consecutive monitoring well at a site
1:	The first sample of the sampling sequence

In addition, an example of a soil sample identification is presented below:

SB1-22'

where:

SB1:	The first consecutive soil boring at a site
22':	The depth of the sample

Soil and water samples typically consist of multiple containers (EnCore samplers or jars) to provide a sufficient amount of sample for the required analyses. For soil samples, three EnCore samples and one to two sample jars may be required; for water samples, varying container types and sizes with generally one to three containers for each analysis are required. A single sample identification number will apply to all containers of the same sample.

The same numbering system will be applied to duplicate samples, with the exception that the duplicate sample will be distinguished from the primary sample, by appending "-dup" to the sample number as follows:

SB1-22':	Primary sample
SB1-22'-dup	Duplicate sample

If blind duplicate samples are collected, the duplicate samples will be designated using sample numbers provided by the Project Manager. Sample numbers used for blind duplicate samples will be unique, and will be distinguishable from primary sample numbers.

If the sample is a field matrix spike/matrix spike duplicate (MS/MSD) sample, the sample identification is the same and extra volume collected as required. Indicate "MS/MSD" in the comments section of the CoC. If samples are filtered (i.e., for metals analysis), this shall also be indicated on the CoC. If both filtered and unfiltered samples are collected from a given location, the filtered sampling time as entered on the label should be five minutes later than the unfiltered sample.

For field blanks, letters are used to denote the type of blank, followed by a sequential number and date, which, at the conclusion of work, indicates the total number of the blank type collected for each day of sampling.

2.6.6.4 Sample Labels

All samples shall be uniquely identified, labeled, and documented in the field at the time of collection. Where necessary, the label will be protected from water and solvents with clean label-protection tape. At a minimum, each label will contain the following information: unique sample location identifier, name of collector, date and time of collection, place of collection, and preservative, if any.

A sample identification label will be affixed to each sample container. A copy of a typical sample identification label is provided in Appendix A. In addition, each sample number, date, and time the sample was obtained will be recorded in the field notebook or appropriate data sheet. Other information to be entered on the label shall include the date and time of sample collection, initials of the sampler, sample identification, the analysis to be performed on the sample, and preservatives used, if any.

2.6.6.5 Sample Packaging

All samples will be packaged carefully in proper containers at proper temperatures to avoid breakage or contamination, and will either be relinquished to a laboratory courier or shipped to the laboratory. Samples will be packed properly for shipment according to DOT regulations. Sample bottle lids will not be mixed; all sample lids will stay with the original containers.

The following procedures will be applied for packaging:

- The sample volume level will be marked by placing the top of the label at the appropriate sample height, or it will be marked with a grease pencil. This procedure will help the laboratory to determine if any leakage occurred during shipment. The label will not cover any bottle preparation QC marks.
- All sample bottles will be wrapped in bubble pack material or similar material and placed in plastic bags to minimize the potential for contamination and breakage during shipment. Soil samples contained in brass or stainless steel liners will be placed in plastic bags. Volatile organic analysis sample containers will be placed in plastic bags; activated carbon will not be used as a packaging material.
- Samples collected from onsite or offsite will not be intermingled in a single container. Separate shipping containers will be used for samples collected onsite or offsite.
- When a 4°C requirement for preserving the sample is indicated, the samples shall be packed in ice or chemical refrigerant to keep them cool during storage and transportation. If ice is used, the ice shall be double-bagged. During transit, it is not always possible to rigorously control the temperature of the samples. As a general rule, storage at low temperature is the best way to preserve most samples. If provided by the laboratory, a temperature blank (a VOA sampling vial filled with water) shall be included in every cooler and used to determine the internal temperature of the cooler upon receipt of the cooler at the laboratory. Alternatively, the laboratory may use an infrared thermometer to measure the temperature of the cooler on receipt.
- Empty space in the cooler will be filled with inert packing material (i.e. bubble-wrap). Under no circumstances will locally obtained material (sawdust, sand, etc.) be used for packing. Newspaper material will not be used.

- The CoC record will be placed in a plastic bag and taped to the inside of the cooler lid.
- All shipping containers will be sealed for shipment to the laboratory. Packing tape will be wrapped around the package at least twice. The packing tape is used as the custody seal.

2.6.7 Sample Custody

Procedures to ensure the custody and integrity of the samples begin at the time of sampling and continue through transport, sample receipt, preparation, analysis and storage, data generation and reporting, and sample disposal. Records concerning the custody and condition of the samples are maintained in field and laboratory records.

Sample custody is maintained by a CoC record form (Appendix A). The Performing Contractor shall maintain CoC records for all field and field QC samples. The custody record must be completed at the sampling site by the individual designated by the Project Manager or Task Manager as responsible for sample shipment. A sample is considered to be under custody if:

- it is in the possession of the responsible person;
- it is in the view of the responsible person;
- it is locked or sealed by the responsible person, to prevent tampering; and
- it is in a designated secure area.

The following minimum information concerning the sample shall be documented on the CoC form:

- unique sample identification;
- date and time of sample collection;
- sample matrix type;
- type of container;
- designation of MS/MSD (if applicable);
- preservative type (if used);
- analyses required;
- signature of collector(s);
- number of containers;
- the name of the laboratory that the samples are sent to;
- serial numbers of custody seals and transportation cases (if used);
- custody transfer signatures and dates and times of sample transfer from the field to transporters and to the laboratory or laboratories; and
- bill of lading or transporter tracking number (if applicable).

A CoC record is required for each shipping container. The original form will be sent with the container to the testing laboratory. The original copy should be promptly returned to the Performing Contractor by laboratory personnel upon receipt of the samples and completion of the form. Copies are retained by the Performing Contractor for the field and office files, and a copy is retained by the testing laboratory.

Field personnel collecting the samples are responsible for the care and custody of the samples until they are properly transferred. All samples will be accompanied by CoC forms. When transferring samples, the individual relinquishing and receiving the samples will sign, date, and note the time on the form, along with the reasons for transference. The person receiving samples will also sign, date, and provide the time of receipt. If a courier is used, the samples are relinquished to the individual delivering the samples, and that person will relinquish the samples to the laboratory when samples are delivered. Unless samples are specified to be held, all samples should be received by the laboratory within 48 hours of the sample collection period or within the specified holding times for the analyses requested.

The individual shipping the containers will record the specific shipping data (e.g., airway bill number) on the original and duplicate records. If sent by mail, the package will be sent by registered mail with a return receipt requested. If sent by common courier, a bill-of-lading will be used. Freight bills, postal service receipts, and bills-of-lading will be retained as part of the permanent project file.

2.6.8 Fixed Laboratory Quality Control

The various QC elements such as analytical DQOs, acceptance criteria, and corrective actions are detailed in the QAPP (Section 3.0). All relevant criteria described in the QAPP for the determination of possible contaminants in samples will be adhered to by the analytical laboratory.

2.6.9 Field Quality Control Samples

Field QC samples will be collected and analyzed as specified in the QAPP in order to assess the consistency and performance of the sampling plan. Field QC samples may include field duplicate and replicate samples, TBs, EBs, and MS/MSD samples. Field QC samples will not be collected for IDW profiling samples.

2.6.9.1 Trip Blank

A trip blank (TB) is a volatile organic analysis (VOA) sample bottle filled in an uncontaminated area with deionized water (organic-free reagent grade, hydrochloric acid-preserved). The TB is transported to the sampling site, handled as a regular sample, and returned to the laboratory with samples submitted for VOC analysis. The TB will not be opened in the field. The purpose of the TB is to assess whether any potential contamination may have been introduced during the transport of the samples to the analytical laboratory. One TB will accompany every shipment container of water samples sent for volatile organic analysis. The TB will be analyzed for the same volatile organic analytes as the regular samples. TBs must be prepared using the same type of containers, analyte-free, deionized water, and preservatives as the field samples. TBs are not required for soil samples. TBs are only applicable to samples collected for VOC

analysis.

2.6.9.2 Equipment Blank

The purpose of the EB is to assess the effectiveness of equipment decontamination procedures. EBs may be collected from soil sampling equipment (e.g., hand augers, split-spoon samplers), groundwater sampling equipment used in more than one well (e.g., pumps, bailers, filters), and other equipment used in the field. EBs will not be collected from dedicated sampling pumps. In each case, the blank shall be collected by pouring analyte-free, reagent grade deionized water into or through the equipment, and then transferring the water into sample containers. The EBs are analyzed for the same analytes as all associated environmental samples. The frequency of all EB collections shall be at a minimum of one per sampling event. More complex sampling programs may require more frequent collection of equipment blank samples, which shall be detailed in the project-specific FSP and/or QAPP Addendum.

2.6.9.3 Field Duplicate Samples

A field duplicate sample is defined as a second sample of the same matrix collected independently, at the same location as the original sample, at a single sampling location, during a single act of sampling. Duplicate samples are collected simultaneously or in immediate succession, using identical recovery techniques, and treated in an identical manner during storage, transportation, and analysis. If blind duplicate samples are collected, the sample containers are assigned an identification number specified by the Project Manager such that they cannot be identified as duplicate samples by laboratory personnel performing the analysis.

The field duplicate data are used to assess the precision of the overall sample collection and analysis process. Precision of soil samples to be analyzed for VOCs is assessed from co-located samples because the compositing process required to obtain uniform samples could result in loss of the compounds of interest. Field duplicate samples will be collected at a frequency of one for every ten field samples (10%). The sample and the duplicate will be analyzed for the same parameters.

2.6.9.4 Matrix Spike/Matrix Spike Duplicate Samples

MS/MSDs are defined as one water or soil sample collected at a single sampling location during a single act of sampling, with triplicate sampling volumes (i.e. 9 VOAs verses 3 for a standard water sample). The MS/MSD samples provide the laboratory with additional sample material for the purpose of performing QC analyses, as described in Section 3.7.2.4. MS/MSD water and soil samples will be collected at a frequency of one for every twenty field samples (5 percent) for each type of sample matrix. The sample and the MS/MSD will be analyzed for the same parameters.

2.7 FIELD MEASUREMENTS

The following sections discuss in detail the field measurements to be performed during investigations. Equipment calibration and maintenance conducted at Sites 1 & 2 are also discussed in this section.

2.7.1 Health and Safety Monitoring

As required by the Site-specific HASP, ambient air quality monitoring may be required at source area(s), control points, and in breathing space(s) to support field programs. Monitoring of organic vapors will be done using an OVA (FID or PID) and/or combustible gas indicator (CGI) calibrated using appropriate chemical standard(s), or by more chemical-specific devices (e.g., Draeger tubes). Where dust may present an inhalation hazard, aerosol monitoring may be conducted using a Mini-RAM (or equivalent) device. Meteorological stations may also be necessary to permit monitoring of parameters such as wind direction, wind speed, dew point, and temperature to facilitate enforcement of the HASP. In certain environments (e.g., landfills, underground fuel storage tank sites) oxygen, carbon dioxide, methane, hydrogen sulfide, and other gases may be necessary to monitor for using either individual or multiple gas monitoring instruments. Explosimeters are used to monitor the atmosphere in areas where explosive conditions may exist. Data loggers may be used to compile and store all forms of field measurements. The Performing Contractor will specify the instruments to be used in support of the site-specific health and safety program. Unless otherwise noted, instruments are to be calibrated, used, and maintained in accordance with manufacturers' recommendations.

2.7.2 Environmental Monitoring

Properties of water, soil, and air will be measured during the field activities. For environmental monitoring, a PID and/or FID will be generally used for applications including field screening soil samples during drilling operations, and for monitoring VOC vapors in air and in wells. Total VOC concentrations will be measured in vapor wells and in soil headspace during drilling. Temperature, EC, pH, ORP, DO, turbidity, alkalinity, and Fe^{+2} may be measured in groundwater samples. In groundwater wells, the depth to water, thickness of any LNAPL or DNAPL layer, volume of water discharged, and well drawdown may be measured.

For monitored natural attenuation of soils, oxygen, carbon dioxide, and methane are of interest and may be monitored in the field using a multi-gas monitor. Fluid flow monitoring (gas and liquid) is conducted to support pump testing and remediation system monitoring. Equipment used to monitor fluid flow shall be specified in site-specific FSP addenda. For monitored natural attenuation in groundwater wells, ORP, DO, Fe^{+2}, and other parameters are also of interest (Weidemeier *et al.* 1994, 1998). These parameters can

be monitored using any of a number of multi-parameter instruments, and field test kits (e.g., HACH). Section 3.6.3 contains descriptions of other field screening techniques to support field programs.

Field parameters and the equipment that will be used for the field measurements are presented in the following table.

Parameters	Equipment
Vapor Concentrations	OVA (FID or PID)
Soil Headspace Total VOCs	OVA (FID or PID)
Combustible gases	CGI
Explosives	Explosimeter
Ambient dust	Mini-RAM or equivalent
EC	Conductivity Meter/probe
pH	pH Meter/probe
Temperature	Thermometer/probe
Hydraulic Head	Electric Tape (Sounder)
Volume of Discharged Groundwater	Graduated 5-gallon bucket or flow meter
LNAPL	Interface probe (Sounder)
ORP	ORP meter/probe
Fe+2	Colorimetric Analysis
Alkalinity	Test kit
Turbidity	Turbidimeter
DO	DO meter/probe

2.7.3 Equipment Calibration

General requirements for equipment calibration and quality control are: (1) following the manufacturer's calibration procedures and frequency for the field tests calibration, (2) using certified standards for calibration materials, (3) the quality control materials and frequency for the field tests, (4) the quality control limits and acceptance criteria for the quality control materials, (5) the acceptance criteria for calibration procedures, (6) the corrective actions for out-of-control events for both calibration and quality control samples, (7) the actions required by field personnel in the event that control parameters exceed the acceptance criteria, and (8) providing the form used to document exceedance of criteria and subsequent corrective actions.

In order to meet DQOs, proper calibration procedures for field and laboratory instrumentation will be followed. All instruments and equipment used during data and sample collection activities will be maintained, calibrated, and operated according to the manufacturers' instructions to ensure that the equipment is functioning within established tolerances and as required by the project. Conventional field instruments including PIDs, FIDs, turbidity meters, and multi-parameter groundwater meters (e.g., pH,

EC, temperature) should be calibrated daily, using standards that bracket the range of probable values, and checked prior to each use. Equipment will be calibrated and maintained in good condition prior to and during use.

Proper maintenance, calibration, and operation of each field instrument will be the responsibility of the field personnel and the instrument technicians assigned to the project. Field equipment will be calibrated prior to use in the field as appropriate. A record of field calibration or calibration checks of analytical instruments will be maintained in the calibration logbook by field personnel. All calibration data, including the numerical value and units of each measurement, will be recorded on a calibration record form. A copy of a calibration record form is provided in Appendix A. All instruments are to be stored, transported, and handled with care to preserve equipment accuracy. Damaged instruments will be taken out of service immediately and not used again until a qualified technician repairs and recalibrates the instruments.

Copies of the instrument manuals and other equipment calibration records (e.g., thermometers, sounders) will be maintained by the Performing Contractor. These records will be subject to QC audit. Any notes on unusual results, changing of standards, battery charging, and operation and maintenance of the field equipment will be included in the calibration logbook.

Calibration procedures and frequencies, maintenance, and decontamination procedures for the instruments used to measure the field parameters are summarized below.

2.7.3.1 Calibration Procedures and Frequencies

The following presents a list of field measurement equipment to be used during the fieldwork, along with the frequency of calibration, acceptance criteria, and corrective action. Calibration is performed in accordance with the manufacturer's instructions, or as per project requirements.

A brief summary of the calibration procedures and frequencies for field measurement equipment is provided below:

- pH/Conductivity/ORP Meter: Calibration for pH is performed every 6 months using standard buffer solutions having pH values of 4, 7, and 10. Calibration knobs are used to set the meter to read the value of the standards. The meter is calibrated at the start and end of each sampling day with pH buffers 4 and 7 or 7 and 10, depending on the expected ranges of pH in the samples for that day. If the reading varies more than 0.10 of a unit between calibration checks, the meter will be recalibrated. Conductivity calibration check is performed at the start of each sampling day by using potassium chloride standard solution. The meter must read within 1 percent of full-scale to be considered calibrated. Readings from conductivity meters are normally stable; thus, calibration checks are usually limited to the beginning and end of the sampling day. If the calibration check at the end of the day indicates the meter is not within tolerance, the data will be flagged to note

the percent difference between the meter and standard. ORP calibration check is performed at the start of each sampling day using YSI ZoBell solution. The meter must be temperature compensated to 25 °C at 1.3 mV/°C. If the mV reading is not within the specified range of the solution, it will be returned to the manufacture for calibration.

- Thermometer: Mercury thermometers and electronic thermometers are calibrated to a National Institute of Standards and Technology (NIST)–traceable thermometer prior to initial use and are visually inspected at least once a year.
- Organic Vapor Analyzer: All calibrations are performed using a commercially prepared, fixed concentration of methane (FID) or hexane (PID) gas balanced as air (zero hydrocarbon contaminant), unless otherwise requested. Field calibration is performed at the start of each day using calibration gas. The OVA will be rechecked with the same calibration gas at the completion of each day of field readings. Recalibration will also be performed in the field if the unit experiences abnormal perturbations or if readings become erratic.
- Conductivity-Based Water Level Sounder: The alarm function is checked by immersion in water. The length of tape is manually checked against a surveyor's steel tape annually.
- Interface Probe: The alarm functions are checked by immersion in water and oil, respectively. The capability of measuring the thickness of the oil layer is checked against a known oil thickness. The length of tape is manually checked against a surveyor's steel tape annually.
- Container: Containers used to measure waste volume, e.g., bailers, or containers used to calculate water flow, are calibrated upon acquisition by measuring the water volume with another calibrated container.
- Turbidity Meter: Turbidity range calibration is checked at the beginning and end of each sampling day using factory-supplied turbidity standards. Calibration knobs are used to set the analog meter to read the value of these standards. The meter is also checked during the sampling period with the standard most representative of the anticipated turbidity of the purged groundwater (typically 0 NTUs to 10 NTUs). If the reading varies by more than one unit between calibration checks, the meter will be recalibrated. Multiple physical conditions can cause variations in readings, including bubbles in the sampled water, wet or dirty sample containers, a wet or dirty lens, a wet or dirty optical sensor, or leakage of incidental light into the sample chamber. The range of the instrument is calibrated every 12 months using the latex turbidity standards. If discrepancies are noted, the potentiometer on the amplifier circuit board is adjusted. The lamp alignment and focus are also checked and adjusted at this time, as necessary.
- Dissolved Oxygen Meter: An internal calibration for the DO meter is performed each time the instrument is turned on. The calibration buttons are used to zero the instrument, and to enter the altitude and approximate salinity of the water. If the DO readings become erratic or a bubble has formed in the oxygen probe reservoir, the probe membrane must be replaced and the meter recalibrated.
- Flow Meter: Flow meters are checked once a year by timing the delivery of water into a container of known volume.
- Ferrous Iron Test Kit: The Fe^{+2} by the Hach 8146 test method employs the phenanthroline chemistry [American Public Health Association (APHA) Standard Methods, 18th ed., method 3500-Fe D and ASTM Method D 1068-88, Iron in Water, Test Method A). Ferrous iron reacts with 1,10-phenanthroline to form an orange colored complex in direct proportion to the ferrous iron concentration. The results are expressed in ppm (mg/L) Fe^{+2}. No calibration is required for field test kits.

2.7.4 Equipment Maintenance

Maintenance responsibilities for field equipment are coordinated through an instrument technician who is responsible for ensuring that available equipment and instrumentation are ready for use, and that returned equipment is checked out, serviced, and returned to available inventory in a timely manner. Maintenance during use is the responsibility of the project team using the equipment. Calibration logbooks contain information on instrument maintenance, calibration, and repair. A separate logbook is maintained for each instrument.

Field measurement equipment will be maintained according to the manufacturer's recommended procedures provided in the operations manual for each instrument. All field measurement equipment shall be decontaminated according to the specifications in Section 2.5.13 prior to any measurement activities and shall be protected from contamination until ready for use. Field measurement equipment will be kept clean to ensure accurate performance and reduce cross contamination. Field measurement equipment will be cleaned, stored, and maintained according to the manufacturer's recommendations.

2.8 FIELD QC PROGRAM

Multiple field sampling parameters will be collected during field operations. These parameters may be associated with phased investigations, routine monitoring, removal actions, and remedial actions. Field QC controls will include measurement of these parameters on duplicate/replicate samples and, where possible, comparison against historical readings from the same location. The sampling DQOs are to obtain sufficient numbers of samples to meet the requirements of the narrative objectives for each work phase and to collect representative samples. Sample representativeness is a function of the sampling design and procedures and the subsequent sample handling procedures designed to maintain the integrity of collected samples. Representativeness will be ensured by using the appropriate sampling and sample handling techniques as directed in Section 2.6. Evaluation of field duplicate/replicate samples and/or MS/MSD samples will provide a measure of the effects of sample inhomogeneity on the representativeness of sampling.

2.8.1 Control Parameters

Duplicate measurements of parameters measured by field instruments (e.g., organic vapor concentration, temperature, pH, ORP, Fe^{+2}, alkalinity, EC, DO, turbidity, water level, etc.) will be made for 10% of the field measurements. The results will be recorded on the field form. Duplicate measurements of field parameters will be considered suspect if they differ by more than 25%. If duplicate field measurements differ by more than 25%, the instruments will be recalibrated and the suspect measurements will be repeated.

Field records will be kept and maintained in sufficient detail to recreate all sampling and measurement activities and to meet the EDD format data input requirements. Record keeping shall follow the guidelines specified in Section 2.9. For all field measurements, numerical values/units and identity/calibration results for each field instrument will be documented.

2.8.2 Control Limits and Corrective Action

During field operations, all activities must be carried out according to the approved site-specific FSP. The Project Manager and sampling team members will be responsible to ensure that all procedures are followed as specified and that measurement data meet the prescribed acceptance criteria. If a problem arises, prompt corrective action must be taken. Engineering and scientific calculations will be checked and corrected as required by technical personnel, and as a rule will not require QC reporting.

Any time an error, deficiency or deviation from specified criteria occurs in the field, it is defined as an out-of-control or non-conformance event. A nonconformance may exist if there is a deviation from or a noncompliance with contract specifications or approved procedures. Nonconformance also includes major errors in documented analysis, data, or results, and deficiencies in documentation of any other aspect of the project that may affect the quality of the results. Some examples of non-conformance events that may occur in the field include:

- field equipment calibration criteria are not met;
- equipment falls into a monitoring well;
- a sampling location is overlooked and not sampled by the field team; or
- pressure transducer failure during a pump test resulting in lost data.

Field personnel or the subcontractor must take the necessary actions to resolve these events and bring the system back into control. These actions are defined as corrective actions. If deviations from the approved plan occur, the Performing Contractor must repeat the activity according to requirements in the form of a corrective action, and document that the corrective action was effective. Alternatively, if no corrective action is taken, the lack of corrective action must also be documented, and approval must be obtained.

In each of these cases, a decision must be made, communicated to the appropriate individual(s), and documented. The degree of non-conformance, in part, influences the degree to which the communications must proceed up the chain of command, and the nature of the documentation. The degree of non-conformance can be assessed by determining whether the non-conforming event will significantly affect the DQOs associated with the program. In cases where a significant effect to the work scope or project DQOs may occur, and a corrective action is either not planned or is not effective, approval is

required along with communications and documentation. The corrective action process including the communications, documentation and approval scheme is presented in Figure 2-1.

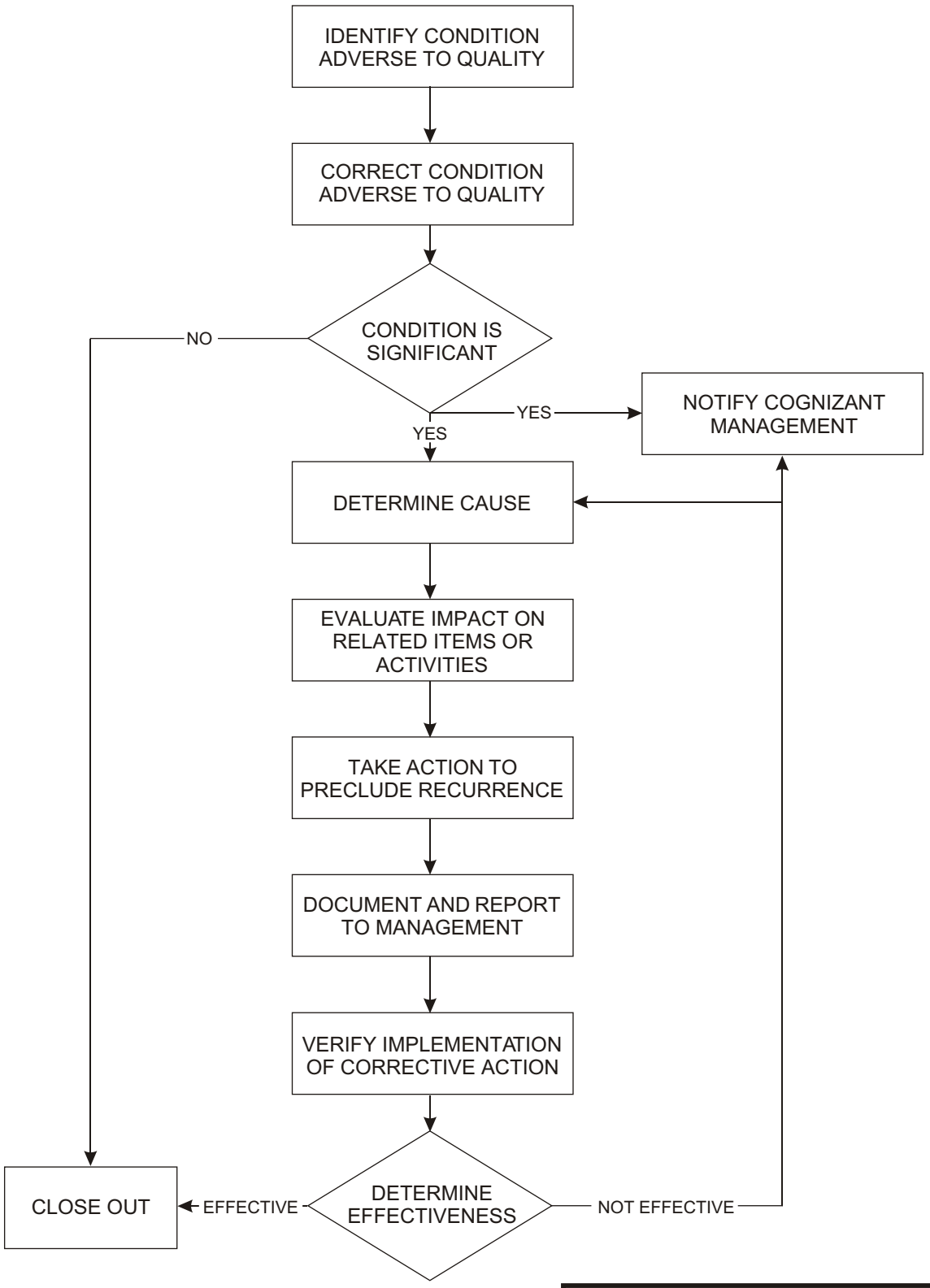
2.8.2.1 Non-Conformance Reporting

Personnel who identify a nonconformance shall immediately report both verbally and in a written report the condition to the Project QC Manager who will review the report. An example of a Nonconformance Report (NCR) is provided in Appendix A. The NCR is filed when a nonconformance event occurs. The sample numbers of any samples affected by the nonconformance should be described in Part 1 of the NCR. The Project QC Manager or QC Auditor will evaluate the nonconformance and complete Part 2 of the NCR. Project Managers or Task Managers may recommend corrective action to resolve the nonconformance and complete Part 3 of the NCR. As the corrective action is implemented and completed, the action will be reviewed and approved by the Program Manager and Project QC Manager, and Part 4 of the NCR will be completed. Based on an evaluation of the nonconformance, work on the specific task will stop and corrective actions will be taken. If the nonconformance involves a major deviation from the approved SAP which may adversely affect the cost and/or schedule of the work, the client will be notified of the nonconformance. If the nonconformance has adversely affected previously gathered data, the Performing Contractor Program Manager will complete Part 2 of the NCR and notify in writing all individuals and organizations that may be affected by the nonconformance and resulting data.

For routine non-conformances, such as field equipment calibration where duplicate field measurements differ by more than 25 percent, a significant impact on DQOs would not be anticipated. In such cases the instrument will be recalibrated in the field by the field personnel, with support by the equipment manufacturer, as needed, without need for communications up the chain-of-command. Communication in such cases may occur between the field personnel and site supervisor, but provided that the corrective action is successful, need not proceed further. Documentation in such cases would be an entry in the field logbook specifying the corrective action as an equipment recalibration.

For non-conforming events that may affect project DQOs (i.e., missed critical sampling location), the non-conforming event must be corrected according to project requirements. The project manager will review each event and exercise professional judgment in recommending a course of action. For instance, the most direct corrective action for a missed critical sampling point is to resample, in order to satisfy the work plan. The proposed course of action (i.e., re-sampling) will be communicated to the LMC POC for approval. Documentation of the corrective action must be written and placed in the job file, and may include telephone contact logs, e-mail correspondence, etc. If corrective actions proved ineffective or if no corrective action was taken, the project manager must communicate to the LMC POC that the

X:\GIS\LOCKHEED 23521-0601\FIG2.CDR



TETRA TECH

Beaumont Sites 1 & 2

Corrective Action Flow Chart

Figure **2-1**

non-conforming event was not corrected and must gain written acknowledgement and approval of the non-corrected, out-of conformance event.

For non-conforming events that may affect project DQOs (i.e., missed critical sampling location), the non-conforming event must be corrected according to project requirements. The project manager will review each event and exercise professional judgment in recommending a course of action. For instance, the most direct corrective action for a missed critical sampling point is to resample, in order to satisfy the work plan. The proposed course of action (i.e., re-sampling) will be communicated to the LMC POC for approval. Documentation of the corrective action must be written and placed in the job file, and may include telephone contact logs, e-mail correspondence, etc. If corrective actions proved ineffective or if no corrective action was taken, the project manager must communicate to the LMC POC that the non-conforming event was not corrected and must gain written acknowledgement and approval of the non-corrected, out-of conformance event.

In significant cases where project DQOs may be significantly affected (e.g., a deep well may be lost due to formation collapse; breaching of a confining layer during a drilling program), communications must be immediate, and proceed from the Program Manager to the LMC POC. The Program Manager will discuss the event/issue and generate a NCR for approval. Documentation of corrective actions for significant events will include a summary of the work, the project task number, a thorough description of what went wrong in the field, how it was corrected, and proof that the system is back in control. All NCRs shall be retained by the Program Manager, and must be made available to the client upon request.

2.8.3 Field Performance and System Audits

Field audits will be conducted to ensure compliance with sampling and sample control protocols. Field audits will evaluate sampling, sample storage, and packaging/shipping procedures. For each field audit, documentation of activities and verification of document control are determined, including log books and standard operating procedures.

Quality Assurance audits are conducted at the request of project management or the client. A written report of a QA project audit will include:

- An assessment of project team status in each major project area;
- Clear statements of areas requiring improvement or problems to be corrected;
- Recommendation and assistance regarding proposed corrective actions or systems improvements; and
- A timetable for any corrective action required.

The Performing Contractor QA Manager will be responsible for the coordination of audits and the disposition of audit records. Field audits shall be conducted at least annually, and at least once every other year at each of the two sites.

A system for issuing a formal Quality Deficiency Notice will be established to address problems identified through independent QC audits. An example of a Quality Deficiency Notice is provided in Appendix A. Each Quality Deficiency Notice will address a specific problem or deficiency, usually identified during the QC audit of project operations. Any Quality Deficiency Notice issued along with the corresponding responses will be tracked. If there is no satisfactory response to a Quality Deficiency Notice within a 30-day time frame, or if there is a dispute concerning the corrective action, the recommendation and/or conflict will be referred to successively higher management levels until the issue is resolved.

2.9 RECORDKEEPING

2.9.1 Field Logbooks

The Performing Contractor shall maintain field records sufficient to recreate all sampling and measurement activities and to meet all EDD loading requirements. The requirements listed in this section apply to all measuring and sampling activities. Requirements specific to individual activities are listed in the section that addresses each activity. These records shall be archived in an easily accessible form and made available to the client upon request.

All information pertinent to a field survey and/or sampling will be recorded in project field logbooks and/or on appropriate data sheets. The field logbook may also be a bound book with fixed pages that cannot be removed, or may consist of daily field activity forms. An example of a daily field activity form is provided in Appendix A. Entries will be made in waterproof ink. Entries will be described at an appropriate level of detail so that the situation can be reconstructed without relying on memory. Information to be recorded in field logbooks for all field activities may include, but is not limited to:

- project name and number;
- location;
- date and time;
- weather conditions;
- personnel protection levels;
- identity of people performing field activities;
- personnel or visitors on the site;
- general work activity;
- field activity subject;

- unusual events or other items pertinent to the history of the investigation;
- subcontractor progress or problems;
- communications with the client or others;
- sampling locations;
- field measurements;
- calibration of field equipment;
- for field measurement records: (1) the numerical value and units of each measurement and (2) the identity of and calibration results for each field instrument; and
- other field-specific activities not recorded on data sheets.

Each data sheet or the end of each entry in the logbook will be signed or initialed and dated by the person making the entries. All original data recorded in field logbooks, on sample tags, or in custody records, as well as other data sheet entries, will be written with waterproof ink. If an error (e.g., incorrect data or sample depth) is made on the document, corrections will be made simply by crossing a single line through the error (in such a manner that the original entry can still be read) and entering the corrected information. All corrections will be initialed and dated.

2.9.2 Data Sheets

Data sheets will be used to document specific field procedures and daily activities. Copies of typical data sheets are provided in Appendix A. Field logbooks or daily field activity forms will be used to document such activities as site reconnaissance. Boring log and monitoring well construction log forms will be used to log soil conditions and drill cuttings during the drilling and construction of wells. Monitoring well development and purging information will be recorded on well development field data sheets and groundwater sampling field data sheets. Water level measurements will be recorded on a water level measurement field data sheet. A CoC record will be used to document transfer-of-custody procedures. If a nonconformance to approved procedure occurs, an NCR form will be completed. Completed data sheets will be maintained in project files by the Performing Contractor.

2.9.3 Photographs

Photographs will be taken of the sampling area, as appropriate, to show the surrounding area, drilling and sampling equipment, and sample activities. The picture number (and roll number, if film is used) will be logged in the appropriate logbook section or on a photograph record form to identify which sampling area is depicted in the photograph. An example of a photograph record form is provided in Appendix A. Each sequence of photographs will be identified by taking a photograph of an information sign on the first frame. The information presented below will be written on each sign to identify the pictures contained in the sequence:

- project;
- location;
- photograph number;
- date
- photographer's name;
- work activity; and
- corrections to documentation (if applicable).

2.10 VALIDITY OF SAMPLING PROGRAM

The validity of a sampling program will qualitatively be assessed by the Performing Contractor through consideration of critical issues with respect to the overall project scope. Since critical issues will be site and project-specific, the list below includes only a few issues to serve as an example and is not exhaustive. Therefore, the Performing Contractor shall develop a list of site-specific issues to enable sampling program validity assessment for each program. Examples of considerations and sampling design issues are listed below.

- Do the suite of analytical tests and analyte lists cover the range of contaminants potentially used or released to the environment at a given site?
- Does a groundwater sentry well that is purported to establish the downgradient extent of a plume exist hydraulically downgradient of the source(s)?
- Do the sampling locations address all potential areas of impact; if not, what is the uncertainty associated with the data set?
- Do the sampling point installation methods and procedures have the potential to have introduced or spread contamination; and/or do the installations themselves represent potential conduits?
- Was the material used to backfill the tank excavation certified clean with analytical laboratory results?

If the responses to any of these issues for a program is no, then a data gap or critical flaw in the sampling program likely exists. In such cases, the program is not strictly valid until data gaps and/or critical flaws in the sampling design or implementation are addressed.

2.11 SITE MANAGEMENT

The goal of site management is to conduct all field operations in an appropriate and efficient manner while minimizing impacts to base operations and personnel. This goal will be met by quickly establishing effective communications between the Performing Contractor and LMC, and through extensive planning and preparation prior to implementing field work. Other personnel may be identified prior to or in the early stages of the planned field activities.

The Performing Contractor will immediately report via telephone to the LMC POC (or their designates) any data or results generated during this investigation which may indicate an imminent health risk.

Following this telephone notification, a written notice will be prepared and delivered within 3 days. This notification shall include supporting documentation.

In order to minimize downtime due to equipment failures, sufficient time will be allotted for drillers to properly maintain their drilling rigs, and for the Performing Contractor to maintain the sampling and monitoring equipment. The Performing Contractor will maintain a backup set of sampling and monitoring equipment whenever possible, as well as a selection of frequently used spare parts. In addition to backup field equipment, a sufficient supply of field expendables will also be maintained onsite and restocked on an as-needed basis. Several alternate field personnel will be identified and made familiar with the SAP and HASP in case substitution for primary project personnel becomes necessary.

3.0 QUALITY ASSURANCE PROJECT PLAN

This QAPP has been prepared to comply with the *Guidance for Quality Assurance Plans* (EPA, 2002a), herein referred to as EPA QA/G-5. The primary function of this QAPP is to describe QA/QC procedures to be used for collection and analysis of environmental samples at Sites 1 & 2. This QAPP describes laboratory-specific information and any QA/QC procedures for analytical testing and data management not already stated in EPA QA/G-5.

This QAPP describes the QA/QC procedures that will be used for analytical work performed by a California State Certified laboratory.

3.1 PURPOSE AND SCOPE

The QAPP outlines QA/QC procedures for analytical and data management aspects of the sampling events at the Site. Where EPA QA/G-5 speaks to QA/QC procedures and criteria the specific reference to that document will be cited. The QAPP contains discussions of the following topics:

- Variances (Section 3.2);
- Quality Assurance Objectives for Measurement Data (Section 3.3);
- Sampling Procedures (Section 3.4);
- Field and Laboratory Sample Custody (Section 3.5);
- Analytical Methods and Procedures (Section 3.6);
- Internal Quality Control Checks (Section 3.7);
- Quality Control Procedures (Section 3.8);
- Laboratory Audits and Performance Evaluation Programs (Section 3.9);
- Preventative Maintenance (Section 3.10);
- Corrective Action (Section 3.11);
- Quality Assurance Reports (Section 3.12); and
- Data Reduction, Validation, and Reporting (Section 3.13).

3.2 VARIANCES

The Performing Contractor along with its subcontractors shall perform their services in accordance with the requirements specified in this QAPP. An approved variance is required for any exception to or deviation from the requirements in this QAPP. An approved variance is also required if additional analytical methods or field sampling techniques are required to support a project but are not part of this QAPP. The sampling and/or analytical method must be included in a QAPP addendum with all the accompanying quality control requirements, i.e., reporting limits, calibration requirements, quality control measures, corrective action, data validation, and reporting requirements.

3.2.1 Procedure for Obtaining a Variance

Variance requests will be submitted in a letter by the Performing Contractor to the client. In the letter, specific variances from the QAPP shall be identified by chapter, subtitle, paragraph, page, and line with supporting justification for the change. When a subcontractor laboratory requests a variance, the Performing Contractor will evaluate the laboratory variance and make recommendations to either accept or reject it. Variances must be approved in writing by the Performing Contractor Program Manager. The variance request and proposed course of action will be communicated to the LMC POC for approval.

3.2.2 Variance Documentation

Requests for variances and corresponding written approvals from the client will be part of the project record. Once approved, a QAPP addendum will be submitted to the client. Only the variances approved by the client shall be included in the final version of the QAPP addendum.

3.2.3 Identification of Analytical Laboratories, Subcontractors, and Their Tasks

When laboratories are chosen to analyze project samples, or if and when additional or alternative laboratories are selected to serve as backup to the primary laboratories, all relevant QA/QC elements (details of laboratory project management organization, laboratory auditing, etc.) will be required by the subcontracting laboratory and detailed in QAPP addenda. This will also be true of any laboratory required for specialty analyses. These secondary laboratories will comply with the QAPP, as appropriate. All QC criteria, calibration procedures, and other requirements stated in the QAPP will be described for any other analytical laboratory in compliance with EPA QA/G-5. Subcontractors will submit project organizational charts to the Performing Contractor that define key project personnel. Subcontractors will delegate the following responsibilities.

3.2.3.1 Subcontracting Laboratories Organization and Responsibilities

Analytical data from samples collected at the Site will be checked by laboratory staff to ensure that appropriate QC measures have been taken and the results are within acceptable ranges. The effectiveness of the QA/QC program is continuously evaluated by the LPM, Laboratory Quality Assurance Manager (LQAM), Section Supervisor and the Laboratory Director. Data that fail prescribed criteria will be reported to the LQAM. Once evaluated, the LPM will immediately notify the Performing Contractor's Project Manager and QA/QC Manager by telephone; and a written follow-up will be sent by email. All communications and data reporting from subcontracting laboratories to the Performing Contractor will be handled through the subcontracting laboratory.

3.2.3.1.1 Laboratory Director

The Laboratory Director's responsibilities include planning, design, and implementation of laboratory procedures and policies, including implementation and management of scientific and technical aspects of the laboratory involving analysis, method development, and QA/QC. The Laboratory Director communicates directly with the LQAM as well as with the specific supervisors of the various sections associated with the laboratory.

3.2.3.1.2 Laboratory QA Manager

The LQAM's responsibilities include review and approval of documents relating to QA/QC procedures (e.g., Quality Assurance Manual, Standard Operating Procedures [SOPs]), supervision of sample control operations as part of this program, and oversight of laboratory certification programs.

The LQAM is independent from laboratory operations and oversees the laboratory's QA program, including internal and external audits of its operations quality issue resolution, and implementation of suitable corrective actions. The LQAM reviews data as needed, provides technical representation of the laboratory's QA procedures, and supervises the preparation of laboratory Standard Operating Procedures. The LQAM has the authority to limit or halt out-of-control processes when warranted. The LQAM may participate in the review of QAPP addenda.

3.2.3.1.3 Laboratory Project Manager

The LPM will be the Performing Contractor's point-of-contact at the subcontracting laboratory for issues such as technical questions regarding analytical results, and scheduling and shipping sample containers.

The LPM ensures that laboratory resources are available to the Performing Contractor, supervises in-house CoC, and submits all daily documentation to the Performing Contractor Laboratory Coordinator. Daily documentation may consist of quality control reports, internal and external CoC, airbills, and cooler receipt forms. The daily documentation submitted to the Performing Contractor Laboratory Coordinator will be specified in the project QAPP addendum. The LPM also schedules and manages daily laboratory operations for the project, communicates problems encountered during analysis to the Performing Contractor Laboratory Coordinator, ensures that laboratory staff are suitably qualified and trained, and makes recommendations concerning staffing, equipment, facilities, and quality program enhancement requirements.

3.2.3.1.4 Laboratory Section Supervisor

The laboratory section supervisors (i.e. section supervisors for organics, metals, etc.) will review laboratory findings on a daily basis, review quality control daily, verify the technical validity of the data, and ensures program compliance. The section supervisors report to the laboratory director.

3.3 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

The quality assurance objective for Sites 1 & 2 is to ensure that environmental sampling and analysis efforts produce credible and scientifically sound data. The DQOs are both qualitative and quantitative statements. The development of DQOs is a systematic and iterative process to evaluate and identify the data needed for decision-making. Analytical data will be obtained using published, standard methods in a State of California Department of Health Services (DHS)-certified laboratory as described in Section 3.6 or QAPP Addenda. Analytical DQOs are achieved through evaluation of analytical methods used, project-specific reporting limits, and laboratory QC, which are detailed in the following sections of this QAPP.

3.3.1 Definition of Criteria

Acceptance criteria is defined in EPA QA/G-4 as specific limits placed on characteristics of an item, process, or service defined in requirements documents. As stated in EPA QA/G-5, measurement performance criteria for new data collection efforts are stated in terms of the desired (assumed) level of uncertainty in data that will be used to address the study question or support the decision.

3.3.2 Measurement of Data Quality

The components associated with measurement of data quality are also described in EPA QA/G-5. Performance and acceptance criteria are often expressed in terms of data quality indicators (DQIs), such as accuracy, precision, representativeness, comparability, and completeness. DQIs are discussed further in Section 3.3.5.

3.3.3 Goals for Criteria

The following criteria are discussed in detail in this QAPP:

- Laboratory accuracy limits and analytical precision criteria for each method for subcontracting laboratories are presented in Analytical Methods and Procedures, found in Section 3.6.
- Overall precision for all sampling activities, which includes both sampling and analytical factors, can be expected to show acceptable Relative Percent Differences (RPDs) of up to 30% for water samples and 40% for soil samples.
- A completeness factor of 95% for water and 90% for soil is acceptable for the field sampling activities.

3.3.4 Data Quality Objective Process

The DQO process is a systematic process for generating environmental data that will be sufficient for their intended use. This process consists of seven steps: (1) State the problem, (2) Identify the decision, (3) Identify the inputs to the decision, (4) Define the boundaries of the study, (5) Develop a decision rule, (6) Specify limits on decision errors, and (7) Optimize the design. The DQO process is iterative, that is, the seven-step process should be repeated, as needed, based on newly acquired data and/or information. The DQO process should be applied to each program and to each site prior to sampling and analysis activities. For examples of the DQO process, refer to *Guidance for the Data Quality Objective Process* (EPA, 2000). The DQO process is described in detail below.

3.3.4.1.1 Step 1: State the Problem

Purpose: Summarize the contamination problem that will require new environmental data, and identify the resources available to resolve the problem.

Activities

1. Identify members of the scoping team. The composition of the scoping team can change based on the scope of the proposed program. At a minimum, the scoping team may include the Program Manager and technical staff (i.e. a risk assessor, a hydrogeologist or geologist, engineer, and/or chemist) and one or more members of LMC. For Step 6 of the DQO process, at least one team member shall be proficient in statistics.

2. Develop/refine the conceptual site model. Include potential sources of contaminants, known or suspected locations of contaminants, and media that are known or suspected to become contaminated.

3. Define the exposure pathways and exposure scenarios. Identify and locate human and ecological receptors.

4. Specify available resources. Include project personnel, time constraints, budgetary information, and a schedule.

5. Write a brief summary of the contamination problem. This will logically tie in with the conceptual model and will include a concise summary of known conditions including site location, site vicinity, site history, and a list of potential or known contaminants and impacted media at the site. Together this information defines the problem to be addressed.

3.3.4.1.2 Step 2: Identify the Decision

Purpose: Identify the decision that requires new environmental data to address the contamination problem.

Activities

1. Identify the key decision for the current phase or stage of the project. Write down a specific statement that focuses the search for information to address the problem. If multiple statements are necessary that cannot be decoupled, it indicates a likelihood of multiple project phases.

2. Identify alternative actions that may be taken based on the findings of the field investigation. The alternative actions that can address the problem should always include consideration of no action, in addition to cleanup alternatives, and even administrative alternatives.

3. Identify relationships between this decision and any other current or subsequent decisions. The output for this step is a concise decision statement that links the principal statement of the problem to possible actions that will address the problem. For multiple decisions, use of a flow chart for organization and prioritization is helpful to illustrate the relationships.

3.3.4.1.3 Step 3: Identify the Inputs to the Decision

Purpose: Identify the information needed to support the decision, and specify which inputs require new environmental measurements.

Activities:

1. Identify the information inputs needed to resolve the decision. Include considerations of physical and chemical testing needs, the matrices addressed, and whether existing data can satisfy the decision. If existing data are not acceptable in terms of data quality, or are otherwise insufficient to satisfy the decision, develop a list of information that will be needed to do so.

2. Identify sources for each information input, and list those inputs that are obtained through environmental measurements. Examples of such sources may include historic records, regulatory guidance, scientific literature, and new data collection.

3. Define the basis for establishing contaminant-specific action levels. The values assigned provide the criteria for choosing among the alternative actions. It is important in this step to understand what information will be used to determine the action level, whether it be a groundwater maximum contaminant level (MCL), a drinking water notification level, California Human Health Screening Level and/or a project-specific risk assessment. Note: The actual value of the contaminant-specific action levels is addressed in Step 5 of the DQO process.

4. Identify potential sampling approaches and appropriate analytical methods. This step begins the sampling plan, when quantities of each sample are identified, appropriate analytical methods and associated detection limits are selected, and appropriate analytical testing laboratories are selected.

3.3.4.1.4 Step 4: Define the Boundaries of the Study

Purpose: Specify the spatial and temporal aspects of the environmental media that the data must represent to support the decision.

Activities:

1. Define the geographic areas and boundaries of the field investigation.

2. Define each environmental medium of concern. For instance, at a firing range cleanup, the medium of concern may be limited to the upper 5 feet of soils, whereas at a launch facility impacts will typically include surface sediments, subsurface soils, and underlying groundwater to the upper bedrock surface.

3. Divide each medium into strata having relatively homogeneous characteristics. This step can reduce the number of samples required to meet the requirements of the decision. Generally at the

Site, surface soils, subsurface soils, and groundwater are considered as relatively homogeneous media. However, review of the conceptual model is appropriate at this stage to assess the degree to which the various media can be expected to exhibit homogeneity.

4. Define the scale of decision-making. In simpler terms, the area of land being sampled (decision unit) should be appropriate to the risk of an incorrect decision. As the decision unit gets smaller, the statistical certainty of the data increases along with the sampling and analytical cost, so the decision is a series of tradeoffs that must be addressed. In many cases, data density is specified in guidance (e.g., for UST excavations, a prescribed number of excavation wall samples is specified based on the linear feet of excavation), and the planning team would correctly adhere to the guidance.

5. Determine the time frame to which the decision applies. For example, a computer model predicts contaminant transport over a period of 30 years; a risk assessment under a residential scenario assumes exposure over an average 8-year length of residence. In these cases, it may not be possible to collect data over the full time frame in which the decision applies. In such cases, one should address discrepancies that may arise from the short time frame of data collection relative to the long time periods for implementing decisions.

6. Determine when to take samples. Conditions may vary over the course of a study due to seasonal patterns, activity patterns, development or facility decommissioning, etc. The degree to which these variations may affect a sampling program should be initially considered in terms of the potential impact, if any, on the data collection and interpretation of the results.

7. Identify practical constraints that may hinder sample collection (reconsider previous steps as necessary). For example, constraints may include site access, subcontractor or equipment availability, and climatic conditions.

3.3.4.1.5 Step 5: Develop a Decision Rule

Purpose: Develop a logical "if…then…" statement that defines the conditions that would cause the decision-maker to choose among alternative actions.

Activities:

1. Specify the parameter of interest (such as mean, median, maximum, or proportion). In some cases, existing regulations may specify which parameter must be used. Most frequently, however, the mean is used to represent a sample population of normal distribution.

2. Specify the action level for the decision. For example, a specified action level is a regulatory standard (e.g., drinking water maximum contaminant level [MCL]), whereas an unspecified action level may be a site-specific, risk-based goal or comparison to background. Once the action level is selected, go back to step 3 to verify that the detection limits for the specified tests remain below the action level(s). Once verification has been done, the Performing Contractor can initiate subcontractor laboratory selection. The Performing Contractor will inform the subcontractor laboratories of the DQOs and forward a copy of the QAPP that specifies all the analytical and other technical requirements for the project. The Performing Contractor will review all variance requests and include among their selection criteria the laboratories whose variance has the least impact on the project DQOs.

3. Combine the outputs of the previous DQO steps into an "if…then…" decision rule that includes the parameter of interest, the action levels, and the alternative actions. An example of a hypothetical decision rule is: "If the true mean dioxin concentration in the surface 2 inches from a

decision unit (20 feet by 100 feet) exceeds 1 ppb, then remove a 6-inch layer of soil. If the true mean is less than 1 ppb, then recommend no further actions with respect to dioxin in surface soil."

3.3.4.1.6 Step 6: Specify Limits on Decision Errors

Purpose: Specify the decision-maker's acceptable limits on decision errors, which are used to establish appropriate performance goals for limiting uncertainty in the data.

Activities:

1. Determine the possible range of the parameter of interest. Approximate upper and lower bounds based on current information, professional judgment, or historical data.
2. Define both types of decision errors and identify the potential consequences of each. Sampling design error occurs when the data collection design does not capture the variability within the decision unit to make the decision. Measurement error is caused by imperfections in the measurement and analysis system (e.g., sample collection, handling, preparation, analysis, storage).
3. Specify a range of possible parameter values where the consequences of decision errors are relatively minor (gray area). Typically, this means assigning a margin of error for the reported value within which a decision cannot be made (see EPA QA/G-4 for activities 3 through 5).
4. Assign probability values to points above and below the action level that reflect the acceptable probability for the occurrence of decision errors.
5. Check the limits on decision errors to ensure they accurately reflect the decision-maker's concern about the relative consequences for each type of decision error. In general, the tolerable limits for making a decision error should decrease as the consequences of the decision error become more severe. In accordance with EPA QA/G-4, this QAPP establishes a 1 percent decision error. Use of a larger error will require submittal of a variance.

3.3.4.1.7 Step 7: Optimize the Design

Purpose: Identify the most resource-effective sampling and analysis design for generating data that are expected to satisfy the DQOs.

Activities:

1. Review the DQO outputs and existing environmental data. Data review should include assessment of detection limits, variability within data set, and data gap identification (if present), to establish the characteristics of the database.
2. Develop general sampling and analysis design alternatives. The goal is to find cost-effective design alternatives that balance the number of samples and the measurement performance, given the feasible choices for spatial and temporal sample designs and measurement methods. The alternatives should include the sample selection technique, the sample type, the number of samples, and the number of analyses per sample.
3. For each design alternative, verify that the DQOs are satisfied. This can be done using Data Quality Objectives Decision Error Feasibility Trials Software (EPA QA/G-4D).

4. Select the most resource-effective design that satisfies all of the DQOs. Criteria include ability to meet DQO constraints and Data Performance Goals, and cost-effectiveness, given the non-technical, economic and heath factors imposed on the project (EPA QA/G-4).

5. Document the operational details and theoretical assumptions of the selected design SAP. Documentation should include the following:

   - Number of samples;
   - Sample type (composite vs. grab samples);
   - Collection technique (e.g., split spoon sampler, whole air canister sample);
   - Physical sample volume;
   - Sample support (i.e., the area, volume, or quantity that each sample represents);
   - Sample locations (surface coordinates and depth) and selection method;
   - Discussion of sample collection, handling, and analytical sequence;
   - Analytical methods; and
   - Statistical sampling scheme.

3.3.4.2 Establishing QC Levels

The QC level for sample collection and analysis will be decided on a project-specific basis. The QC Levels will be based upon the DQO process and inputs from the LMC, the Program Manager, and project team. The justification for the QC Level will be detailed in the project-specific QAPP addenda. In the absence of QAPP addenda, default QC criteria will conform to Revision 0 of the SAP.

3.3.5 Data Quality Indicators

The project-specific QAPP and QAPP addenda will identify the types of QA samples that will be collected to evaluate the quality of the data, whether it is screening or definitive. Indicators of data quality are:

- Accuracy;
- Precision;
- Representativeness;
- Comparability; and
- Completeness.

Definitions for these indictors are provided below. The QC samples that evaluate data quality (e.g., duplicate samples, EBs, TBs, MS/MSD samples, laboratory control samples [LCSs]) are discussed in Section 3.7 and should be used for internal quality control checks.

3.3.5.1 Accuracy

Accuracy reflects the degree to which the measured value represents the actual or "true" accepted value for a given parameter among individual measurements of the same property under prescribed similar

conditions. Analytical accuracy is measured by comparing the percent recovery of analytes spiked into a LCS and MS against a control limit. Surrogate compound recoveries are also used to assess accuracy and method performance for each sample analyzed.

Accuracy is a statistical measurement of correctness and includes components of random error (variability due to imprecision) and systemic error. It therefore reflects the total error associated with a measurement. A measurement is accurate when the value reported does not differ from the true value or known concentration of the spike or standard. Analytical accuracy is measured by comparing the percent recovery (%R) of analytes spiked into an LCS to a control limit (refer to Table 3-1 for the formula). For volatile and semivolatile organic compounds, surrogate compound recoveries are also used to assess accuracy and method performance for each sample analyzed. Analysis of performance evaluation (PE) samples shall also be used to provide additional information for assessing the accuracy of the analytical data being produced.

Both accuracy and precision are calculated for each analytical batch, and the associated sample results are interpreted by considering these specific measurements. Accuracy values should be compared to the approved control limits (see Tables 3-6, 3-7, 3-8, and 3-9) for specified analytes.

3.3.5.2 Precision

Precision measures the reproducibility of measurements. It is strictly defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions. Analytical precision is the measurement of the variability associated with duplicate (two) or replicate (more than two) analyses. Laboratories use the LCS to determine the precision of the analytical method. If the recoveries of analytes in the LCS are within established control limits, then precision is within limits. In this case, the comparison is not between a sample and a duplicate sample analyzed in the same batch, rather the comparison is between the sample and samples analyzed in previous batches. Total precision is the measurement of the variability associated with the entire sampling and analysis process. It is determined by analysis of duplicate or replicate field samples and measures variability introduced by both the laboratory and field operations. Field duplicate samples and MSD samples shall be analyzed to assess field and analytical precision. The precision measurement is determined using the RPD between the duplicate sample results. For replicate analyses, the relative standard deviation (RSD) is determined. The formulas for calculating RPD and RSD are given in Table 3-1.

Field duplicate/replicate, laboratory duplicate, and MSD samples will be used to assess field and analytical precision, and the precision measurement will be determined using the RPD between the duplicate sample results.

3.3.5.3 Representativeness

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. Representativeness is a qualitative parameter mostly concerned with the proper design of the sampling program.

Representativeness shall be achieved through use of the standard field, sampling, and analytical procedures. Representativeness is also determined by appropriate program design, with consideration of elements such as proper well locations, drilling and installation procedures, and sampling locations. Decisions regarding sample/well/boring locations and numbers and the statistical sampling design are documented in each project-specific work plan. Representativeness may be evaluated using either statistical or qualitative methods as appropriate to the project. Objectives for representativeness are defined for each sampling and analysis task and are a function of the investigative objectives.

3.3.5.4 Comparability

Comparability is the confidence with which one data set can be compared to another. Sample data should be compared with other measurements for similar samples and sample conditions. The objective for this QA/QC program is to produce data with the greatest possible degree of comparability. The number of matrices sampled and the range of field conditions encountered are considered in determining comparability. Comparability is achieved by using standard methods for sampling and analysis, as covered in the FSP and QAPP, respectively, reporting data in standard units, normalizing results to standard conditions, and using standard and comprehensive reporting formats.

Complete field documentation using standardized data collection forms shall support the assessment of comparability. Analysis of PE samples and reports from audits shall also be used to provide additional information for assessing the comparability of analytical data. Examples of standard calculations used to evaluate data sets are presented in Table 3-1. Comparability should take into consideration varying field conditions (seasonal changes), data produced under different DQOs, different equipment and/or procedures used by the Performing Contractor or its subcontractors, and potential involvement of multiple laboratories during the life of a project**.**

3.3.5.5 Completeness

The completeness of the data will be evaluated based upon the percentage of data judged to be valid relative to the total tests requested. The completeness goal is to generate a sufficient amount of valid data to meet project needs. For completeness requirements, valid data are defined as usable data that meet the objectives of the specific project [i.e. all results not qualified with a rejected ("R") flag]. The requirements for completeness of aqueous and soil samples are 95% and 90%, respectively.

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that is expected to be obtained under correct, normal conditions. It is calculated according to the following formula:

Completeness (%) = [Number of usable results / Number of possible results] x 100.

Table 3-1
Statistical Calculations

Statistic	Symbol	Formula	Definition	Uses
Mean	$\overline{X}$	$\frac{\left(\sum_{i=1}^{n} x_i\right)}{n}$	Measure of central tendency	Used to determine average value of measurements
Standard Deviation	S	$\left(\frac{\Sigma(x_i-\bar{x})^2}{(n-1)}\right)^{1/2}$	Measure of relative scatter of the data	Used in calculating variation of measurements
Relative Standard Deviation	RSD	$(S/\overline{X}) \times 100$	Relative standard deviation, adjusts for magnitude of observations	Used to assess precision for replicate results
Percent Difference	Percent D	$\frac{x_1 - x_2}{x_1} \times 100$	Measure of the difference of two observations	Used to assess accuracy
Relative Percent Difference	RPD	$\left(\frac{(X1 - X_2)}{(X1 + X2)/2}\right) \times 100$	Measure of variability that adjusts for the magnitude of observations	Used to assess total and analytical precision of duplicate measurements
Percent Recovery (LCS)	Percent R	$\left(\frac{X_{meas}}{X_{true}}\right) \times 100$	Recovery of spiked compound in clean matrix	Used to assess accuracy in LCS samples
Percent Recovery (MS)	Percent R	$\frac{\left(\begin{array}{c}\text{value of}\\ \text{spiked}\\ \text{sample}\end{array} - \begin{array}{c}\text{value of}\\ \text{unspiked}\\ \text{sample}\end{array}\right)}{\text{Value of added spike}} \times 100$	Recovery of spiked compound in sample matrix	Used to assess matrix effects and total precision in MS samples

Statistic	Symbol	Formula	Definition	Uses
Correlation Coefficient	r	$(COD)^{1/2}$		Evaluation of "goodness of fit" of a regression line
Coefficient of Determination	COD	see SW8000B	Indication of error associated with regression curves	Evaluation of "goodness of fit" of a polynomial equation

Completeness is calculated for the aggregation of usable data for each analyte measured for any particular sampling event or other defined set of samples. Completeness is calculated and reported for each method, matrix, and analyte combination. The number of usable results determines the completeness of the data set. The laboratory is not required to calculate completeness. The Performing Contractor shall review the validated data for usability for the project and calculate completeness based on the usable data. It is the responsibility of the Performing Contractor to review the appropriateness of the flags based on the DQOs and guidelines presented in the QAPP. Quality assurance objectives for completeness will be defined by the DQOs for the project and in revised if necessary in project-specific QAPP addenda.

3.4 SAMPLING PROCEDURES

Section 2.6 of the FSP provides details of the field sampling procedures.

3.4.1 Sampling Protocols

Sections 2.6.1 through 2.6.5 of the FSP provide descriptions of the field sampling protocols.

3.4.2 Sample Containers

Sample containers are purchased pre-cleaned and treated according to EPA specifications for the appropriate laboratory methods. Sample containers that are reused are decontaminated between uses by EPA-recommended procedures (EPA, 1992). Containers are stored in clean areas to prevent exposure to fuels, solvents, and other contaminants. Amber glass bottles are used routinely where glass containers are specified in the sampling protocol.

Preservation of samples is required so that samples retain their integrity. The most common preservation techniques include pH adjustment and temperature control. Pre-cleaned containers for groundwater samples, containing the appropriate preservatives as specified in Tables 3-2, 3-3, or 3-4, will be provided by the laboratories. Field personnel collecting environmental samples will use EPA-recommended containers and adhere to EPA-recommended preservation techniques for the parameters of concern (Tables 3-2, 3-3, and 3-4). The minimum sample volumes required for each type of analysis are also specified and must be met.

3.4.2.1 Sample Volumes, Container Types, and Preservation Requirements

The Performing Contractor will provide a comprehensive list of sample volumes, container types, and preservation methods for samples collected (Tables 3-2, 3-3, and 3-4). Guidance for sample volumes, container type, preservation, and holding times can be found within the respective EPA document that contains the analytical method (see Section 3.6).

A list of EPA test methods and the related source documents that contain the above guidance may be located in *EPA 901/3-88-001, Index to EPA Test Methods, May 2000* (EPA, 2001b). Tables 3-2, 3-3, and 3-4 contain the general conventions concerning this guidance.

Any departures from the requirements of the guidance documents will require an approved variance. If the Performing Contractor deviates from sample type, the new method shall be approved in advance via a request for a variance. The Performing Contractor will request a variance from the client POC. Once this variance has been approved in writing, the departure from the conventional sampling and analysis requirements will be included in the project-specific QAPP addendum.

3.4.3 Record Keeping

Details of record keeping procedures and requirements are provided in Section 2.9.

3.5 FIELD AND LABORATORY SAMPLE CUSTODY

This section summarizes field operations and laboratory sample identification data, sample packaging/shipping, sample handling and custody pertaining to field activities and laboratory operations.

3.5.1 Field Operations

Section 2.6.6 contains descriptions of sample handling procedures.

3.5.1.1 Sample Identification

Section 2.6.6.3 contains detailed descriptions of sample identification procedures.

3.5.1.2 Sample Packaging and Shipping

Section 2.6.6.5 contains detailed instructions for sample packaging and shipping.

3.5.1.3 Performing Contractor Sample Handling and Custody

Procedures to ensure the custody and integrity of the samples begin at the time of sampling and continue through transport, sample receipt, preparation, analysis and storage, data generation and reporting, and sample disposal. Documentation of the custody and condition of the samples is maintained in field and laboratory records. The CoC procedures described in Section 2.6.7 will be followed to guarantee documented sample custody.

Table 3-2
Required Volumes, Sample Containers and Holding Times for Selected Analytical Methods for Water and Soil Samples

Parameter	Container[3]	Amounts Required[1]		Preservation[2]		Maximum Holding Times[5,6]
		Water[4] Milliliters	Soil Grams	Water	Soil	
Chloride (EPA Method 300.0)	P	500	N/A	Cool ≤ 6°C	Cool ≤ 6°C	28 days
Fluoride (EPA Method 300.0)	P	500	N/A	Cool ≤ 6°C	Cool ≤ 6°C	28 days
Nitrate (EPA Method 300.0)	P	500	N/A	Cool ≤ 6°C	Cool ≤ 6°C	48 hours
Nitrite (EPA Method 300.0)	P	500	N/A	Cool ≤ 6°C	Cool ≤ 6°C	48 hours
Phosphate, ortho (EPA Method 300.0)	P	500	N/A	Cool ≤ 6°C	Cool ≤ 6°C	48 hours
Sulfate (EPA Method 300.0)	P	100	N/A	Cool ≤ 6°C	Cool ≤ 6°C	28 days
Alkalinity (EPA Method 310.1)	P	100	N/A	Cool ≤ 6°C	Cool ≤ 6°C	14 days
Perchlorate (EPA Method 314.0)	P	250	50	Cool ≤ 6°C	Cool ≤ 6°C	28 days
Perchlorate (EPA Method 331.0/ EPA Method 332.0)	P	250	50	Cool ≤ 6°C	Cool ≤ 6°C	28 days
Sulfide (EPA Method 376.2)	P	100	10	Cool ≤ 6°C Zn-Acetate/ NaOH; pH >9	Cool ≤ 6°C	7 days
Metals (EPA Method SW6000/7000 Series)[7]	Water –P Soil – G, Tefon lined cap	250 x 2 bottles	50	Cool ≤ 6°C HNO3 to pH <2	Cool ≤ 6°C	6 months
Mercury (EPA Method SW7470A/SW7471A)7	as above	as above	10	Cool ≤ 6°C HNO3 to pH <2	Cool ≤ 6°C	28 days
Chromium VI (EPA Method 7199.0/218.6)	P	250	50	Cool ≤ 6°C NH_4 Buffer	Cool ≤ 6°C NH_4 Buffer	24 hours (water); 30 days until extraction, 4 days after extraction (soil)
Total petroleum hydrocarbons (TPH)-volatile (EPA Method 8015 (modified))						
Gasoline:	G, Teflon- lined septum	3 x 40	50	Cool ≤ 6°C HCL	Cool ≤ 6°C Encore	14 days (water and soil); 7 days if unpreserved by acid
Diesel:	G, Teflon lined cap	1000	50	Cool ≤ 6°C	Cool ≤ 6°C	14 days until extraction, 40 days after extraction

Parameter	Container[3]	Amounts Required[1]		Preservation[2]		Maximum Holding Times[5,6]
		Water[4] Milliliters	Soil Grams	Water	Soil	
Organochlorine pesticides (EPA Method SW8081A)	Water – G, Teflon lined cap Soil – G, Teflon lined cap or 1-ring	1,000	50	Cool ≤ 6°C	Cool ≤ 6°C	7 days (water) and 14 days (soil) until extraction, 40 days after extraction
PCBs as Aroclors (EPA Method SW8082)	Water – G, Teflon lined cap Soil – G, Teflon lined cap or 1-ring	1,000	50	Cool ≤ 6°C	Cool ≤ 6°C	7 days (water) and 14 days (soil) until extraction, 40 days after extraction
Organophosphorus pesticides/ Compounds (EPA Method 8141A)	Water – G, Teflon lined cap Soil – G, Teflon lined cap or 1-ring	1,000	50	Cool ≤ 6°C	Cool ≤ 6°C	7 days until extraction and 40 days after extraction (water); 14 days until extraction and 40 days after extraction (soil)
Chlorinated phenoxy acid herbicides (EPA Method SW8151A)	Water – G, Teflon lined cap Soil – G, Teflon lined cap or 1-ring	1,000	50	Cool ≤ 6°C	Cool ≤ 6°C	7 days until extraction and 40 days after extraction (water); 14 days until extraction and 40 days after extraction (soil)
Volatile organic compounds (EPA Method SW8260B)	G, Teflon lined septum, Soil – 3 Encores	40 x 3 VOAs	50	Cool ≤ 6°C HCL to pH <2	Cool ≤ 6°C	14 days (7 days if not pH adjusted) (water) 48 hours (soil)
1,2,3-Trichloropropane (EPA Method 524.1)	G, Teflon lined septum	40 x 3 VOAs	N/A	Cool ≤ 6°C HCL to pH <2	N/A	14 days (7 days if not pH adjusted) (water)
Semivolatile organic compounds (EPA Method SW8270C)	G, Teflon screw cap, Soil – G, Teflon lined cap or 1-ring	1,000	50	Cool ≤ 6°C	Cool ≤ 6°C	7 days (water) and 14 days (soil) until extraction, 40 days after extraction
Polynuclear Aromatic Hydrocarbons, 1,4-Dioxane, and N-Nitrosodimethylamine (EPA Method SW8270C SIM)	G, Teflon screw cap Soil – G, Teflon lined cap or 1-ring	1,000	50	Cool ≤ 6°C	Cool ≤ 6°C	7 days until extraction, 40 days after extraction
N-Nitrosodimethylamine (E521)	G, Teflon screw cap	3,000	N/A	Cool ≤ 6°C	N/A	10 days until extraction, 20 days after extraction
RDX (E529)	G, Teflon screw cap	1,000	N/A	Cool ≤ 6°C	N/A	7 days until extraction, 40 days after extraction

Parameter	Container[3]	Amounts Required[1]		Preservation[2]		Maximum Holding Times[5,6]
		Water[4] Milliliters	Soil Grams	Water	Soil	
Dioxins and furans (EPA Method 8290)	G, Teflon-lined cap	1,000	50	Cool ≤ 6°C, store in dark, 0.008% $Na_2S_2O_3$	Cool ≤ 6°C	30 days until extraction and 45 days after extraction (water and soil)
Polynuclear Aromatic Hydrocarbons (EPA Method SW8310)	G, Teflon-lined cap	1,000	50	Cool ≤ 6°C, store in dark, 0.008% $Na_2S_2O_3$	Cool ≤ 6°C	7 days until extraction and 40 days after extraction (water); 14 days until extraction and 40 days after extraction (soil)
Explosives (EPA Method SW8330)	G, Teflon-lined cap	1,000	50	Cool ≤ 6°C	Cool ≤ 6°C	7 days until extraction and 40 days after extraction (water); 14 days until extraction and 40 days after extraction (soil)
Methane / Ethane / Ethene (Gas) (RSK-175)	G, Teflon-lined septum	40 x 3 VOAs	N/A	Cool ≤ 6°C HCl, pH <2	N/A	14 days
Fatty Acids (AM23G)	G, Teflon-lined septum	40 x 3 VOAs	N/A	Cool ≤ 6°C	N/A	14 days
Common anions (EPA Method 9056A)	P, G	50	50	Cool ≤ 6°C	Cool ≤ 6°C	28 days for Br^-, F^-, Cl^-, and SO_4^{-2}; 48 hours for NO_3^-, NO_2^- and PO_4^{-3}

Notes: 1 – Minimums.
2 – Samples will be preserved immediately after they are collected. For composite samples, each sample may be preserved by maintaining them at 4°C until compositing and sample splitting are completed.
3 – Polyethylene (P) or glass (G). Soil samples may be collected in either glass jars or stainless steel or brass liners with both ends sealed with Teflon paper and plastic caps. All volatile soil samples are samples with Encore described in SW 5035A.
4 – Do not prewash bottle with samples.
5 – Holding times are for both water and soil unless otherwise stated. The times listed are maximum times that samples may be held before analysis.
6 – Extraction holding times are from date of sample collection; analysis times are from date of extraction.
7 – If analyzing for dissolved metals, sample shall be filtered in the field through a 0.45 micrometer (µm) filter immediately (within 15 minutes) after collection and before preservation. Analytical method for dissolved metals is EPA Method 200.8.
°C – Degrees Celsius
EPA – United States Environmental Protection Agency
G – glass
N/A – Not applicable
P – polyethylene
SIM – Selected ion monitoring.

Source: This table includes the requirements of the EPA, as published in the Code of Federal Regulations (CFR).

Table 3-3
Required Volumes, Sample Containers and Holding Times for Selected Analytical Methods for Gas Samples

	Amounts Required[1]		
Parameter[2]	**Container**	**Air (by volume)**	**Maximum Holding Times[3]**
Hydrogen (AM20GAX)	Septum Crimp Top Vial	50 cm^3 of headspace	14 days
Volatile organic compounds (EPA Method TO-15)	Summa	1 L	14 days

Notes:

1 – Minimums.
2 – Mircoseeps method (Laboratory).
3 – The times listed are maximum times that samples may be held before analysis.
EPA – United States Environmental Protection Agency
Source: This table includes the requirements of the EPA, as published in the Code of Federal Regulations (CFR).

Table 3-4
Required Amounts, Sample Containers and Holding Times for Selected Analytical Methods for Asbestos Samples

Parameter	**Container**	**Amounts Required[1]**	**Maximum Holding Times[2]**
Air Sample by Phase Contrast Microscopy (PCM) (NIOSH 7400)	Filter paper	7 fibers/mm^2 of sample filter	NA
Bulk Sample - by Polarized Light Microscopy (PLM) (EPA/600/R-93/116)	G, Teflon-lined cap	50 g	NA
Bulk Sample by PLM - Point Count Method PC100 (EPA/600/R-93/116)	G, Teflon-lined cap	50 g	NA
Bulk by Transmission Electron Microscopy (TEM) (EPA/600/R-93/116)	G, Teflon-lined cap	50 g	NA

Notes:

1 – Minimums.
2 – The times listed are maximum times that samples may be held before analysis.
EPA – United States Environmental Protection Agency
g-grams
L- liter
min - minute
NA – Not applicable.

Source: This table includes the requirements of the EPA, as published in the Code of Federal Regulations (CFR).

3.5.2 Subcontractor Laboratory Operations

The following subsections summarize laboratory sample identification data, sample packaging and shipping, sample handling, and custody pertaining to laboratory operations.

3.5.2.1 Subcontracting Laboratories

All initial sample receipt, log-in, and storage are the responsibility of the Sample Custodian. The Sample Custodian is responsible for retaining documents, and for verifying data entered into the sample custody records. The Sample Custodian is also responsible for ensuring that the sample storage is secure and maintained at the proper temperature.

The LPM provides a second review of the entire log-in procedure and is ultimately responsible for its correctness and completeness.

3.5.2.2 Sample Handling

Upon receipt of samples by the laboratory, the integrity of the shipping container will be checked and verification made that the custody seals (packing tape wrapped around cooler) are intact. The presence of ice or ice substitute (e.g., blue ice) will be noted and the temperature will be documented. All receipt information and observations will be documented on a sample receipt form and the CoC record. A copy of a typical sample receipt form is provided in Appendix C. Any discrepancies requiring corrective action will be recorded on the laboratory corrective action form. A copy of a typical corrective action form is provided in Appendix C.

For the safety of the laboratory personnel involved, coolers containing samples shall be opened in a hood in case any containers of potentially contaminated sample material have broken. Checking pH from an aliquot of the sample using pH paper is an acceptable procedure except for VOCs where an additional sample is required to check preservation. The occurrence of any anomalies in the received samples and their resolution shall be documented in laboratory records.

The ideal temperature for maintaining sample integrity is defined as 4°C ±2°C. If the temperature is below 2°C, all associated samples will be inspected to determine if any ice has formed in the containers. All temperature violations will be reported immediately by telephone with a follow-up hard copy to the Performing Contractor QA/QC Manager. The violation and corrective actions will be described on the laboratory corrective action form (Appendix C). Based on the ideal temperature definition of 4°C ±2°C, a temperature violation will occur if the temperature exceeds 6°C or is below 2°C.

All refrigerated storage areas are maintained at 4°C ±2°C. Volatile samples are stored in refrigerated areas segregated from all other samples. Information about samples with suspected high contamination levels will be noted by the sample collectors on the CoC forms. Samples identified as having potentially high amounts of volatile compounds will be shipped and stored separately from all other samples to prevent cross-contamination. The temperature will be monitored and recorded daily by the sample custodian. All monitoring information will be recorded in a log book specifically assigned to that refrigerator.

All samples will remain in the proper environment to guarantee sample integrity until analytical and validated QA/QC results have been generated. Environmental samples whose holding times have expired may have some limited usefulness. These samples will be stored for a period of time corresponding to two times the EPA recommended holding time with the exception of samples to be analyzed for metals, which will be maintained for a period of 6 months. Any discrepancy in sample handling or analysis requiring corrective action will be documented on the laboratory corrective action form (Appendix C).

3.5.2.3 Sample Identification and Tracking

All sample information shall then be entered into a tracking system, and unique analytical sample identifiers shall be assigned. A copy of this information shall be reviewed by the laboratory for accuracy. Sample holding time tracking begins with the collection of samples and continues until the analysis is complete. Holding times for methods required routinely are summarized in Tables 3-2, 3-3, and 3-4. Subcontracted analyses shall be documented with the CoC form. Procedures ensuring internal laboratory CoC shall also be implemented and documented by the laboratory. Instructions concerning the analysis specified for each sample shall be communicated to the analysts. Analytical batches shall be created, and laboratory QC samples shall be introduced into each batch.

3.5.2.4 Laboratory Information Management System

The Laboratory Information Management System (LIMS) is a set of proprietary computer software programs that compile, sort, and output data results generated by the analytical testing conducted at the laboratory. Most LIMS are relational database systems that interface directly with laboratory analytical instrumentation and user terminals that are password protected. Data flow into the LIMS is safeguarded by the LIMS manager who restricts access by granting authorization levels and password information to personnel on an individual basis. All data entry and data edits are tracked by passwords. The LIMS software documentation is a matter of proprietary code auditing performed by the software manufacturers.

Relevant information specific to samples received will be recorded in the LIMS. Information to be

recorded in the LIMS includes:

- Date samples were received;
- Source of the samples;
- Specific sample identification;
- All analytical tests requested for each sample; and
- Number of samples associated with each analytical or preparatory batch

Each sample received by the laboratory will be given a discrete identification number linking the sample to the field identification given by the Performing Contractor. The laboratory sample identification number will be sequentially assigned by the LIMS. This unique numbering system will enable the laboratory to accurately track the dates and times of analysis, the QA/QC, and the final disposition of each sample.

3.5.2.5 Sample Custody Records

All samples are tracked internally through the LIMS, which can be accessed from each analytical workstation. Therefore, an analyst or LPM can obtain the complete sample test request invoice for a given set of samples at any time.

Samples are also manually tracked using a copy of the Performing Contractor CoC record. A copy of the completed original CoC will be forwarded to the Performing Contractor with the final report.

3.6 ANALYTICAL METHODS AND PROCEDURES

Target analytes for sample analysis at Sites 1 & 2 are presented in Table 3-5. The list of target analytes has been established based on previous data collected from Sites 1 & 2 and/or anticipated field activities to be performed. The analytical detection limits should be established at sufficiently low levels to support human health and ecological risk assessment. A variety of risk-based criteria and guidelines are available to establish a basis for setting analytical detection limits which are low enough to support human health and ecological risk assessment. Depending on the environmental medium and receptor groups selected for evaluation, detection limits should be comparable to or lower than the most protective (i.e., lowest) human health or environmental criteria or guideline specified for each chemical.

The following lists the currently available criteria and guidelines for four environmental media. The reference list provides webpages where the majority of these criteria can be obtained.

Soil:

- CHSSLs for residential land use (OEHHA, 2005);
- Regional Screening Levels for residential land use (RSLs; USEPA, 2009);

- USEPA Ecological Soil Screening Levels (Eco-SSLs) for plants, soil invertebrates, birds, and mammals (USEPA, 2003-2008);
- U.S. Department of Energy toxicological benchmarks for plants and soil invertebrates (Efroymson et al., 1997a, b); and
- Lower of the consensus-based threshold effect concentration (TEC) and the threshold effect level (TEL) for freshwater sediments (Buchman, 2008; MacDonald et al., 2000);

Soil gas:

- CHHSLs for residential land use (OEHHA, 2005).

Water:

- Tap water RSLs (USEPA, 2008);
- California Department of Public Health Maximum Contaminant Levels (MCLs), Public Health Goals (PHGs; CDPH, 2009a) and Notification Limits (NLs; CDPH, 2009b);
- California Toxics Rule (CTR) criteria for the protection of inland surface waters freshwater aquatic life (USEPA, 2000; Cal EPA, 2008);
- National Recommended Ambient Water Quality Critieria for Freshwater Aquatic Life Protection (U.S. EPA 2006); and
- U.S. Department of Energy water solution-based toxicological benchmarks for plants (Efroymson et al., 1997a)

Air:

- Cal EPA Reference Exposure Levels (RELs) (Cal EPA, 2009); and
- Human health ambient air RSLs (USEPA, 2008)

Table 3-5 summarizes the lowest screening level from the guidance listed above for each media. A comprehensive list of the screening levels showing the human health and ecological screening levels obtained from the sources listed above for soil, sediment, water is provided in Appendix B. The lowest screening level was used as a basis for developing the analytical detection limits for Sites 1 & 2. Analytes for which screening levels are not attainable using currently available analytical methods are indicated in Table 3-5. In instances where the screening level is unattainable using the analytical methods described herein, the following action shall be implemented.

- For regulated parameters:
  - If the parameter MDL is at or below the regulatory screening level, then the regulatory screening level (for example, the MCL) shall be used as a the screening level.
  - If the parameter MDL is above the regulatory screening level, the screening level shall default to the MDL per the analytical method.
- For non-regulated parameters:
  - The screening level shall default to the MDL per the analytical method.

QAPP addenda will be prepared if additional project-specific scopes of work require analytical methods that are not listed in the SAP. The QAPP addenda will list additional analyses required for specific

projects in order to meet project DQOs. If lower detection limits than those listed in the above tables are required for a specific task, a QAPP addendum will be prepared to address the specific analytical requirements and method. For each analysis, the following information will be included in Tables 3-6, 3-7, 3-8; and/or 3-9: parameter name, reference and method number, the matrix, analyte of interest, matrix-specific %R and RPD, and matrix-specific practical quantitation limit (PQL). Generally, the PQL is the laboratory reporting limit (RL) for non-diluted samples and is equal to the lowest point in the calibration curve. There may be instances where high analyte concentrations, heterogeneity of samples, or matrix interferences preclude achieving the detection limits specified or associated QC criteria. In such instances, the reason for deviations from the detection limits or associated QC criteria will be reported in the laboratory QA report.

Standard analytical methods to be used for the sample analyses are referenced in the following documents:

- Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition Updates III (EPA 1996);
- Methods for Chemical Analysis of Water and Wastes (EPA, 1983a);
- EPA 901/3-88-001, Index to EPA Test Methods, May 2000 (EPA 2001b);
- Asbestos Hazard Emergency Response Act (AHERA) 40 CFR Part 763;
- Analytical Method AM20GAx Standard Operating Procedure for the Analysis of Biodegradation Indicator Gases (Microseeps, Incorporated);
- Standard Operating Procedure for the Analyses of Low level Volatile Fatty Acids by Ion Chromatography (Microseeps, Incorporated);
- Method 521 Determination Of Nitrosamines In Drinking Water By Solid Phase Extraction And Capillary Column Gas Chromatography With Large Volume Injection And Chemical Ionization Tandem Mass Spectrometry (MS/MS) , Version 1 September 2004 (EPA, 2004); and
- Method 529 Determination Of Explosives And Related Compounds In Drinking Water By Solid Phase Extraction And Capillary Column Gas Chromatography/Mass Spectrometry (GC/MS), Revision 1.0, September 2002 (EPA, 2002).

Table 3-5 Target Analytes and Human Health and Ecological Screening Levels for Soil, Sediment, Water and Soil Gas

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
Metals						
Aluminum	50	50	300	300	-	
Antimony	0.27	5.0	6.0	6.0	-	
Arsenic	0.070	5.9	0.0040*	0.0040*	-	Screening level not attainable for water and surface water. The MCL (10 µg/L) can be attained for this parameter using the analytical method described in this QAPP.
Barium	330	500	1,000	1,000	-	
Beryllium	10	10	1.0	1.0	-	
Cadmium	0.36	0.596	0.040	0.04	-	
Calcium	-	-	-	-	-	
Chromium (total)	26	37.3	50	50	-	
Chromium III	26	88	50	50	-	
Chromium VI	1.0	1.0	-	11	-	
Cobalt	13	13	11	11	-	
Copper	28	31.6	60	9.0	-	
Iron	55,000	-	10,000	10,000	-	
Lead	11	35	2.0	2.0	-	
Magnesium	-	-	-	-	-	
Manganese	500	-	880	880	-	
Mercury	0.10	0.174	0.57	0.05	-	
Molybdenum	2.0	2.0	180	180	-	
Nickel	30	18	12	12	-	
Potassium	-	-	-	-	-	
Selenium	0.52	0.52	50	5.0	-	
Silver	2.0	2.0	100	3.2	-	
Sodium	-	-	-	-	-	
Thallium	1.0	1.0	0.10	0.10	-	
Vanadium	2.0	2	50	50	-	
Zinc	50	50	400	120	-	
Perchlorate						
Perchlorate	1.0	4.0	6.0	6.0	-	
General Minerals						
Bromide	-	-	-	-	-	

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
Chloride	-	-	-	-	-	
Fluoride	-	-	1,000	1,000	-	
Nitrate	130,000	-	45,000	45,000	-	
Nitrite	7,800	-	1,000	1,000	-	
Phosphate	-	-	-	-	-	
Sulfate	-	-	-	-	-	
Total Petroleum Hydrocarbons						
TPH as Gasoline and Light Hydrocarbons (C4 to C12)	-	-	-	-	-	
TPH as Diesel (C13 to C22)	-	-	-	-	-	
TPH as Heavy Hydrocarbons (C23 to C40)	-	-	-	-	-	
Total TPH as Diesel and Heavy Hydrocarbon (C13 to C40)	-	-	-	-	-	
VOCs						
1,1,1,2-Tetrachloroethane	2.0	-	0.52	0.52	-	
1,1,1-Trichloroethane	9,000	-	200	200	991,000	
1,1,2,2-Tetrachloroethane	0.59	-	0.067	0.067	-	
1,1,2-Trichloro-1,2,2-Trifluor oethane	43,000	-	1,200	1,200	-	
1,1,2-Trichloroethane	1.1	-	0.24*	0.24*	-	Screening level not attainable for water and surface water. The MCL (5 µg/L) can be attained for this parameter using the analytical method described in this QAPP.
1,1-Dichloroethane	3.4	-	2.4	2.4	-	
1,1-Dichloroethene	250	-	6.0	0.057	-	
1,1-Dichloropropene	-	-	-	-	-	
1,2,3-Trichlorobenzene	20	-	-	-	-	
1,2,3-Trichloropropane	0.091	-	0.0050	0.005	-	
1,2,4-Trichlorobenzene	20	-	5.0	5.0	-	
1,2,4-Trimethylbenzene	67	-	15	15	-	

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
1,2-Dibromo-3-chloropropane	0.0056*	-	0.00032*	0.00032*	-	Screening level not attainable for soil, water and surface water. Parameter is regulated. Default to method detection limit described in this QAPP.
1,2-Dibromoethane	0.034	-	0.0065*	0.0065*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
1,2-Dichlorobenzene	2,000	-	370	370	-	
1,2-Dichloroethane	0.45	-	0.15	0.15	50	
1,2-Dichloropropane	0.93	-	0.39*	0.39*	-	Screening level not attainable for water and surface water. The MCL (5 µg/L) can be attained for this parameter using the analytical method described in this QAPP.
1,3,5-Trimethylbenzene	47	-	12	12	-	
1,3-Dichlorobenzene	-	-	-	-	-	
1,3-Dichloropropane	1,600	-	730	730	-	
1,3-Dichloropropene	1.7	-	0.20*	0.20*	-	Screening level not attainable. Parameter currently not regulated. Default to method detection limit described in this QAPP.
1,4-Dichlorobenzene	2.6	-	0.43*	0.43*	-	Screening level not attainable for water and surface water. The MCL (5 µg/L) can be attained for this parameter using the analytical method described in this QAPP.
1,4-Dioxane	18	-	3.0	3.0	-	
2,2-Dichloropropane	-	-	-	-	-	
2-Butanone (Methyl ethyl ketone)	28,000	-	7,100	7,100	-	
2-Chlorotoluene	1,600	-	140	140	-	
2-Hexanone	-	-	-	-	-	
2,4,6-Trinitrotoluene (TNT)	19	-	1.0	1.0	-	
4-Chlorotoluene	5,500	-	140	140	-	
4-Methyl-2-Pentanone (MIBK)	5,300	-	2,000	2,000	-	
Acetone	61,000	-	22,000	22,000	-	
Benzene	1.1	-	0.15*	0.15*	36	Screening level not attainable for water and surface water. The MCL (1 µg/L) can be attained for this parameter using the analytical method described in this QAPP.

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
Bromobenzene	94	-	20	20	-	
Bromochloromethane	-	-	-	-	-	
Bromodichloromethane	0.28	-	0.12*	0.12*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Bromoform	61	-	8.5	4.3	-	
Bromomethane	7.9	-	8.7	8.7	-	
Carbon Disulfide	670	-	160	160	-	
Carbon Tetrachloride	0.25	-	0.10*	0.10*	25	Screening level not attainable for water and surface water. The MCL (0.5 µg/L) can be attained for this parameter using the analytical method described in this QAPP.
Chlorobenzene	40	-	91	91	-	
Chloroethane	-	-	-	-	-	
Chloroform	0.30	-	0.19*	0.19*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Chloromethane	120	-	190	190	-	
cis-1,2-Dichloroethene	780	-	6.0	6.00	15,900	
cis-1,3-Dichloropropene	1.7	-	0.43*	0.43*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Dibromochloromethane	0.70	-	0.15*	0.15*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Dibromomethane	780	-	370	370	-	
Dichlorodifluoromethane	190	-	390	390	-	
Ethylbenzene	5.7	-	1.5	1.5	-	
Hexachlorobutadiene	6.2	-	0.86*	0.86*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Isopropylbenzene	-	-	770	770	-	
m,p-Xylene	4,500	-	1,400	1,400	-	
Methylene Chloride	11	-	4.0	4.0	-	

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
Methyl-t-Butyl Ether (MTBE)	39	-	12	12	4,000	
n-Butylbenzene	-	-	260	260	-	
n-Propylbenzene	-	-	260	260	-	
m-Xylene	4,500	-	1,400	1,400	319,000	
o-Xylene	5,300	-	1,000	1,000	315,000	
p-Xylene	4,700	-	11,000	11,000	317,000	
Xylenes (total)	600	-	1,750	1,750	-	
p-Isopropyltoluene	-	-	-	-	-	
sec-Butylbenzene	-	-	260	260	-	
Styrene	300	300	100	100	-	
tert-Butylbenzene	-	-	260	260	-	
Tetrachloroethene	0.57	-	0.060*	0.060*	180	Screening level not attainable for water and surface water. The MCL (5 µg/L) can be attained for this parameter using the analytical method described in this QAPP.
Toluene	200	200	150	150	135,000	
trans-1,2-Dichloroethene	110	-	10	10	31,900	
trans-1,3-Dichloropropene	1.7	-	0.20*	0.20*	-	Screening level not attainable for water and surface water. The MCL (0.5 µg/L) can be attained for this parameter using the analytical method described in this QAPP.
Trichloroethene	2.8	-	0.80	0.80	528	
Trichlorofluoromethane	800	-	150	150	-	
Vinyl Chloride	0.060	-	0.016*	0.016*	13	Screening level not attainable for water and surface water. The MCL (0.5 µg/L) can be attained for this parameter using the analytical method described in this QAPP.
SVOCs						
Aniline	85	-	12	12	-	
Azobenzene	4.9	-	0.12*	0.12*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Butyl benzyl phthalate	260	-	35	35	-	
4-Bromophenyl phenyl ether	-	-	-	-	-	
Benzoic acid	240,000	-	150,000	150,000	-	

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
Benzidine	0.00050*	-	0.000094*	0.000086*	-	Screening level not attainable for soil, water, and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Benzyl alcohol	31,000	-	18,000	18,000	-	
4-Chloro-3-methylphenol	-	-	-	-	-	
bis(2-Chloroethoxy) methane	180	-	110	110	-	
bis(2-Chloroethyl) ether	0.19*	-	0.012*	0.012*	-	Screening level not attainable for soil, water, and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
bis(2-Chloroisopropyl) ether	-	-	-	-	-	
4-Chloroaniline	2.4	-	0.34*	0.34*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
2-Chlorophenol	390	-	180	81	-	
2-Chloronaphthalene	6,300	-	2,900	1,000	-	
4-Chlorophenyl phenyl ether	-	-	-	-	-	
Dibenzofuran	-	-	-	-	-	
3,3'-Dichlorobenzidine	1.1	-	0.15*	0.021*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
1,2-Dichlorobenzene	2,000	-	370	370	-	
1,3-Dichlorobenzene	-	-	-	-	-	
1,4-Dichlorobenzene	2.6	-	0.43*	0.43*	-	Screening level not attainable for water and surface water. The MCL (75 µg/L) can be attained for this parameter using the analytical method described in this QAPP.
2,4-Dichlorophenol	180	-	110	77	-	
Diethyl phthalate	100	100	20,000	17,000	-	
7,12-Dimethylbenz[a]anthracene	0.0018*	-	0.00027*	0.00027*	-	Screening level not attainable for soil, water, and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
2,4-Dimethylphenol	1,200	-	730	380	-	
Dimethyl phthalate	200	-	-	-	-	
4,6-Dinitro-2-methylphenol	-	-	-	-	-	

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
Di-n-butylphthalate	200	200	3,700	2,000	-	
Di-n-octylphthalate	-	-	-	-	-	
2,4-Dinitrophenol	20	20	73	69	-	
2,4-Dinitrotoluene	1.6	-	0.22*	0.11*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
2,6-Dinitrotoluene	61	-	37	37	-	
bis(2-Ethylhexyl) phthalate	35	-	4.8*	1.2*	-	Screening level not attainable for water and surface water. The MCL (6 µg/L) can be attained for this parameter using the analytical method described in this QAPP.
Hexachlorobutadiene	6.2	-	0.86*	0.44*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Hexachlorocyclopentadiene	10	10	50	40	-	
Hexachlorobenzene	0.3	-	0.042*	0.00028*	-	Screening level not attainable for water and surface water. The MCL (1 µg/L) cannot be attained for this parameter using the analytical method described in this QAPP. Default to method detection limit described in this QAPP.
Hexachloroethane	35	-	4.8*	1.4*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Isophorone	510	-	71	8.4	-	
1-Methylnaphthalene	22	-	2.3*	2.3*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
2-Methylnaphthalene	29	-	150	150	-	
2-Methylphenol (o-Cresol)	3,100	-	1,800	1,800	-	
4-Methylphenol (p-Cresol)	310	-	180	180	-	
N-Nitrosodimethylamine	0.0023*	-	0.00042*	0.00042*	-	Screening level not attainable for soil, water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
N-Nitrosodiphenylamine	20	-	14	3.3	-	
N-Nitrosodi-n-propylamine	0.069*	-	0.0096	0.0050	-	Screening level not attainable for soil, water, and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
2-Nitroaniline	180	-	110	110	-	
3-Nitroaniline	-	-	-	-	-	
4-Nitroaniline	24	-	3.4*	3.4*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Nitrobenzene	4.4	-	0.12*	0.12*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
2-Nitrophenol	-	-	-	-	-	
4-Nitrophenol	7.0	-	-	-	-	
Pentachlorophenol	2.1	3.0	0.56	0.27	-	
Phenol	30	70	10,000	10,000	-	
Pyridine	78	-	37	37	-	
1,2,4-Trichlorobenzene	20	-	8.2	8.2	-	
2,4,5-Trichlorophenol	4.0	4.0	3,700	3,700	-	
2,4,6-Trichlorophenol	10	-	6.1	1.4*	-	Screening level not attainable for surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
PAHs						
Acenaphthene	20	0.00671*	100	100	-	Screening level not attainable for sediments. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Acenaphthylene	-	-	-	-	-	
Anthracene	29	0.0469	11,000	8,300	-	
Benzo(a)pyrene	0.015	0.0319	0.0029*	0.0029*	-	Screening level not attainable for water and surface water. The MCL (0.2 µg/L) not be attained for this parameter using the analytical method described in this QAPP.

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
Benzo(a)anthracene	0.15	0.0317	0.029*	0.0038*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Benzo(b)fluoranthene	0.15	-	0.029*	0.0038*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Benzo(k)fluoranthene	1.1	-	0.29	0.0038*	-	Screening level not attainable for surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Benzo(g,h,i)perylene	1.1	-	-	-	-	
Chrysene	1.1	0.0571	2.9	0.0038*	-	Screening level not attainable for surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Dibenz(a,h)anthracene	0.015	0.00622*	0.0029*	0.0029*	-	Screening level not attainable for sediment, water, and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Fluorene	29	-	1,500	1,100	-	
Fluoranthene	29	0.0212	1,500	130	-	
Indeno(1,2,3-cd)pyrene	0.15	-	0.029	0.0038	-	
Naphthalene	3.9	0.0346	0.14	0.14	32	
Phenanthrene	29	0.0419	-	-	-	
Pyrene	29	0.053	1,100*	830*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Explosives						
2-Amino-4,6-Dinitrotoluene	150	-	73	73	-	
4-Amino-2,6-Dinitrotoluene	150	-	73	73	-	
1,3-Dinitrobenzene	6.1	-	3.7	3.7	-	
2,4-Dinitrotoluene	1.6	-	0.22	0.22	-	
2,6-Dinitrotoluene	61	-	37	37	-	
HMX	3,800	-	1,800	1,800	-	
2-Nitrotoluene	2.9	-	0.31	0.31	-	

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
2/4-Nitrotoluene	-	-	-	-	-	
3-Nitrotoluene	1,200	-	730	730	-	
4-Nitrotoluene	30	-	4.2	4.2	-	
Nitrobenzene	4.4	-	0.12	0.12	-	
RDX	5.5	-	0.61	0.61	-	
Tetryl	240	-	150	150	-	
1,3,5-Trinitrobenzene	2,200	-	1,100	1,100	-	
2,4,6-Trinitrotoluene	19	-	2.2	2.2	-	
Pesticides						
Aldrin	0.029	-	0.0040*	0.000049*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Azinphos Methyl	-	-	-	-	-	
alpha-BHC (α-hexachlorocyclohexane)	0.077	-	0.011*	0.0026*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
beta-BHC (β-hexachlorocyclohexane)	0.27	-	0.037*	0.0091*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
delta-BHC (δ-hexachlorocyclohexane)	-	-	-	-	-	
gamma-BHC (γ - hexachlorocyclohexane, (Lindane))	0.52	0.00094	0.061	0.019*	-	Screening level not attainable for surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Bolstar	-	-	-	-	-	
Chlordane (total)	0.43	0.00324	0.19	0.00057*	-	Screening level not attainable for surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Chlorpyrifos	180	-	110	110	-	
Coumaphos	-	-	-	-	-	

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
4,4'-DDD	0.021	0.00354	0.28	0.00031*	-	Screening level not attainable for surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
4,4'-DDE	0.021	0.00142	0.20	0.00022*	-	Screening level not attainable for surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
4,4'-DDT	0.021	0.00119	0.20	0.00022*	-	Screening level not attainable for surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Demeton-o	2.4	-	1.5	1.5	-	
Demeton-s	-	-	-	-	-	
Diazinon	43	-	26	26	-	
Dichlorvos	1.7	-	0.23	0.23	-	
Dieldrin	0.0049*	0.0019*	0.0042*	0.000052*	-	Screening level not attainable for soil, sediment, water, and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Disulfoton	2.4	-	1.5	1.5	-	
Endosulfan I	370	-	220	0.056	-	
Endosulfan II	-	-	-	-	-	
Endosulfan sulfate	-	-	-	-	-	
Endrin	18	0.00222	2.0	0.036*	-	Screening level not attainable for surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Endrin aldehyde	-	-	-	-	-	
Endrin Ketone	-	-	-	-	-	
Ethoprop	-	-	-	-	-	
Fensulfothion	-	-	-	-	-	
Fenthion	-	-	-	-	-	
Heptachlor	0.11	0.00060	0.010	0.000079*	-	Screening level not attainable for surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
Heptachlor epoxide	0.053	-	0.0074*	0.000039*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Merphos	1.8	-	1.1	1.1	-	
Methyl Parathion	15	-	9.1	9.1	-	
Methoxychlor	310	-	40	40	-	
Mevinphos	-	-	-	-	-	
Naled	120	-	73	73	-	
Phorate	12	-	7.3	7.3	-	
Phosdrin	-	-	-	-	-	
Ronnel	3,100	-	1,800	1,800	-	
Stirophos	20	-	2.8	2.8	-	
Trichloronate	-	-	-	-	-	
Tokuthion	-	-	-	-	-	
Toxaphene	0.44	0.00010	0.061*	0.00020*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Chlorinated Herbicides						
Acifluorfen	-	-	-	-	-	
Bentazon	1,800	-	1,100	1,100	-	
Chloramben	920	-	550	550	-	
2,4-D (2,4-Dichlorophenoxyacetic acid)	690	-	70	70	-	
Dalapon	1,800	-	200	200	-	
2,4-DB (4-(2,4-dichlorophenoxy) butanoic acid)	490	-	290	290	-	
Dicamba	1,800	-	1,100	1,100	-	
3,5-Dichlorobenzoic Acid	-	-	-	-	-	
Dichloroprop	-	-	-	-	-	
Dinoseb	61	-	7	7.0	-	
MCPA	31*	-	18	18	-	Screening level not attainable for soil. Parameter currently not regulated. Default to method detection limit described in this QAPP.

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
MCPP	61*	-	37	37	-	Screening level not attainable for soil. Parameter currently not regulated. Default to method detection limit described in this QAPP.
4-Nitrophenol	-	-	-	-	-	
Pentachlorophenol	3.0	-	0.56*	0.27*	-	Screening level not attainable for water and surface water. Parameter currently not regulated. Default to method detection limit described in this QAPP.
Picloram	4,300	-	500	500	-	
2,4,5-T (2,4,5-Trichlorophenoxyacetic acid)	610	-	370	370	-	
2,4,5-TP(2-(2,4,5-trichlorophenoxy)propionic acid, Silvex)	490	-	50	50	-	
Gases (Volatile Organics) in water						
Methane	-	-	-	-	-	
Ethane	-	-	-	-	-	
Ethene	-	-	-	-	-	
Hydrogen	-	-	-	-	-	
					-	
Fatty Acids					-	
Acetic Acid	-	-	-	-	-	
Propionic Acid	-	-	-	-	-	
Butyric Acid	-	-	-	-	-	
Lactic Acid and HIBA	-	-	-	-	-	
Pyruvic Acid	-	-	-	-	-	
i-Pentanoic Acid	-	-	-	-	-	
Pentanoic Acid	-	-	-	-	-	
i-Hexanoic Acid	-	-	-	-	-	
Hexanoic Acid	-	-	-	-	-	
PCBs						
PCBs	0.089	0.0341	-	-	-	
Aroclor 1016	3.9	-	0.96	0.96	-	

	SOIL	SEDIMENT	WATER	SURFACE WATER	SOIL GAS	COMMENT*
	Lowest Value	Lowest Value	Lowest Value	Lowest Value	Lowest Value	
Parameter	mg/kg	mg/kg	µg/L	µg/L	µg/m^3	
Aroclor 1221	0.17	-	0.0068	0.0068	-	
Aroclor 1232	0.17	-	0.0068	0.0068	-	
Aroclor 1242	0.22	-	0.034	0.034	-	
Aroclor 1248	0.22	-	0.034	0.034	-	
Aroclor 1254	0.22	0.060	0.034	0.034	-	
Aroclor 1260	0.22	-	0.034	0.034	-	
Dioxins						
2,3,7,8-TCDD	0.0000045	0.00000085	0.00000052	0.0000000050	-	

3.6.1 Method Detection Limits

Method detection limits (MDLs) (Tables 3-6. 3-7, 3-8, and 3-9) are required for all methods of quantitative analysis to evaluate each method's performance. MDLs for any analytical procedures depend on the matrix of the sample being tested. The laboratory performs MDL studies for each instrument, method, analyte, and matrix on an annual basis. The MDLs must be less than or equal to half the PQL for each individual analyte.

MDLs may need to be updated more often than annually if, for example, new instrumentation is used, new extraction technique or solvents are used, different sample volumes are received, new matrices are analyzed, or new detectors are used.

Each MDL study is performed as specified in 40 CFR Part 136, Appendix B. Results for soil analysis are to be reported on a dry weight basis after percent moisture is determined. Because multiple instruments are often used to report data for the same method, laboratory MDLs may be derived from multiple instrument sets.

The MDL levels for GC/MS methods are normally established using full ion mass scans for each target analyte. If full ion mass scans do not give the sensitivity required for an appropriate MDL level (i.e. conformational sampling), the MDL level may be reacquired using the single ion mass scans for the particular analyte in question. In this situation, the GC/MS instrument QC that applies to the full ion mass scan mode must also apply to the single ion mass scan mode.

3.6.2 Practical Quantitation Limits

All analytes have an established PQL (Tables 3-6. 3-7, 3-8, and 3-9), which is validated by having the level of the PQL included as one level in the multilevel calibration curve. Any concentrations reported at or above the PQL are considered quantified data of known precision and accuracy, in contrast to concentrations reported below the PQL, which are considered estimated values. For those results falling between the MDL and the PQL, an "J" flag shall be applied to the results by the laboratory, indicating the variability associated with the result. No results shall be reported below the MDL.

Table 3-6
Summary of Analytes and QAPP Objectives for Aqueous Samples

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
TTLC Metals by Method 6010B/7470A						
Container: *Plastic*			***Amount Required:*** *500 ml*			
Preservation: *HNO_3 to pH<2, Cool, ≤ 6°C*			***Holding Time:*** *6 months, 28 days for Hg*			
Aluminum	0.015	0.06	mg/L	80	120	15
Antimony	0.05	0.10	mg/L	80	120	15
Arsenic	0.05	0.10	mg/L	80	120	15
Barium	0.03	0.05	mg/L	80	120	15
Beryllium	0.01	0.05	mg/L	80	120	15
Cadmium	0.01	0.05	mg/L	80	120	15
Chromium	0.01	0.05	mg/L	80	120	15
Cobalt	0.01	0.05	mg/L	80	120	15
Copper	0.01	0.05	mg/L	80	120	15
Lead	0.05	0.10	mg/L	80	120	15
Mercury by 7470A	0.001	0.002	mg/L	80	120	15
Molybdenum	0.01	0.05	mg/L	80	120	15
Nickel	0.01	0.05	mg/L	80	120	15
Selenium	0.05	0.10	mg/L	80	120	15
Silver	0.01	0.05	mg/L	80	120	15
Thallium	0.05	0.10	mg/L	80	120	15
Vanadium	0.03	0.05	mg/L	80	120	15
Zinc	0.01	0.05	mg/L	80	120	15
Metals by Method 6020B/7470A						
Container: *Plastic*			***Amount Required:*** *500 ml*			
Preservation: *HNO_3 to pH <2 , Cool, ≤ 6°C*			***Holding Time:*** *6 months, 28 days for Hg*			
Antimony	0.004	0.02	µg/L	80	120	15
Arsenic	0.051	0.26	mg/L	80	120	15
Barium	0.015	0.08	mg/L	80	120	15
Beryllium	0.029	0.15	mg/L	80	120	15
Cadmium	0.013	0.07	mg/L	80	120	15
Chromium	0.067	0.34	mg/L	80	120	15
Cobalt	0.005	0.03	mg/L	80	120	15
Copper	0.017	0.08	mg/L	80	120	15
Lead	0.005	0.03	mg/L	80	120	15
Mercury by 7470A	0.001	0.002	mg/L	80	120	15
Molybdenum	0.008	0.04	mg/L	80	120	15
Nickel	0.016	0.08	mg/L	80	120	15
Selenium	0.120	0.60	mg/L	80	120	15

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Silver	0.057	0.28	mg/L	80	120	15
Thallium	0.004	0.02	mg/L	80	120	15
Vanadium	0.022	0.10	mg/L	80	120	15
Zinc	0.175	0.87	mg/L	80	120	15
Method EPA 7199A						
***Container**: Plastic*			***Amount Required**: 250 ml*			
***Preservation**: Cool, ≤ 6°C*			***Holding Time**: 24 Hours*			
Chromium, Hexavalent	2.0	2.0	µg/L	80	120	20
Total Petroleum Hydrocarbons by Modified EPA 8015B						
***Container:** Amber Glass, Teflon Lined Cap*			***Amount Required:** 1,000 ml*			
***Preservation:** Cool, ≤ 6°C*			***Holding Time:** Extraction: 7 days Analysis: 40 days*			
TPH as Diesel (C_{13} to C_{22})	0.1	0.5	mg/L	75	125	20
TPH as Heavy Hydrocarbons (C_{23} to C_{40})	0.1	0.5	mg/L	70	130	30
Total TPH as Diesel and Heavy Hydrocarbon (C_{13} to C_{40})	0.1	0.5	mg/L	70	130	30
8015B surrogates						
Chlorobenzene				75	125	
Total Petroleum Hydrocarbons by Modified EPA 8015B						
***Container:** 40 ml Glass vial, Teflon Lined Septum*			***Amount Required:** 40 ml X 3*			
***Preservation:** HCL to pH <2, Cool, ≤ 6°C, No Head space*			***Holding Time:** 14 days*			
TPH as Gasoline and Light Hydrocarbons (C_4 to C_{12})	0.005	0.010	mg/L	68	125	20
8015B surrogates						
4-Bromofluorobenzene				75	125	
Organochlorine Pesticide Compounds by EPA 8081A						
***Container:** Amber Glass ,Teflon Lined Cap*			***Amount Required:** 1,000 ml*			
***Preservation:** Cool, ≤ 6°C*			***Holding Time:** Extraction: 7 days Analysis: 40 days*			
4,4'-DDD (DDD)	0.10	0.20	µg/L	70	130	130
4,4'-DDE (DDE)	0.10	0.20	µg/L	70	130	30
4,4'-DDT (DDT)	0.10	0.20	µg/L	40	140	40
Aldrin	0.05	0.10	µg/L	40	140	40
Chlordane	0.05	0.10	µg/L	70	130	30
Dieldrin	0.10	0.20	µg/L	40	140	40
Endosulfan 1	0.05	0.10	µg/L	70	130	30
Endosulfan 11	0.10	0.20	µg/L	70	130	30
Endosulfan sulfate	0.10	0.20	µg/L	70	130	30

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Endrin	0.10	0.20	µg/L	40	140	40
Endrin aldehyde	0.10	0.20	µg/L	70	130	30
Endrin ketone	0.10	0.20	µg/L	70	130	30
Gamma-Chlordane	0.05	0.10	µg/L	70	130	30
Heptachlor	0.05	0.10	µg/L	40	140	40
Heptachlor epoxide	0.05	0.10	µg/L	70	130	30
Methoxychlor	0.05	1.0	µg/L	70	130	30
Toxaphene	5.0	10	µg/L	70	130	30
alpha-Chlordane	0.05	0.10	µg/L	70	130	30
alpha-Hexachlorocyclohexane (Alpha-BHC)	0.05	0.10	µg/L	70	130	30
Beta- Hexachlorocyclohexane (Betta-BHC)	0.05	0.10	µg/L	70	130	30
delta- Hexachlorocyclohexane (Delta-BHC)	0.05	0.10	µg/L	70	130	30
gamma- Hexachlorocyclohexane (Gamma-BHC, Lindane)	0.05	0.10	µg/L	40	140	40
8081A surrogates						
Tetrachloro-m-xylene			µg/L	*30*	*150*	
Decachlorobiphenyl			µg/L	*30*	*150*	
PCB Compounds by EPA 8082						
Container: *Amber Glass, Teflon Lined Cap*			***Amount Required:*** *1,000 ml*			
Preservation: *Cool, ≤ 6°C*			***Holding Time:*** *Extraction: 7 days Analysis: 40 days*			
Aroclor-1016 (PCB-1016)	1.0	2.0	µg/L	70	130	30
Aroclor-1221 (PCB-1221)	2.0	4.0	µg/L	70	130	30
Aroclor-1232 (PCB-1232)	1.0	2.0	µg/L	70	130	30
Aroclor-1248 (PCB-1248)	1.0	2.0	µg/L	70	130	30
Aroclor-1254 (PCB-1254)	1.0	2.0	µg/L	70	130	30
Aroclor-1260 (PCB-1260)	1.0	2.0	µg/L	75	125	20
Aroclor-1262 (PCB-1262)	1.0	2.0	µg/L	70	130	30
Aroclor-1268 (PCB-1268)	1.0	2.0	µg/L	70	130	30
8082 surrogates						
2,4,5,6-Tetrachloro-m-xylene			µg/L	75	125	
Decachlorobiphenyl			µg/L			
Organophosphorous Pesticides by EPA 8141A						
Container: *Amber Glass, Teflon Lined Cap*			***Amount Required:*** *1,000 ml*			
Preservation: *Cool, ≤ 6°C*			***Holding Time:*** *Extraction: 7 days Analysis: 40 days*			
Azinphos Methyl	0.5	1.0	µg/L	70	130	30
Bolstar	0.35	0.7	µg/L	70	130	30

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Chlorpyrifos	0.34	0.7	µg/L	70	130	30
Coumaphos	1.0	2.0	µg/L	70	130	30
Demeton-o	0.6	1.2	µg/L	70	130	30
Demeton-s	0.6	1.2	µg/L	70	130	30
Diazinon	1.0	2.0	µg/L	70	130	30
Dichlorovos	4.0	8.0	µg/L	70	130	30
Disulfoton	0.35	0.7	µg/L	70	130	30
Ethoprop	1.0	2.0	µg/L	70	130	30
Fensulfothion	0.4	0.8	µg/L	70	130	30
Fenthion	0.4	0.8	µg/L	70	130	30
Merphos	1.0	2.0	µg/L	70	130	30
Mevinphos	2.5	5.0	µg/L	70	130	30
Naled	2.5	5.0	µg/L	70	130	30
Parathion Methyl	0.6	1.2	µg/L	70	130	30
Phorate	0.2	0.4	µg/L	70	130	30
Ronnel	0.35	0.7	µg/L	70	130	30
Stirophos	4.0	8.0	µg/L	70	130	30
Tokuthion	0.35	0.7	µg/L	70	130	30
Trichloronate	4.0	8.0	µg/L	70	130	30
8141A surrogates						
Tributyl Phosphate			µg/L			
Triphenyl Phosphate			µg/L			
Chlorinated Herbicides by EPA 8151A						
Container: *Amber Glass, Teflon Lined Cap*			***Amount Required:*** *1,000 ml*			
Preservation: *Cool, ≤ 6°C*			***Holding Time:*** *Extraction: 7 days Analysis: 40 days*			
Acifluorfen	1.0	1.0	µg/L	70	130	30
Bentazon	0.5	0.5	µg/L	70	130	30
Chloramben	0.5	0.5	µg/L	70	130	30
2,4-D	0.5	0.5	µg/L	36	152	21
Dalapon	1.0	1.0	µg/L	70	130	30
2,4-DB	0.5	0.5	µg/L	70	130	30
Dicamba	0.5	0.5	µg/L	70	130	30
3,5-Dichlorobenzoic Acid	0.5	0.5	µg/L	70	130	30
Dichloroprop	0.5	0.5	µg/L	70	130	30
Dinoseb	0.5	0.5	µg/L	70	130	30
MCPA	100	100	µg/L	70	130	30
MCPP	100	100	µg/L	70	130	30
4-Nitrophenol	0.5	0.5	µg/L	70	130	30
Pentachlorophenol (PCP)	0.5	0.5	µg/L	70	130	30

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Picloram	0.5	0.5	µg/L	70	130	30
2,4,5-T (2,4,5-Trichlorophenoxyacetic Acid)	0.5	0.5	µg/L	44	141	35
2,4,5-TP (Silvex)	0.5	0.5	µg/L	31	148	36
8151A surrogates						
2,4-dichlorophenylacetic				0	123	
Volatile Organic Compounds by EPA 8260B						
Container: *40 ml Glass vial, Teflon Lined Septum* ***Amount Required:*** *40 ml X 3* ***Preservation:*** *HCL to pH<2, Cool, ≤ 6°C, No Head space* ***Holding Time:*** *14 days*						
1,1,1,2-Tetrachloroethane	0.5	1.0	µg/L	70	130	30
1,1,1-Trichloroethane	0.5	1.0	µg/L	75	125	20
1,1,2,2-Tetrachloroethane	0.5	1.0	µg/L	70	130	30
1,1,2-Trichloro-1,2,2-Trifluoroethane	0.5	1.0	µg/L	70	130	30
1,1,2-Trichloroethane	0.5	1.0	µg/L	70	130	30
1,1-Dichloroethane	0.5	1.0	µg/L	70	130	30
1,1-Dichloroethene	0.5	1.0	µg/L	75	125	20
1,1-Dichloropropene	0.5	1.0	µg/L	70	130	30
1,2,3-Trichlorobenzene	0.5	1.0	µg/L	70	130	30
1,2,3-Trichloropropane	0.5	1.0	µg/L	70	130	30
1,2,4-Trichlorobenzene	0.5	1.0	µg/L	70	130	30
1,2,4-Trimethylbenzene	0.5	1.0	µg/L	70	130	30
1,2-Dibromo-3-Chloropropane	2.5	5.0	µg/L	70	130	30
1,2-Dibromoethane	0.5	1.0	µg/L	70	130	30
1,2-Dichlorobenzene	0.5	1.0	µg/L	70	130	30
1,2-Dichloroethane	0.5	1.0	µg/L	70	130	30
1,2-Dichloropropane	0.5	1.0	µg/L	70	130	30
1,2-Dichloropropene	0.5	1.0	µg/L	70	130	30
1,3,5-Trimethylbenzene	0.5	1.0	µg/L	70	130	30
1,3-Dichlorobenzene	0.5	1.0	µg/L	70	130	30
1,3-Dichloropropene	0.5	1.0	µg/L	70	130	30
1,4-Dichlorobenzene	0.5	1.0	µg/L	70	130	30
2,2-Dichloropropane	0.5	1.0	µg/L	70	130	30
2-Butanone (Methylethyl kethone [MEK])	5.0	5.0	µg/L	70	130	30
2-Chloroethyl Vinylether	2.5	5.0	µg/L	70	130	30
2-Chlorotoluene	0.5	1.0	µg/L	70	130	30
2-Hexanone	2.5	5.0	µg/L	70	130	30
4-Chlorotoluene	0.5	1.0	µg/L	70	130	30

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
4-Methyl-2-Pentanone	2.5	10	µg/L	70	130	30
Acetone	10	10	µg/L	70	130	30
Benzene	0.5	1.0	µg/L	75	125	20
Bromobenzene	0.5	1.0	µg/L	70	130	30
Bromochloromethane	0.5	1.0	µg/L	70	130	30
Bromodichloromethane	0.5	1.0	µg/L	70	130	30
Bromoform	2.5	5.0	µg/L	70	130	30
Bromomethane	1.5	3.0	µg/L	70	130	30
Carbon Disulfide	0.5	1.0	µg/L	70	130	30
Carbon Tetrachloride	0.5	1.0	µg/L	70	130	30
Chlorobenzene	0.5	1.0	µg/L	75	125	20
Chloroethane	1.5	3.0	µg/L	70	130	30
Chloroform	0.5	1.0	µg/L	75	125	20
Chloromethane	1.5	10	µg/L	70	130	30
cis-1,2-Dichloroethene	0.5	1.0	µg/L	70	130	30
cis-1,3-Dichloropropene	0.5	1.0	µg/L	70	130	30
Dibromochloromethane	0.5	1.0	µg/L	70	130	30
Dibromomethane	0.5	1.0	µg/L	70	130	30
Dichlorodifluoromethane	1.5	3.0	µg/L	70	130	30
Ethylbenzene	0.5	1.0	µg/L	75	125	20
Hexachlorobutadiene	1.5	3.0	µg/L	70	130	30
Isopropylbenzene	0.5	1.0	µg/L	70	130	30
Methylene Chloride	2.0	1.0	µg/L	70	130	30
MTBE	0.5	1.0	µg/L	70	130	30
n-Butylbenzene	0.5	1.0	µg/L	70	130	30
n- Propylbenzene	0.5	1.0	µg/L	70	130	30
Naphthalene	0.5	1.0	µg/L	70	130	30
p- Isopropyltoluene	0.5	1.0	µg/L	70	130	30
sec-Butylbenzene	0.5	1.0	µg/L	70	130	30
Styrene	0.5	1.0	µg/L	70	130	30
tert-Butylbenzene	0.5	1.0	µg/L	70	130	30
Tetrachloroethene	0.5	1.0	µg/L	70	130	30
Toluene	0.5	1.0	µg/L	75	125	20
trans-1,2-Dichloroethene	0.5	1.0	µg/L	70	130	30
trans-1,3-Dichloropropene	0.5	1.0	µg/L	70	130	30
Trichloroethene	0.5	1.0	µg/L	75	125	20
Trichlorofluoromethane	0.83	1.0	µg/L	70	130	30
Vinyl Acetate	0.5	5.0	µg/L	70	130	30
Vinyl Chloride	0.5	3.0	µg/L	70	130	30
o-xylene	0.5	1.0	µg/L	75	125	20

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
m,p-xylene	1.0	2.0	µg/L	75	125	20
8260B surrogates						
Toluene-d8			µg/L	75	125	
4-Bromofluorobenzene			µg/L	75	125	
Dibromofluoromethane			µg/L	75	125	
Semi-Volatile Organic Compounds by EPA 8270C						
Container: *Amber Glass, Teflon Lined Cap* ***Amount Required:*** *1,000 ml* ***Preservation:*** *Cool, ≤ 6°C* ***Holding Time:*** *Extraction: 7 days Analysis: 40 days*						
1,2,4-Trichlorobenzene	5.0	10	µg/L	39	98	20
1,2-Dichlorobenzene	5.0	10	µg/L	70	130	30
1,3-Dichlorobenzene	5.0	10	µg/L	70	130	30
1,4-Dichlorobenzene	5.0	10	µg/L	36	97	20
2,4,5-Trichlorophenol	5.0	10	µg/L	70	130	30
2,4,6-Trichlorophenol	5.0	10	µg/L	70	130	30
2,4-Dichlorophenol	5.0	10	µg/L	70	130	30
2,4-Dimethylphenol	5.0	10	µg/L	70	130	30
2,4-Dinitrophenol	5.0	10	µg/L	70	130	30
2,4-Dinitrotoluene	5.0	10	µg/L	24	96	20
2,6-Dinitrotoluene	5.0	10	µg/L	70	130	30
2-Chloronaphthalene	5.0	10	µg/L	70	130	30
2-Chlorophenol	5.0	10	µg/L	27	123	20
2-Methylnaphthalene	5.0	10	µg/L	70	130	30
2-Methylphenol	5.0	10	µg/L	70	130	30
2-Nitroaniline	5.0	10	µg/L	70	130	30
2-Nitrophenol	5.0	10	µg/L	70	130	30
3,3-Dichlorobenzidine	5.0	10	µg/L	70	130	30
3-Methylphenol	5.0	10	µg/L	70	130	30
3-Nitroaniline	5.0	10	µg/L	70	130	30
4,6-Dinitro-2-methylphenol	5.0	10	µg/L	70	130	30
4-Bromophenyl Phenyl Ether	5.0	10	µg/L	70	130	30
4-Chloro-3-methylphenol	5.0	10	µg/L	39	98	20
4-Chloroanoline	5.0	10	µg/L	70	130	30
4-Chlorophenyl Phenyl Ether	5.0	10	µg/L	70	130	30
4-Methylphenol	5.0	10	µg/L	70	130	30
4-Nitroaniline	5.0	10	µg/L	70	130	30
4-Nitrophenol	5.0	10	µg/L	10	80	20
Acenaphthene	5.0	10	µg/L	46	118	20
Acenaphthylene	5.0	10	µg/L	70	130	30
Aniline	5.0	10	µg/L	70	130	30

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Anthracene	5.0	10	µg/L	70	130	30
Azobenzene	5.0	10	µg/L	70	130	30
Benzo (a) anthracene	5.0	10	µg/L	70	130	30
Benzo (a) pyrene	5.0	10	µg/L	70	130	30
Benzo (b) fluoranthene	5.0	10	µg/L	70	130	30
Benzo (g,h,I) perylene	5.0	10	µg/L	70	130	30
Benzo (k) fluoranthene	5.0	10	µg/L	70	130	30
Benzidine	10	20	µg/L	70	130	30
Benzoic Acid	5.0	10	µg/L	70	130	30
Benzyl Alcohol	5.0	10	µg/L	70	130	30
Bis-(2-chloroethoxy)methane	5.0	10	µg/L	70	130	30
Bis-(2-chloroethyl)ether	5.0	10	µg/L	70	130	30
Bis-(2-chloroisopropyl)ether	5.0	10	µg/L	70	130	30
Bis-(2-ethylhexyl) Phthalate	5.0	10	µg/L	70	130	30
Butyl Benzyl Phthalate	5.0	10	µg/L	70	130	30
Chrysene	5.0	10	µg/L	70	130	30
7,12-Dimethylbenz[a]anthracene	5.0	10	µg/L	70	130	30
Dibenzo (a,h) anthracene	5.0	10	µg/L	70	130	30
Dibenzofuran	5.0	10	µg/L	70	130	30
Diethyl Phthalate	5.0	10	µg/L	70	130	30
Dimethyl Phthalate	5.0	10	µg/L	70	130	30
Di-n-butyl Phthalate	5.0	10	µg/L	70	130	30
Di-n-octyl Phthalate	5.0	10	µg/L	70	130	30
Fluoranthene	5.0	10	µg/L	70	130	30
Fluorene	5.0	10	µg/L	70	130	30
Hexachlorobenzene	5.0	10	µg/L	70	130	30
Hexachlorobutadiene	5.0	10	µg/L	70	130	30
Hexachlorocyclopentadiene	5.0	10	µg/L	70	130	30
Hexachloroethane	5.0	10	µg/L	70	130	30
Indeno-(1,2,3-cd) pyrene	5.0	10	µg/L	70	130	30
Isophorone	5.0	10	µg/L	70	130	30
1-Methylnaphthalene	5.0	10	µg/L	70	130	30
2-Methylnaphthalene	5.0	10	µg/L	70	130	30
Naphthalene	5.0	10	µg/L	70	130	30
Nitrobenzene	5.0	10	µg/L	70	130	30
N-Nitrosodi-n-propylamine	5.0	10	µg/L	41	111	20
N-Nitrosodiphenylamine	5.0	10	µg/L	70	130	30
Pentachlorophenol	5.0	10	µg/L	40	113	20
Phenanthrene	5.0	10	µg/L	70	130	30
Phenol	5.0	10	µg/L	12	98	20

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Pyridine	10	20	µg/L	12	98	20
Pyrene	5.0	10	µg/L	26	1127	20
8270C surrogates						
2-Fluorobiphenyl			µg/L	30	115	
2-Fluorophenol			µg/L	25	121	
Nitrobenzene-d5			µg/L	23	120	
Phenol-d5			µg/L	24	113	
p-Terphenyl-d14			µg/L	18	137	
2,4,6-Tribromophenol			µg/L	19	122	
Polynuclear Aromatic Hydrocarbons by EPA 8270SIM						
Container: *Amber Glass, Teflon Lined Cap*			***Amount Required:*** *1,000 ml*			
Preservation: *Cool, ≤ 6°C, Dark*			***Holding Time:*** *Extraction: 7 days Analysis: 40 days*			
Acenaphthene	0.10	0.20	µg/L	75	125	30
Acenaphthylene	0.10	0.20	µg/L	75	125	30
Anthracene	0.10	0.20	µg/L	75	125	30
Benzo (a) anthracene	0.10	0.20	µg/L	75	125	20
Benzo (a) pyrene	0.10	0.20	µg/L	75	125	20
Benzo (b) fluoranthene	0.10	0.20	µg/L	75	125	30
Benzo (g,h,i) perylene	0.10	0.20	µg/L	40	160	20
Benzo (k) fluoranthene	0.10	0.20	µg/L	75	125	30
Chrysene	0.10	0.20	µg/L	75	125	30
Dibenzo (a, h) anthracene	0.10	0.20	µg/L	75	125	30
7,12-Dimethylbenz[a]anthracene	0.10	0.20	µg/L	75	125	30
Fluoranthene	0.10	0.20	µg/L	75	125	30
Fluorene	0.10	0.20	µg/L	75	125	30
Indeno (1,2,3-cd) pyrene	0.10	0.20	µg/L	75	125	30
Naphthalene	0.10	0.20	µg/L	70	120	20
Phenanthrene	0.10	0.20	µg/L	75	125	30
Pyrene	0.10	0.20	µg/L	660	110	30
8270 SIM surrogates						
p-terphenyl-d14			µg/L	75	125	
Dioxins and Furans by EPA 8290A						
Container: *Plastic, Teflon Lined Cap*			***Amount Required:*** *1,000 ml*			
Preservation: *Cool, ≤ 6°C*			***Holding Time:*** *Extraction: 30 days Analysis: 45 days*			
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	0.005	0.01	ng/L	70	130	30
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	0.025	0.05	ng/L	70	130	30

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.025	0.05	ng/L	70	130	30
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.025	0.05	ng/L	70	130	30
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	0.025	0.05	ng/L	70	130	30
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	0.025	0.05	ng/L	70	130	30
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	0.05	0.10	ng/L	70	130	30
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	0.005	0.01	ng/L	70	130	30
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	0.025	0.05	ng/L	70	130	30
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	0.025	0.05	ng/L	70	130	30
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.025	0.05	ng/L	70	130	30
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	0.025	0.05	ng/L	70	130	30
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	0.025	0.05	ng/L	70	130	30
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.025	0.05	ng/L	70	130	30
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	0.025	0.05	ng/L	70	130	30
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	0.025	0.05	ng/L	70	130	30
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	0.05	0.10	ng/L	70	130	30
Polynuclear Aromatic Hydrocarbons by EPA 8310 ***Container:*** *Amber Glass, Teflon Lined Cap* ***Amount Required:*** *1,000 ml* ***Preservation:*** *Cool, ≤ 6°C, Dark* ***Holding Time:*** *Extraction: 7 days* *Analysis: 40 days*						
Acenaphthene	0.10	0.20	µg/L	75	125	30
Acenaphthylene	0.10	0.20	µg/L	75	125	30
Anthracene	0.10	0.20	µg/L	75	125	30
Benzo (a) anthracene	0.10	0.20	µg/L	75	125	20
Benzo (a) pyrene	0.10	0.20	µg/L	75	125	20
Benzo (b) fluoranthene	0.10	0.20	µg/L	75	125	30
Benzo (g,h,i) perylene	0.10	0.20	µg/L	40	160	20
Benzo (k) fluoranthene	0.10	0.20	µg/L	75	125	30
Chrysene	0.10	0.20	µg/L	75	125	30

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Dibenzo (a, h) anthracene	0.10	0.20	µg/L	75	125	30
7,12-Dimethylbenz[a]anthracene	0.10	0.20	µg/L	75	125	30
Fluoranthene	0.10	0.20	µg/L	75	125	30
Fluorene	0.10	0.20	µg/L	75	125	30
Indeno (1,2,3-cd) pyrene	0.10	0.20	µg/L	75	125	30
Naphthalene	0.10	0.20	µg/L	70	120	20
Phenanthrene	0.10	0.20	µg/L	75	125	30
Pyrene	0.10	0.20	µg/L	660	110	30
8310 surrogates						
p-terphenyl-d14			µg/L	*75*	*125*	
Explosives by EPA 8330A						
Container: *Plastic, Teflon Lined Cap*			***Amount Required:*** *1,000 ml*			
Preservation: *Cool, ≤ 6°C*			***Holding Time:*** *Extraction: 7 days Analysis: 40 days*			
1,3,5- TNB	0.5	1.0	µg/L	64	139	30
1,3- DNB	0.5	1.0	µg/L	47	158	30
2,4,6- TNT	0.5	1.0	µg/L	52	143	30
2,4-DNT	0.5	1.0	µg/L	61	135	30
2,6-DNT	0.5	1.0	µg/L	60	137	30
HMX	0.5	1.0	µg/L	51	161	30
m-Nitrotoluene	0.5	1.0	µg/L	48	132	30
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	0.5	1.0	µg/L	22	174	30
Nitrobenzene	0.5	1.0	µg/L	49	138	30
o-Nitrotoluene	0.5	1.0	µg/L	43	133	30
p-Nitrotoluene	0.5	1.0	µg/L	48	132	30
RDX	0.5	1.0	µg/L	81	120	30
8310 surrogates						
3,4- DNB			µg/L	70	130	
Gasses in Water by RSK 175						
Container: *Glass, Teflon Lined Septum*			***Amount Required:*** *40 ml X 3*			
Preservation: *Cool, ≤ 6°C*			***Holding Time:*** *14 days*			
Ethane	0.01	0.01	µg/L	75	125	30
Ethene	0.01	0.01	µg/L	75	125	30
Methane	0.015	0.015	µg/L	75	125	30
Hydrogen by AM20GAX						
Container: *Septum Crimp Top Vile*			***Amount Required:*** *50 cm^3*			
Preservation: *Cool, ≤ 6°C*			***Holding Time:*** *14 days*			

ANALYTE		MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Hydrogen		0.06	0.06	nM	75	125	30
Fatty Acids by AM23G							
Container: *Glass, Teflon Lined Septum* ***Amount Required:*** *40 ml X 3* ***Preservation:*** *Cool, ≤ 6°C* ***Holding Time:*** *14 days*							
Acetic Acid		0.07	0.07	mg/L	70	130	30
Propionic Acid		0.07	0.07	mg/L	70	130	30
Butyric Acid		0.07	0.07	mg/L	70	130	30
Lactic Acid and HIBA		0.10	0.10	mg/L	70	130	30
Pyruvic Acid		0.07	0.07	mg/L	70	130	30
i-Pentanoic Acid		0.07	0.07	mg/L	70	130	30
Pentanoic Acid		0.07	0.07	mg/L	70	130	30
i-Hexanoic Acid		0.1	0.1	mg/L	70	130	30
Hexanoic Acid		0.1	0.1	mg/L	70	130	30
Common Anions by EPA 9056A							
Container: *Plastic, Teflon Lined Cap* ***Amount Required:*** *50 ml* ***Preservation:*** *Cool, ≤ 6°C* ***Holding Time:*** *28 days for Br^-, F^-, Cl^-, and SO_4^{-2}, 24 hours for NO_3^-, NO_2^- and PO^4*							
Bromide		0.25	0.5	mg/L	85	115	20
Chloride		0.5	1.0	mg/L	85	115	20
Fluoride		0.5	1.0	mg/L	85	115	20
Nitrate		0.5	1.0	mg/L	85	115	20
Nitrite		0.5	1.0	mg/L	85	115	20
Phosphate		0.5	1.0	mg/L	85	115	20
Sulfate		0.5	1.0	mg/L	85	115	20
General Minerals							
Container: *Plastic, Teflon Lined Cap* ***Amount Required:*** *250 ml* ***Preservation:*** *Cool, ≤ 6°C* ***Holding Time:*** *28 days*							
Bicarbonate Alk. as $CaCO_3$	SM2320B	1.0	2.0	mg/L	80	120	15
Carbonate Alk. as $CaCO_3$	SM2320B	1.0	2.0	mg/L	80	120	15
Hydroxide Alk. as $CaCO_3$	SM2320B	1.0	2.0	mg/L	80	120	15
Alkalinity Total as $CaCO_3$	310.1	1.0	2.0	mg/L	80	120	15
Anions Total	Calc.	0.01	0.01	meq/L	70	130	30
Cations Total	Calc.	0.01	0.01	meq/L	70	130	30
Ion Balance	Calc.	0.01	0.01	%	80	120	15
Chloride	325.3	0.5	1.0	mg/L	80	120	15

ANALYTE		MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Specific Conductance	120.1	5.0	10	umhos/cm	80	120	15
Fluoride	340.2	0.1	0.2	mg/L	80	120	15
Hardness Total as $CaCO_3$	130.2	1.0	2.0	mg/L	80	120	15
Nitrate as Nitrogen	352.1	0.05	0.10	mg/L	80	120	15
Nitrite as Nitrogen	354.1	0.01	0.02	mg/L	80	120	15
pH	150.1	0.01	0.01	std. unit	80	120	
Sulfate	375.4	5.0	10	mg/L	80	120	15
Surfactants(MBAS)	425.1	0.03	0.05	mg/L	80	120	15
Total Dissolved Solids	160.1	5.0	10	mg/L	80	120	15
Aluminum	200.7	0.05	0.10	mg/L	80	120	15
Calcium	200.7	0.25	0.50	mg/L	80	120	15
Copper	200.7	0.01	0.02	mg/L	80	120	15
Iron	200.7	0.02	0.05	mg/L	80	120	15
Magnesium	200.7	0.25	0.50	mg/L	80	120	15
Manganese	200.7	0.005	0.010	mg/L	80	120	15
Potassium	200.7	0.5	1.0	mg/L	80	120	15
Sodium	200.7	0.25	0.50	mg/L	80	120	15
Zinc	200.7	0.015	0.030	mg/L	80	120	15
Emergent Chemicals							
Perchlorate by EPA Method 314.0							
Container: *Plastic, Teflon Lined Cap*				***Amount Required:*** *250 ml*			
Preservation: *Cool, ≤ 6°C*				***Holding Time:*** *28 days*			
Perchlorate		2.3	4.0	µg/L	70	130	30
Perchlorate by EPA Method 332.0							
Container: *Plastic, Teflon Lined Cap*				***Amount Required:*** *250 ml*			
Preservation: *Cool, ≤ 6°C*				***Holding Time:*** *28 days*			
Perchlorate		0.1	0.7	µg/L	70	130	30
NDMA by EPA Method SW8270C SIM							
Container: *Glass, Teflon Lined Cap*				***Amount Required:*** *1,000 ml*			
Preservation: *Cool, ≤ 6°C*				***Holding Time:*** *Extraction: 7 days Analysis: 40 days*			
N-Nitrosodimethylamine (NDMA)		0.01	0.04	µg/L	70	130	30
8270SIM surrogates							
N-Nitrosodimethylamine-d6				µg/L	70	130	
NDMA by EPA Method E521							
Container: *Glass, Teflon Lined Cap*				***Amount Required:*** *3,000 ml*			
Preservation: *Cool, ≤ 6°C*				***Holding Time:*** *Extraction: 10 days Analysis: 20 days*			

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
N-Nitrosodimethylamine (NDMA)	0.66	2.0	ng/L	70	130	30
E521 surrogates						
N-Nitrosodimethylamine-d6			ng/L	70	130	
RDX by EPA Method E529						
Container: *Glass, Teflon Lined Cap*			***Amount Required:*** *1,000 ml*			
Preservation: *Cool, ≤ 6°C*			***Holding Time:*** *Extraction: 7 days Analysis: 40 days*			
RDX	0.1	0.2	µg/L	70	130	30
E529 surrogates						
Nitrobenzene-d5			µg/L	70	130	
1,3,5-trimethyl-2-nitrobenzene			µg/L	70	130	
1,2,4-trimethyl-5-nitrobenzene			µg/L	70	130	
1,2,3-TCP by EPA Method E524.1						
Container: *Glass, Teflon Lined Cap*			***Amount Required:*** *40 ml X 3*			
Preservation: *HCL, pH<2, Cool, ≤ 6°C*			***Holding Time:*** *14 days*			
1,2,3-Trichloropropane (TCP)	0.0017	0.005	µg/L	70	130	30
E524.1 surrogates						
1,2,3-TCP-d5			µg/L	70	130	
1,4-Dioxane by EPA Method 8270SIM						
Container: *Glass, Teflon Lined Cap*			***Amount Required:*** *1,000 ml*			
Preservation: *Cool, ≤ 6°C*			***Holding Time:*** *Extraction: 7 days Analysis: 40 days*			
1,4–Dioxane	0.6	1.0	µg/L	70	130	30
8270SIM surrogates						
1,4–Dioxane–d8				80	120	

Notes: ml – milliliter
mg/L – milligram per liter
µg/L – microgram per liter
ng/L – nanogram per liter
nM – nano mol
meq – milliequivalent
µmhos/cm – microsiemens per centimeter
cm – centimeter

Table 3-7
Summary of Analytes and QAPP Objectives for Soil and Sediment Samples

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
TTLC Metals by Method 6010B/7471A						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap*			***Amount Required:*** *50 g*			
Preservation: *Cool, ≤ 6°C*			***Holding Time:*** *6 months, 28 days for Hg*			
Aluminum	2.6	20	mg/kg	80	120	15
Antimony	1.0	5.0	mg/kg	80	120	15

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Arsenic	1.0	5.0	mg/kg	80	120	15
Barium	2.5	5.0	mg/kg	80	120	15
Beryllium	1.3	2.5	mg/kg	80	120	15
Cadmium	1.3	2.5	mg/kg	80	120	15
Chromium	2.5	5.0	mg/kg	80	120	15
Cobalt	2.5	5.0	mg/kg	80	120	15
Copper	2.5	5.0	mg/kg	80	120	15
Lead	2.5	5.0	mg/kg	80	120	15
Mercury by 7471A	0.1	0.2	mg/kg	80	120	15
Molybdenum	2.5	5.0	mg/kg	80	120	15
Nickel	2.5	5.0	mg/kg	80	120	15
Selenium	1.0	5.0	mg/kg	80	120	15
Silver	2.5	5.0	mg/kg	80	120	15
Thallium	1.0	5.0	mg/kg	80	120	15
Vanadium	2.5	5.0	mg/kg	80	120	15
Zinc	2.5	5.0	mg/kg	80	120	15
Metals by Method 6020B						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g*						
Preservation: *Cool, ≤ 6°C, Dark* ***Holding Time****6 months, 28 days for Hg*						
Antimony	0.05	0.1	mg/kg	80	120	15
Arsenic	0.15	0.3	mg/kg	80	120	15
Barium	0.15	0.3	mg/kg	80	120	15
Beryllium	0.15	0.3	mg/kg	80	120	15
Cadmium	0.1	0.2	mg/kg	80	120	15
Chromium	0.2	0.4	mg/kg	80	120	15
Cobalt	0.4	0.8	mg/kg	80	120	15
Copper	0.3	0.6	mg/kg	80	120	15
Lead	0.1	0.2	mg/kg	80	120	15
Mercury by 7471A	0.1	0.2	mg/kg	80	120	15
Molybdenum	0.05	0.1	mg/kg	80	120	15
Nickel	0.1	0.2	mg/kg	80	120	15
Selenium	0.1	0.2	mg/kg	80	120	15
Silver	0.1	0.2	mg/kg	80	120	15
Thallium	0.01	0.02	mg/kg	80	120	15
Vanadium	0.05	0.1	mg/kg	80	120	15
Zinc	1.25	2.5	mg/kg	80	120	15
Method EPA 7199A						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g*						
Preservation: *Cool, ≤ 6°C* ***Holding Time:*** *Extraction: 1 month Analysis: 70 Hours*						

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Chromium, Hexavalent	0.20	0.20	mg/kg	65	110	20
Total Petroleum Hydrocarbons by Modified EPA 8015B ***Container:*** *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g* ***Preservation:*** *Cool, ≤ 6°C* ***Holding Time:*** *Extraction: 14 days Analysis: 40 days*						
TPH as Diesel (C_{13} to C_{22})	5.0	10	mg/kg	75	125	20
TPH as Heavy Hydrocarbons(C_{23} to C_{40})	5.0	10	mg/kg	70	130	30
Total TPH as Diesel and Heavy Hydrocarbons (C_{13} to C_{40})	5.0	10	mg/kg	70	130	30
8015B surrogates						
Chlorobenzene				75	125	
Total Petroleum Hydrocarbons by Modified EPA 8015B ***Container:*** *Clear Wide Mouth Glass, Teflon Lined Cap, Encore or pre-preserved 40ml vials X 3.* ***Amount Required:*** *50 g, or 5 g X 3* ***Preservation:*** *Cool, ≤ 6°C* ***Holding Time:*** *Extraction: 14 days Analysis: 40 days*						
TPH as Gasoline and Light Hydrocarbons (C_4 to C_{12})	0.50	1.0	mg/kg	75	125	20
8015B surrogates						
4-Bromofluorobenzene				75	125	
Organochlorine Pesticide Compounds by EPA 8081A ***Container:*** *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g* ***Preservation:*** *Cool, ≤ 6°C* ***Holding Time:*** *Extraction: 14 days Analysis: 40 days*						
Aldrin	10	50	µg/kg	40	140	40
Chlordane	40	200	µg/kg	70	130	30
alpha-Chlordane	10	50	µg/kg	70	130	30
4,4'-DDD (DDD)	10	50	µg/kg	70	130	30
4,4'-DDE (DDE)	10	50	µg/kg	70	130	30
4,4'-DDT (DDT)	10	50	µg/kg	40	140	40
Dieldrin	10	50	µg/kg	40	140	40
Endosulfan 1	10	50	µg/kg	70	130	30
Endosulfan 11	10	50	µg/kg	70	130	30
Endosulfan sulfate	10	50	µg/kg	70	130	30
Endrin	10	50	µg/kg	40	140	40
Endrin aldehyde	10	50	µg/kg	70	130	30
Endrin ketone	10	50	µg/kg	70	130	30
Gamma-Chlordane	10	50	µg/kg	70	130	30
Heptachlor	10	50	µg/kg	40	140	40
Heptachlor epoxide	10	50	µg/kg	70	130	30
alpha-Hexachlorocyclohexane	10	50	µg/kg	70	130	30

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
(Alpha-BHC)						
Beta- Hexachlorocyclohexane (Betta-BHC)	10	50	µg/kg	70	130	30
delta- Hexachlorocyclohexane (Delta-BHC)	10	50	µg/kg	70	130	30
gamma- Hexachlorocyclohexane (Gamma-BHC, Lindane)	10	50	µg/kg	40	140	40
Toxaphene	40	0.20	µg/kg	70	130	30
8081A surrogates						
Tetrachloro-m-xylene			µg/kg	30	150	
Decachlorobiphenyl			µg/kg	30	150	
PCB Compounds by EPA 8082 ***Container:*** *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g* ***Preservation:*** *Cool, ≤ 6°C* ***Holding Time:*** *Extraction: 14 days; Analysis: 40 days*						
Aroclor-1016 (PCB-1016)	35	35	µg/kg	70	130	30
Aroclor-1221 (PCB-1221)	70	70	µg/kg	70	130	30
Aroclor-1232 (PCB-1232)	35	35	µg/kg	70	130	30
Aroclor-1242 (PCB-1242)	35	35	µg/kg	70	130	30
Aroclor-1248 (PCB-1248)	35	35	µg/kg	70	130	30
Aroclor-1254 (PCB-1254)	35	35	µg/kg	70	130	30
Aroclor-1260 (PCB-1260)	35	35	µg/kg	50	150	20
Aroclor-1262 (PCB-1262)	35	35	µg/kg	70	130	30
Aroclor-1268 (PCB-1268)	35	35	µg/kg	70	130	30
8082 surrogates						
Tetrachloro-m-xylene			µg/kg	50	150	
Organophosphorous Pesticides by EPA 8141A ***Container:*** *Amber Glass, Teflon Lined Cap* ***Amount Required:*** *50 gr* ***Preservation:*** *Cool, ≤ 6°C* ***Holding Time:*** *Extraction: 14 days; Analysis: 40 days*						
Azinphos Methyl	0.025	0.05	µg/kg	70	130	40
Bolstar	0.02	0.04	µg/kg	70	130	40
Chlorpyrifos	0.025	0.05	µg/kg	70	130	40
Coumaphos	0.02	0.1	µg/kg	70	130	40
Demeton-o	0.03	0.06	µg/kg	70	130	40
Demeton-s	0.3	0.6	µg/kg	70	130	40
Diazinon	0.3	0.6	µg/kg	70	130	40
Dichlorovos	0.02	0.04	µg/kg	70	130	40
Disulfoton	0.02	0.04	µg/kg	70	130	40
Ethoprop	0.05	0.10	µg/kg	70	130	40
Fensulfothion	0.02	0.04	µg/kg	70	130	40

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Fenthion	0.025	0.05	µg/kg	70	130	40
Merphos	0.05	0.1	µg/kg	70	130	40
Mevinphos	0.125	0.25	µg/kg	70	130	40
Naled	0.125	0.25	µg/kg	70	130	40
Parathion Methyl	0.03	0.06	µg/kg	70	130	40
Phorate	0.01	0.02	µg/kg	70	130	40
Ronnel	0.02	0.04	µg/kg	70	130	40
Stirophos	0.2	0.4	µg/kg	70	130	40
Tokuthion	0.03	0.06	µg/kg	70	130	40
Trichloronate	0.20	0.40	µg/kg	70	130	40
8141A surrogates						
Tributyl Phosphate			µg/kg			
Triphenyl Phosphate			µg/kg			
Chlorinated Herbicides by EPA 8151A						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap*			***Amount Required:*** *50 g*			
Preservation: *Cool, ≤ 6°C*			***Holding Time:*** *Extraction: 14 days Analysis: 40 days*			
Acifluorfen	20	20	µg/kg	70	130	30
Bentazon	10	10	µg/kg	70	130	30
Chloramben	10	10	µg/kg	70	130	30
2,4-D	10	10	µg/kg	36	157	55
Dalapon	20	20	µg/kg	70	130	30
2,4-DB	10	10	µg/kg	70	130	30
Dicamba	10	10	µg/kg	70	130	30
3,5-Dichlorobenzoic Acid	10	10	µg/kg	70	130	30
Dichloroprop	10	10	µg/kg	70	130	30
Dinoseb (DNBP, 2-sec-Butyl-4,6-dinitrophenol)	20	20	µg/kg	70	130	30
MCPA	2,000	2,000	µg/kg	70	130	30
MCPP	2,000	2,000	µg/kg	70	130	30
4-Nitrophenol	10	10	µg/kg	70	130	30
Pentachlorophenol (PCP)	10	10	µg/kg	70	130	30
Picloram	10	10	µg/kg	70	130	30
2,4,5-T (2,4,5-Trichlorophenoxyacetic Acid)	10	10	µg/kg	69	140	35
2,4,5-TP (Silvex)	10	10	µg/kg	32	149	36
8151A surrogates						
2,4-dichlorophenylacetic			µg/kg	70	130	

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Volatile Organic Compounds by EPA 8260B						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap, Encore or pre-preserved 40ml vials X 3.*			***Amount Required:*** *50 g, or 5 g X 3*			
Preservation: *Cool, ≤ 6°C*			***Holding Time:*** *48 hours*			
1,1,1,2-Tetrachloroethane	5.0	10	µg/kg	70	130	30
1,1,1-Trichloroethane	5.0	10	µg/kg	75	125	20
1,1,2,2-Tetrachloroethane	5.0	10	µg/kg	70	130	30
1,1,2-Trichloroethane	5.0	10	µg/kg	70	130	30
1,1-Dichloroethane	5.0	10	µg/kg	70	130	30
1,1-Dichloroethene	5.0	10	µg/kg	75	125	20
1,1-Dichloropropene	5.0	10	µg/kg	70	130	30
1,2,3-Trichlorobenzene	5.0	10	µg/kg	70	130	30
1,2,3-Trichloropropane	5.0	10	µg/kg	70	130	30
1,2,4-Trichlorobenzene	5.0	10	µg/kg	70	130	30
1,2,4-Trimethylbenzene	5.0	10	µg/kg	70	130	30
1,2-Dibromo-3-Chloropropane	25	50	µg/kg	70	130	30
1,2-Dibromoethane	5.0	10	µg/kg	70	130	30
1,2-Dichlorobenzene	5.0	10	µg/kg	70	130	30
1,2-Dichloroethane	5.0	10	µg/kg	70	130	30
1,2-Dichloropropane	5.0	10	µg/kg	70	130	30
1,3,5-Trimethylbenzene	5.0	10	µg/kg	70	130	30
1,3-Dichlorobenzene	5.0	10	µg/kg	70	130	30
1,3-Dichloropropane	5.0	10	µg/kg	70	130	30
1,4-Dichlorobenzene	5.0	10	µg/kg	70	130	30
2,2-Dichloropropane	5.0	10	µg/kg	70	130	30
2-Butanone (Methylethyl kethone [MEK])	25	50	µg/kg	70	130	30
2-Chloroethyl Vinylether	50	50	µg/kg	70	130	30
2-Chlorotoluene	5.0	10	µg/kg	70	130	30
2-Hexanone	25	50	µg/kg	70	130	30
4-Chlorotoluene	5.0	10	µg/kg	70	130	30
4-Methyl-2-Pentanone	25	50	µg/kg	70	130	30
Acetone	25	50	µg/kg	70	130	30
Benzene	2.0	10	µg/kg	75	125	20
Bromobenzene	5.0	10	µg/kg	70	130	30
Bromochloromethane	5.0	10	µg/kg	70	130	30
Bromodichloromethane	5.0	10	µg/kg	70	130	30
Bromoform	25	50	µg/kg	70	130	30
Bromomethane	15	30	µg/kg	70	130	30
Carbon Disulfide	25	50	µg/kg	70	130	30

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Carbon Tetrachloride	5.0	10	µg/kg	70	130	30
Chlorobenzene	5.0	10	µg/kg	75	125	20
Chloroethane	15	30	µg/kg	70	130	30
Chloroform	5.0	10	µg/kg	75	125	20
Chloromethane	15	30	µg/kg	70	130	30
cis-1,2-Dichloroethene	5.0	10	µg/kg	70	130	30
cis-1,3-Dichloropropene	5.0	10	µg/kg	70	130	30
Dibromochloromethane	5.0	10	µg/kg	70	130	30
Dibromomethane	5.0	10	µg/kg	70	130	30
Dichlorodifluoromethane	15	30	µg/kg	70	130	30
Ethylbenzene	2.0	10	µg/kg	75	125	20
Hexachlorobutadiene	5.0	10	µg/kg	70	130	30
Isopropylbenzene	5.0	10	µg/kg	70	130	30
Methylene Chloride	25	50	µg/kg	70	130	30
MTBE	5.0	10	µg/kg	70	130	30
n-Butylbenzene	5.0	10	µg/kg	70	130	30
n- Propylbenzene	5.0	10	µg/kg	70	130	30
Naphthalene	5.0	10	µg/kg	70	130	30
p- Isopropyltoluene	5.0	10	µg/kg	70	130	30
sec-Butylbenzene	5.0	10	µg/kg	70	130	30
Styrene	5.0	10	µg/kg	70	130	30
tert-Butylbenzene	5.0	10	µg/kg	70	130	30
Tetrachloroethene	5.0	10	µg/kg	70	130	30
Toluene	2.0	10	µg/kg	75	125	20
trans-1,2-Dichloroethene	5.0	10	µg/kg	70	130	30
trans-1,3-Dichloropropene	5.0	10	µg/kg	70	130	30
Trichloroethene	5.0	10	µg/kg	75	125	20
Trichlorofluoromethane	5.0	10	µg/kg	70	130	30
Vinyl Acetate	25	50	µg/kg	70	130	30
Vinyl Chloride	15	30	µg/kg	70	130	30
o-xylene	2.0	10	µg/kg	75	125	20
m,p-xylenes	2.0	20	µg/kg	75	125	20
8260B surrogates						
1,2-dichloroethane-d4			µg/kg	58	160	
Toluene-d8			µg/Kg	*75*	*125*	
4-Bromofluorobenzene			µg/Kg	*75*	*125*	
Dibromofluoromethane			µg/Kg	*75*	*125*	

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Semi-Volatile Organic Compounds by EPA 8270C						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g*						
Preservation: *Cool, ≤ 6°C* ***Holding Time:*** *Extraction: 14 days Analysis: 40 days*						
1,2,4-Trichlorobenzene	250	500	µg/kg	38	107	20
1,2-Dichlorobenzene	250	500	µg/kg	70	130	30
1,3-Dichlorobenzene	250	500	µg/kg	70	130	30
1,4-Dichlorobenzene	250	500	µg/kg	28	104	20
2,4,5-Trichlorophenol	250	500	µg/kg	70	130	30
2,4,6-Trichlorophenol	250	500	µg/kg	70	130	30
2,4-Dichlorophenol	250	500	µg/kg	70	130	30
2,4-Dimethylphenol	250	500	µg/kg	70	130	30
2,4-Dinitrophenol	250	500	µg/kg	70	130	30
2,4-Dinitrotoluene	250	500	µg/kg	28	89	20
2,6-Dinitrotoluene	250	500	µg/kg	70	130	30
2-Chloronaphthalene	250	500	µg/kg	70	130	30
2-Chlorophenol	250	500	µg/kg	25	102	20
1-Methylnaphthalene	250	500	µg/kg	70	130	30
2-Methylnaphthalene	250	500	µg/kg	70	130	30
2-Methylphenol	250	500	µg/kg	70	130	30
2-Nitroaniline	250	500	µg/kg	70	130	30
2-Nitrophenol	250	500	µg/kg	70	130	30
3,3-Dichlorobenzidine	250	500	µg/kg	70	130	30
3-Methylphenol	250	500	µg/kg	70	130	30
3-Nitroaniline	250	500	µg/kg	70	130	30
4,6-Dinitro-2-methylphenol	250	500	µg/kg	70	130	30
4-Bromophenyl Phenyl Ether	250	500	µg/kg	70	130	30
4-Chloro-3-methylphenol	250	500	µg/kg	40	99	20
4-Chloroaniline	250	500	µg/kg	70	130	30
4-Chlorophenyl Phenyl Ether	250	500	µg/kg	70	130	30
4-Methylphenol	250	500	µg/kg	70	130	30
4-Nitroaniline	250	500	µg/kg	70	130	30
4-Nitrophenol	250	500	µg/kg	11	114	20
Acenaphthene	250	500	µg/kg	31	137	20
Acenaphthylene	250	500	µg/kg	70	130	30
Anthracene	250	500	µg/kg	70	130	30
Benzo (a) anthracene	250	500	µg/kg	70	130	30
Benzo (a) pyrene	250	500	µg/kg	70	130	30
Benzo (b) fluoranthene	250	500	µg/kg	70	130	30

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Benzo (g,h,i) perylene	250	500	µg/kg	70	130	30
Benzo (k) fluoranthene	250	500	µg/kg	70	130	30
Benzidine	250	500	µg/kg	70	130	30
Benzoic Acid	250	500	µg/kg	70	130	30
Benzyl Alcohol	250	500	µg/kg	70	130	30
Bis-(2-chnloroethoxy)methane	250	500	µg/kg	70	130	30
Bis-(2-chloroethyl)ether	250	500	µg/kg	70	130	30
Bis-(2-chloroisopropyl)ether	250	500	µg/kg	70	130	30
Bis-(2-ethylhexyl) Phthalate	250	500	µg/kg	70	130	30
Butyl Benzyl Phthalate	250	500	µg/kg	70	130	30
Chrysene	250	500	µg/kg	70	130	30
Dibenzo (a,h) anthracene	250	500	µg/kg	70	130	30
Dibenzofuran	250	500	µg/kg	70	130	30
Diethyl Phthalate	250	500	µg/kg	70	130	30
7,12-Dimethylbenz[a]anthracene	250	500	µg/kg	70	130	30
Dimethyl Phthalate	250	500	µg/kg	70	130	30
Di-n-butyl Phthalate	250	500	µg/kg	70	130	30
Di-n-octyl Phthalate	250	500	µg/kg	70	130	30
Fluoranthene	250	500	µg/kg	70	130	30
Fluorene	250	500	µg/kg	70	130	30
Hexachlorobenzene	250	500	µg/kg	70	130	30
Hexachlorobutadiene	250	500	µg/kg	70	130	30
Hexachlorocyclopentadiene	250	500	µg/kg	70	130	30
Hexachloroethane	250	500	µg/kg	70	130	30
Indeno-(1,2,3-cd) pyrene	250	500	µg/kg	70	130	30
Isophorone	250	500	µg/kg	70	130	30
Naphthalene	250	500	µg/kg	70	130	30
Nitrobenzene	250	500	µg/kg	70	130	30
N-Nitrosodi-n-propylamine	250	500	µg/kg	41	126	20
N-Nitrosodiphenylamine	250	500	µg/kg	70	130	30
Pentachlorophenol	250	500	µg/kg	13	125	20
Phenanthrene	250	500	µg/kg	70	130	30
Phenol	250	500	µg/kg	26	90	20
Pyridine	250	500	µg/kg	70	130	30
Pyrene	250	500	µg/kg	35	142	20
8270C surrogates						
2-Fluorobiphenyl			µg/kg	30	115	
2-Fluorophenol			µg/kg	25	121	
Nitrobenzene-d5			µg/kg	23	120	
Methoxychlor	10	50	µg/kg			

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Phenol-d5			µg/kg	21	113	
Terphenyl-d14			µg/kg	18	137	
2,4,6-Tribromophenol			µg/kg	19	122	
Polynuclear Aromatic Hydrocarbons by EPA 8270 SIM						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g* ***Preservation:*** *Cool, ≤ 6°C, Dark* ***Holding Time:*** *Extraction: 7 days Analysis: 40 days*						
Acenaphthene	10	20	µg/kg	75	125	30
Acenaphthylene	10	20	µg/kg	75	125	30
Anthracene	10	20	µg/kg	75	125	30
Benzo (a) anthracene	10	20	µg/kg	75	125	20
Benzo (a) pyrene	10	20	µg/kg	75	125	20
Benzo (b) fluoranthene	10	20	µg/kg	75	125	30
Benzo (g,h,i) perylene	10	20	µg/kg	75	125	30
Benzo (k) fluoranthene	10	20	µg/kg	75	125	30
Chrysene	10	20	µg/kg	75	125	30
Dibenzo (a, h) anthracene	10	20	µg/kg	75	125	30
7,12-Dimethylbenz[a]anthracene	10	20	µg/kg	75	125	30
Fluoranthene	10	20	µg/kg	75	125	30
Fluorene	10	20	µg/kg	75	125	30
Indeno (1,2,3-cd) pyrene	10	20	µg/kg	75	125	30
Naphthalene	10	20	µg/kg	75	125	20
Phenanthrene	10	20	µg/kg	75	125	30
Pyrene	10	20	µg/kg	75	125	30
8270 SIM surrogates						
p-terphenyl-d14			µg/kg	75	125	
Dioxins and Furans by EPA 8290A						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g* ***Preservation:*** *Cool, ≤ 6°C* ***Holding Time:*** *Extraction: 30 days Analysis: 45 days*						
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	0.5	1.0	ng/kg	70	130	40
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	0.5	1.0	ng/kg	70	130	40
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	1.25	2.5	ng/kg	70	130	40
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	1.25	2.5	ng/kg	70	130	40
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	1.25	2.5	ng/kg	70	130	40

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	1.25	2.5	ng/kg	70	130	40
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	2.5	5.0	ng/kg	70	130	40
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	0.5	1.0	ng/kg	70	130	40
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	0.5	1.0	ng/kg	70	130	40
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	0.5	1.0	ng/kg	70	130	40
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	1.25	2.5	ng/kg	70	130	40
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	1.25	2.5	ng/kg	70	130	40
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	1.25	2.5	ng/kg	70	130	40
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	1.25	2.5	ng/kg	70	130	40
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	1.25	2.5	ng/kg	70	130	40
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	1.25	2.5	ng/kg	70	130	40
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	2.5	5.0	ng/kg	70	130	40
Polynuclear Aromatic Hydrocarbons by EPA 8310 ***Container:*** *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g* ***Preservation:*** *Cool, ≤ 6°C, Dark* ***Holding Time:*** *Extraction:14 days* *Analysis: 40 days*						
Acenaphthene	0.01	0.02	mg/kg	75	125	
Acenaphthylene	0.01	0.02	mg/kg	75	125	30
Anthracene	0.01	0.02	mg/kg	75	125	30
Benzo (a) anthracene	0.01	0.02	mg/kg	75	125	20
Benzo (a) pyrene	0.01	0.02	mg/kg	75	125	20
Benzo (b) fluoranthene	0.01	0.02	mg/kg	75	125	30
Benzo (g,h,i) perylene	0.01	0.02	mg/kg	75	125	30
Benzo (k) fluoranthene	0.01	0.02	mg/kg	75	125	30
Chrysene	0.01	0.02	mg/kg	75	125	30
Dibenzo (a, h) anthracene	0.01	0.02	mg/kg	75	125	30
Fluoranthene	0.01	0.02	mg/kg	75	125	30
Fluorene	0.01	0.02	mg/kg	75	125	30
Indeno (1,2,3-cd) pyrene	0.01	0.02	mg/kg	75	125	30
Naphthalene	0.01	0.02	mg/kg	75	125	20
Phenanthrene	0.01	0.02	mg/kg	75	125	30
Pyrene	0.01	0.02	mg/kg	75	125	30

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
8310 surrogates						
p-terphenyl-d14			mg/kg	75	125	
Explosives by EPA 8330A						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g* ***Preservation:*** *Cool, ≤ 6°C, Dark* ***Holding Time:*** *Extraction:14 days Analysis: 40 days*						
1,3,5- TNB	0.125	0.25	mg/kg	70	130	40
1,3- DNB	0.125	0.25	mg/kg	70	130	40
2,4,6- TNT	0.125	0.25	mg/kg	70	130	40
2,4-DNT	0.125	0.25	mg/kg	70	130	40
2,6-DNT	0.13	0.26	mg/kg	70	130	40
HMX	1.1	2.2	mg/kg	70	130	40
m-Nitrotoluene	0.125	0.25	mg/kg	70	130	40
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	0.325	0.65	mg/kg	70	130	40
Nitrobenzene	0.13	0.26	mg/kg	70	130	40
o-Nitrotoluene	0.125	0.25	mg/kg	70	130	40
p-Nitrotoluene	0.125	0.25	mg/kg	70	130	40
RDX	0.5	1.0	mg/kg	70	130	40
8310 surrogates						
3,4-DNB			mg/Kg	70	130	
Common Anions by EPA 9056A						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g* ***Preservation:*** *Cool, ≤ 6°C, Dark* ***Holding Time: :*** *28 days for Br^-, F^-, Cl^-, and SO_4^{-2}, 24 hours for NO_3^-, NO_2^- and PO^4*						
Bromide	2.5	5	mg/kg	70	130	40
Chloride	5	10	mg/kg	70	130	40
Fluoride	5	10	mg/kg	70	130	40
Nitrate	5	10	mg/kg	70	130	40
Nitrite	5	10	mg/kg	70	130	40
Phosphate	5	10	mg/kg	70	130	40
Sulfate	5	10	mg/kg	70	130	40
Emergent Chemicals						
EPA Method 314.0						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g* ***Preservation:*** *Cool, ≤ 6°C, Dark* ***Holding Time: :*** *28 days*						
Perchlorate	13.8	100	µg/kg			

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
EPA Method 331/332.0						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g*						
Preservation: *Cool, ≤ 6°C, Dark* ***Holding Time: :*** *28 days*						
Perchlorate	1.0	1.0	µg/kg			
EPA Method SW8270C SIM						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g*						
Preservation: *Cool, ≤ 6°C, Dark* ***Holding Time: :*** *Extraction: 14 days Analysis: 40 days*						
N-Nitrosodimethylamine (NDMA)	0.2	2.0	µg/kg	70	130	40
8270C SIM surrogates						
N-Nitrosodimethylamine-d6			µg/kg	70	130	
EPA Method E529						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g*						
Preservation: *Cool, ≤ 6°C, Dark* ***Holding Time: :*** *Extraction: 7 days Analysis: 40 days*						
RDX	50	100	µg/kg	70	130	40
E529 surrogates						
Nitrobenzene-d5			µg/kg	70	130	
1,3,5-trimethyl-2-nitrobenzene			µg/kg	70	130	
1,2,4-trimethyl-5-nitrobenzene			µg/kg	70	130	
EPA Method E524.1						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g*						
Preservation: *Cool, ≤ 6°C, Dark* ***Holding Time: :*** *Extraction: 14 days Analysis: 40 days*						
1,2,3-Trichloropropane	0.66	1.6	µg/kg	70	130	40
E524.1 surrogates						
1,2,3-Trichloropropane-d5			µg/kg	70	130	
EPA Method 8270SIM						
Container: *Clear Wide Mouth Glass, Teflon Lined Cap* ***Amount Required:*** *50 g*						
Preservation: *Cool, ≤ 6°C, Dark* ***Holding Time: :*** *Extraction: 14 days Analysis: 40 days*						
1,4–Dioxane	31	200	µg/kg	70	130	40
8270SIM surrogates						
1,4–Dioxane–d8				80	120	

Notes: mg / kilogram– milligram per kilogram
g - gram
ng / kg – nanogram per kilogram

Table 3-8 Summary of Analytes and QAPP Objectives for Gaseous Samples

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Volatile Organic Compounds By EPA TO-15 (By GC/MS)						
Container: *Summa Canister*			***Amount Required:*** *1 liter*			
Preservation: *None*			***Holding Time:*** *14 Days*			
Acetone	5.0	5.0	µg/m^3	70	130	<30
Benzene	1.0	1.0	µg/m^3	70	130	<30
Bromodichloromethane	1.5	1.5	µg/m^3	70	130	<30
Bromoform	1.5	1.5	µg/m^3	70	130	<30
Bromomethane	1.5	1.5	µg/m^3	70	130	<30
2-Butanone (MEK)	5.0	5.0	µg/m^3	70	130	<30
Carbon Disulfide	1.5	1.5	µg/m^3	70	130	<30
Carbon Tetrachloride	2.0	2.0	µg/m^3	70	130	<30
Chlorobenzene	1.0	1.0	µg/m^3	70	130	<30
Chloroethane	1.5	1.5	µg/m^3	70	130	<30
Chloroform	1.5	1.5	µg/m^3	70	130	<30
Chloromethane	1.0	1.0	µg/m^3	70	130	<30
Dibromochloromethane	1.5	1.5	µg/m^3	70	130	<30
1,2-Dibromoethane (EDB)	2.0	2.0	µg/m^3	70	130	<30
1,2-Dichlorobenzene	2.0	2.0	µg/m^3	70	130	<30
1,3-Dichlorobenzene	2.0	2.0	µg/m^3	70	130	<30
1,4-Dichlorobenzene	2.0	2.0	µg/m^3	70	130	<30
Dichlorodifluoromethane (R-12)	2.0	2.0	µg/m^3	70	130	<30
1,1-Dichloroethane	1.5	1.5	µg/m^3	70	130	<30
1,2-Dichloroethane (EDC)	1.5	1.5	µg/m^3	70	130	<30
1,1-Dichloroethene	1.5	1.5	µg/m^3	70	130	<30
cis-1,2-Dichloroethene	1.5	1.5	µg/m^3	70	130	<30
trans-1,2-Dichloroethene	1.5	1.5	µg/m^3	70	130	<30
1,2-Dichloropropane	1.5	1.5	µg/m^3	70	130	<30
cis-1,3-Dichloropropene	1.5	1.5	µg/m^3	70	130	<30
trans-1,3-Dichloropropene	1.5	1.5	µg/m^3	70	130	<30
Ethylbenzene	1.5	1.5	µg/m^3	70	130	<30
4-Methyl-2-pentanone(MIBK)	5.0	5.0	µg/m^3	70	130	<30
Methyl t-Butyl Ether(MTBE)	1.0	1.0	µg/m^3	70	130	<30
Methylene Chloride (DCM)	5.0	5.0	µg/m^3	70	130	<30
Styrene	1.5	1.5	µg/m^3	70	130	<30
1,1,2,2-Tetrachloroethane	2.0	2.0	µg/m^3	70	130	<30
Tetrachloroethene	1.5	1.5	µg/m^3	70	130	<30
Toluene	1.0	1.0	µg/m^3	70	130	<30
1,2,4-Trichlorobenzene	1.0	1.0	µg/m^3	70	130	<30
1,1,1-Trichloroethane	1.5	1.5	µg/m^3	70	130	<30

ANALYTE	MDL	PQL	UNITS	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
1,1,2-Trichloroethane	1.5	1.5	µg/m^3	70	130	<30
Trichloroethene	1.5	1.5	µg/m^3	70	130	<30
Trichlorofluoromethane (R-11)	2.0	2.0	µg/m^3	70	130	<30
Trichlorotrifluoroethane (R-113)	2.5	2.5	µg/m^3	70	130	<30
1,2,4-Trimethylbenzene	1.5	1.5	µg/m^3	70	130	<30
1,3,5-Trimethylbenzene	1.5	1.5	µg/m^3	70	130	<30
Vinyl Acetate	5.0	5.0	µg/m^3	70	130	<30
Vinyl Chloride	1.0	1.0	µg/m^3	70	130	<30
o-Xylene	1.0	1.0	µg/m^3	70	130	<30
Naphthalene	5.0	5.0	µg/m^3	70	130	<30
m,p-Xylene	2.0	2.0	µg/m^3	70	130	<30
TO-15 surrogates						
4-bromofluorobenzene			µg/m^3	70	130	
1,2-Dichloroethane-d4			µg/m^3	70	130	
Toluene-d8			µg/m^3	70	130	

Notes: ng – nanogram
µg/m^3– microgram per cubic meter

Table 3-9 Summary of Analytes and QAPP Objectives for Asbestos

ANALYTE		MDL	PQL	LOWER CONTROL LIMIT %	UPPER CONTROL LIMIT %	RPD LIMIT
Asbestos						
Air Sample by Phase Contrast Microscopy (PCM)	NIOSH 7400	7 fibers / mm^2 of sample filter	NA	NA	NA	NA
Bulk Sample - by Polarized Light Microscopy (PLM)	EPA/600/R-93/116	1%	NA	NA	NA	NA
Bulk Sample by PLM - Point Count Method PC100	EPA/600/R-93/116	0.1%	NA	NA	NA	NA
Bulk by Transmission Electron Microscopy (TEM)	EPA/600/R-93/116	1%	NA	NA	NA	NA

Notes: NA – Not applicable.

3.6.3 Screening Analytical Methods

Screening data are generated by rapid methods of analysis with less rigorous sample preparation, less calibration, and/or fewer QC requirements than are necessary to produce definitive data. Sample preparation steps may be restricted to simple procedures, such as dilution with a solvent, instead of elaborate extraction/digestion and cleanup. Screening data may provide analyte identification and quantitation, although the quantitation may be relatively imprecise. Physical test methods (e.g., dissolved

oxygen measurements, temperature and pH measurements, moisture content, turbidity, and conductance) and others carried out in a field or fixed-base laboratory have been designated by definition as screening methods. Examples of common screening analytical methods that may be conducted during field work activities at the Site are provided in Table 3-10. Other screening methods may be used as appropriate and should be identified in project-specific QAPP Addenda. Data generated by screening methods shall be confirmed by analyses that generate definitive data. Confirmation samples shall be selected to include both detected and non-detected results from the screening method.

Table 3-10 Screening Analytical Methods

Method	Parameter	Water	
		RL	Unit
EPA Method SW9040	pH (water)	N/A	N/A
EPA Method SW9045	pH (soil)	N/A	N/A
EPA Method SW9050	Conductance	N/A	N/A
EPA Method 170.1	Temperature	N/A	N/A
EPA Method 180.1	Turbidity	N/A	N/A
EPA Method 310.1	Alkalinity[1]	0.02	mg/L
EPA Method 360.1	Dissolved oxygen	0.2	mg/L
EPA Method 376.2	Total sulfide		
ASTM D422	Standard Method for Particle-Size Analysis of Soils	N/A	N/A
ASTM D1498	Oxidation-reduction potential	N/A	N/A
ASTM D3416	Methane in soil gas	N/A	N/A
EPA Method SW3550	Percent solids	N/A	N/A
Organic vapor analyses via handheld detector	Soil gas screening for halogenated aromatic compounds, and petroleum hydrocarbons	1-10	ppmv
HACH 8141	Ferrous iron	1.0	mg/L

Notes:

1 - alkalinity measured as calcium carbonate equivalence
RL – reporting limit

3.6.3.1 Screening Analytical Method Descriptions

This section contains brief method descriptions for each screening analytical method.

3.6.3.1.1 EPA Method SW9040B (water) and SW9045C (soil): pH

Method SW9040 shall be used to measure the pH of water samples. The pH of soil samples shall be measured using method SW9045C. Measurements are determined electrometrically using either a glass electrode in combination with a reference potential or a combination electrode.

3.6.3.1.2 EPA Method SW9050A: Conductance

Standard conductivity meters shall be used. Temperature shall be reported.

3.6.3.1.3 EPA Method 170.1: Temperature

Temperature measurements are made with a mercury-filled or dial type centigrade thermometer, or a thermistor.

3.6.3.1.4 EPA Method 180.1: Turbidity

This method is based on a comparison of the light scattered by the sample under defined conditions with the light intensity scattered by a standard reference suspension. The higher the intensity, the greater the turbidity is. Turbidity measurements are made in a nephelometer and are reported in terms of NTUs. The working range for the method is from 0 to 40 NTUs. Higher levels of turbidity can be measured by diluting the sample with turbidity-free deionized water.

3.6.3.1.5 EPA Method 310.1: Alkalinity

An unaltered sample shall be titrated to an end point of pH 4.5 using hydrochloric acid or sulfuric acid. Alkalinity is measured as calcium carbonate equivalence.

3.6.3.1.6 EPA Method 376.2: Total Sulfide

This method measures total and dissolved sulfide. Sulfide reacts with p-aminodimethylaniline in the presence of ferric chloride to produce methylene blue. Methylene blue is measured at 625 nanometers and the methylene blue concentration indicates the sulfide concentration.

3.6.3.1.7 EPA Method 360.1: Dissolved Oxygen

An instrument probe, usually dependent upon an electrochemical reaction, is used for measuring the concentration of dissolved oxygen in water. Under steady-state conditions, the current or potential can be correlated with dissolved oxygen concentrations.

3.6.3.1.8 ASTM D422: Standard Method for Particle-Size Analysis of Soils

This method covers the quantitative determination of the distribution of particle sizes in soils. The distribution of particle sizes larger than 75 μm (retained on the No. 200 sieve) is determined by sieving,

while the distribution of particle sizes smaller than 75 μm is determined by a sedimentation process using a hydrometer.

3.6.3.1.9 ASTM D1498: Oxidation-Reduction Potential

This method is designed to measure the ORP in water, which is defined as the electromotive force between a noble metal electrode and a reference electrode when immersed in a solution.

3.6.3.1.10 ASTM D3416: Methane in Soil Gas

An aliquot of the soil gas sample is introduced into a prechromatographic or stripper column, which removes hydrocarbons other than methane and carbon monoxide. Methane and carbon monoxide are passed through a chromatographic column where they are separated. The methane is measured by an FID. Quantitation is performed by comparing the sample response to the response of a known concentration of methane.

3.6.3.1.11 SW-846 (described in Method SW3550): Percent Solids

Percent solids is determined for solid samples undergoing analysis for inorganic and organic analytes. The sample is weighed, dried, and then reweighed. Percent solids is calculated as:

$$\frac{\text{Dried Weight}}{\text{Initial Weight}} \text{ x } 100 = \% \text{ solids}$$

The solid content is used to calculate results for soil samples on a dry weight basis using the calculation presented below:

$$\frac{\text{Result of analysis on a wet weight basis}}{\% \text{ solids} / 100} = \text{Result of analysis on a dry weight basis}$$

All MDLs for solids samples shall be reported on a dry weight basis. Soil sample results shall be reported on a dry weight basis.

3.6.3.1.12 Real-Time Portable Organic Vapor Analyzers

Two types of portable analyzers shall be used to perform real-time nonspecific analyses of hydrocarbon vapors. The instruments include an FID (e.g., Foxboro Century OVA) and a PID (e.g., HNu Systems trace gas analyzer, MiniRAE) organic vapor monitor. One or more of these instruments may be used at a specific site, depending on the contaminant species of interest. When used together, the instruments provide complementary information because they are sensitive to different types of hydrocarbon vapors.

The portable analyzers shall be used as a screening tool to help determine the optimum locations for the collection of samples. Field data recorded on the CoC forms give the laboratory analysts an indication of

the approximate concentration of contaminants and aid in calculating dilution factors before analysis. Additionally, the real-time instruments are used to aid in selecting the proper level of PPE and monitoring air emissions during sampling activities. The comparability of results obtained from the PID and FID instruments can be considered only to be within the variability of this type of screening instrument. Comparability is greatest when the instruments are calibrated with the same standards and operated within similar concentration ranges.

The FID uses the principle of hydrogen flame ionization to detect and measure total hydrocarbon vapors. The FID has a dynamic operating range from 1 parts per million by volume (ppmv) to 10 ppmv or 1 ppmv to 100,000 ppmv, depending on the instrument, and provides a nonspecific response to total hydrocarbons. If concentrations exceed the range of the instrument, a dilution probe shall be attached to the FID to allow elevated vapor concentrations to be measured. The instrument is highly sensitive to compounds such as methane, benzene, and acetone, but is less sensitive to alcohols and halogenated compounds.

During operation, a sample is drawn into the probe and transmitted to the detection chamber by an internal pumping system. Inside the chamber, the sample is exposed to a hydrogen flame that ionizes the organic vapors. As the organic vapors burn, the ions produced are collected on an electrode in the chamber, and a current proportional to the hydrocarbon concentration is generated. This current is measured and displayed on the meter.

The PID uses a photoionization detector to detect and measure total hydrocarbon vapors. The instrument has an operating range of 0 to 2,000 ppm. During operation, a gas sample is drawn into the probe and past an ultraviolet light source by an internal pumping system. Contaminants in the sample are ionized, producing an instrument response if their ionization potential is equal to or less than the ionizing energy supplied by the lamp. The radiation produces a free electron for each molecule of ionized contaminant, which generates a current directly proportional to the number of ions produced. This current is measured and displayed on the meter. The PID measures the *total* value for all species present with ionization potentials less than or equal to that of the lamp.

Methane Soil Gas Analysis

Tedlar bags may be used to sample methane if analyzed within 24 hours. Methods SW8015B, EPA TO-3, or ASTM 3416 may be used for sample analysis. Hand held field instruments (e.g., Land Tech Gas Analyzer GA-90, Gas Emissions Monitor GEM-500, GEM-2000) might also be used to analyze methane. Oxygen and carbon dioxide should also be analyzed if methane detections are above 5,000 ppmv. Hand held field instrumentation will be calibrated and operated in accordance with manufacturer instructions.

Hydrogen Sulfide Soil Gas Analysis

Black Tedlar bags, gas-tight syringes wrapped in aluminum foil, or treated Summa canisters may be used to sample hydrogen sulfide. Methods EPA TO-16 or South Coast Air Quality Management District 307-91 may be used for sample analysis. Hand held instruments (e.g., Jerome 631-X or LTX-310) might also be used to analyze hydrogen sulfide. Hand held field instrumentation will be calibrated and operated in accordance with manufacturer instructions.

3.6.3.1.13 HACH Method 8141: Ferrous Ion

Ferrous ion is measured by a visible spectrophotometer. A typical RL is 1.0 mg/L.

3.6.3.2 Calibration and QC Procedures for Screening Methods

Table 3–11 presents the calibration and QC procedures for each screening method. These requirements, as well as the corrective action criteria, are included. In this table, the first two columns designate the method number and the class of analytes that may be determined by the method. The third column lists the method-required calibration and QC elements. The fourth column designates the minimum frequency for performing each calibration and QC element. The fifth column designates the acceptance criteria for each calibration and QC element. The sixth column designates the corrective action in the event that a calibration or QC element does not meet the acceptance criteria.

Table 3-11 Summary of Calibration and QC Procedures for Screening Methods

Method	Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
SW9045B	pH (water)	Two-point calibration with pH buffers that bracket the expected sample pH	Once per day at the beginning of testing	± 0.05 pH unit on repeat measurement of the calibration buffers	Check with new buffers; if still out, repair meter; repeat calibration check
		pH 7 buffer	At each sample location	± 0.1 pH unit	Recalibrate
		Field duplicate	10% of field samples	± 0.1 pH unit	Correct problem, repeat measurement. If still out, repeat calibrations and reanalyze samples

Method	Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
SW9045C	pH (soil)	Two-point calibration with pH buffers that bracket the expected sample pH	Once per day at the beginning of testing	± 0.05 pH unit on repeat measurement of the calibration buffers	Check with new buffers; if still out, repair meter; repeat calibration check
		pH 7 buffer	At each sample location	± 0.1 pH unit	Recalibrate
		Field duplicate	10% of field samples	± 0.1 pH unit	Correct problem, repeat measurement. If still out, repeat calibrations and reanalyze samples
SW9050A	Conductance	Calibration with KCl standard	Once per day at beginning of testing	± 5%D	If calibration is not achieved, check meter, standards, and probe; recalibrate
		Field duplicate	10% of field samples	± 5%RPD	Correct problem, repeat measurement
E170.1	Temperature	Calibrate field or laboratory thermometers against NIST certified thermometer	Initially calibrate all new thermometers. Recalibrate all thermometers once every 12 months.	Temperature of the measuring device must match the NIST thermometer measurement	Apply correction factors to individual thermometers
E180.1	Turbidity	Calibration with one formazin standard per instrument range used	Once per day at beginning of testing	Follow manufacturer's protocol for calibration	If calibration is not achieved, check meter; replace if necessary, recalibrate
		Field duplicate	10% of field samples	RPD ≤ 20%	Correct problem, repeat measurement
None	Organic vapor concentra-tions (FID and PID)	Three-point calibration	Monthly	$r \geq 0.995$	Recalibrate; check instrument and, if necessary, replace
		Calibration verification and check	Daily at beginning and end of day	Response ± 20% of expected value	Correct problem, recalibrate

Method	Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
ASTM D1498	Oxidation-reduction Potential (ORP)	Sensitivity verification	Daily	ORP should decrease when pH is increased	If ORP increases, correct the polarity of electrodes. If ORP still does not decrease, clean electrodes and repeat procedure.
		Calibration with one standard	Once per day	Two successive readings ± 20 millivolts	Correct problem, recalibrate
		Field duplicate	10% of field samples	± 10 millivolts	Correct problem, repeat measurement
E310.1	Alkalinity	Field duplicate	10% of field samples	RPD ≤ 20%	Correct problem, repeat measurement
E360.1	Dissolved oxygen	Field duplicate	10% of field samples	RPD ≤ 20%	Correct problem, repeat measurement
ASTM D3416	Methane in soil gas	Three point calibration	Daily, prior to sample analysis	r ≥ 0.995	Recalibrate
		Method blank	Daily or one per batch, whichever is more frequent	< RL	Clean system; reanalyze blank and repeat until all analytes < RL
		Duplicate	1 per batch or 10%	RPD ≤ 20%	Analyze third aliquot: if still out, flag data with J
HACH 8146	Field Based Ferrous ion	Four-point calibration Blank Field duplicate	Daily One/Batch 10% of field samples	R > 0.995 <RL RPD < 20%	Recalibrate Reanalyze samples under <RL blank Correct problem Repeat measurement
HACH 8146	Field Based Ferrous ion	Four-point calibration Blank Field duplicate	Daily One/Batch 10% of field samples	R > 0.995 <RL RPD < 20%	Recalibrate Reanalyze samples under <RL blank Correct problem Repeat measurement

Notes: a. All corrective actions shall be documented and the records shall be maintained by the Performing Contractor.

3.6.3.3 Definitive Data Sample Preparation Methods

Extraction and digestion procedures for liquid and solid matrices to be analyzed with methods presented in this section are outlined in Table 3–12. Variations from those listed in Table 3–12 are to be specified in QAPP Addenda.

Table 3-12 Extraction and Digestion Procedures

Method	Parameter
EPA 300	Common Anions in Soil
SW1311	Toxicity Characteristic Leaching Procedure
SW3005A	Acid Digestion of Water Samples for Metals Analysis
SW3010A	Acid Digestion of Aqueous Samples and Extracts for Metals Analysis
SW3015	Microwave Assisted Acid Digestion of Aqueous Samples and Extracts for Metals Analysis
SW3020A	Acid Digestion of Aqueous Samples and Extracts for Metals Analysis
SW3050B	Acid Digestion of Solids, Sediments, and Sludges for Metals Analysis
SW3051	Microwave Assisted Acid Digestion of Solids, Sediments, and Sludges for Metals Analysis
SW3060A	Alkaline Digestion for Hexavalent Chromium
SW3510C	Separatory Funnel Liquid-Liquid Extraction
SW3520C	Continuous Liquid-Liquid Extraction
SW3535A	Solid-Phase Extraction
SW3540C/SW3541	Soxhlet Extraction
SW3545	Pressurized Fluid Extraction
SW3550B	Ultrasonic Extraction
SW3585	Waste Dilution for Volatile Organics
SW5021	Volatile Organic Compounds in Soils and Other Solid Matrices Using Equilibrium Headspace Analysis
SW5030B	Purge and Trap for Volatile Organic Compounds
SW5031	Volatile, Nonpurgeable, Water-Soluble Compounds by Azeotropic Distillation
SW5032	Volatile Organic Compounds by Vacuum Distillation
SW5035A	Closed-System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples

3.6.3.3.1 Inorganic Prep Methods

3.6.3.3.2 Method 300.0: Common Anions in Water

A 10 to 1 water to solid mixture is prepared and filtered prior to analysis.

3.6.3.3.3 Method SW1311: Toxicity Characteristic Leaching Procedure

Method SW1311 is used to prepare samples for determination of the concentration of organic (semivolatile and volatile) and inorganic constituents that are leachable from waste or other material.

Quality Control is accomplished by preparing a toxicity characteristic leaching procedure (TCLP) blank at a rate of one blank for every 20 extractions conducted in the extraction vessel. Additional extract is prepared so one MS is performed for each waste type (samples of similar waste types shall be batched together). One MS must be analyzed in each analytical batch. These QA measures are in accordance with the requirements of EPA method SW1311.

3.6.3.3.4 Method SW3005A: Acid Digestion of Water Samples for Metals Analysis

This method is an acid digestion procedure used to prepare water samples for metals analysis. The digested samples are analyzed for total recoverable and dissolved metals determination by inductively coupled plasma (ICP) analysis. For analysis of total recoverable metals, the entire sample is acidified at collection time. For analysis of dissolved metals, the samples are filtered upon collection and then acidified.

3.6.3.3.5 Method SW3010A: Acid Digestion of Aqueous Samples and Extracts for Metals Analysis

Method SW3010A is used to prepare aqueous or waste samples for total metals determination by ICP. The samples are vigorously digested with acid and then diluted.

3.6.3.3.6 Method SW3015: Microwave Assisted Acid Digestion of Aqueous Samples and Extracts for Metals Analysis

This method is used to prepare aqueous or waste samples that contain suspended solids for total metals determination by graphite furnace atomic absorption (GFAA) spectroscopy or ICP. The samples are digested with acid and heated in a microwave.

3.6.3.3.7 Method SW3020A: Acid Digestion of Aqueous Samples and Extracts for Metals Analysis

Method SW3020A is used to prepare aqueous or waste samples for total metals determination by GFAA spectroscopy or ICP. The samples are vigorously digested with acid and then diluted.

3.6.3.3.8 Method SW3050B: Acid Digestion of Solids, Sediments, and Sludges for Metals Analysis

Method SW3050B is used to prepare sediment, sludge, and soil samples for metals analysis by ICP or by GFAA spectroscopy. A sample is digested then refluxed with acid. A separate aliquot of the sample is dried for a total solids and/or percent moisture determination.

3.6.3.3.9 Method SW3051: Microwave Assisted Acid Digestion of Solids, Sediments, and Sludges for Metals Analysis

Method SW3051 is used to prepare sediment, sludge, and soil samples for metals analysis by GFAA spectroscopy or ICP. The samples are digested with acid and heated in a microwave. A separate aliquot of the sample is dried for a total solids and/or percent moisture determination.

3.6.3.3.10 Method SW3060A: Alkaline Digestion for Hexavalent Chromium

Method SW3060A is used to prepare sediment, sludge, and soil samples for analysis of hexavalent chromium by ultraviolet-visible (UV-VIS) spectrophotometry. The samples are digested with sodium hydroxide.

3.6.3.3.11 Organic Prep Methods

3.6.3.3.12 Method SW3510C: Separatory Funnel Liquid-Liquid Extraction

Method SW3510C is designed to quantitatively extract nonvolatile and semivolatile organic compounds from liquid samples using standard separatory funnel techniques. The sample and the extracting solvent must be immiscible in order to yield recovery of target compounds. Subsequent cleanup and detection methods are described in the organic analytical method used to analyze the extract.

3.6.3.3.13 Method SW3520C: Continuous Liquid-Liquid Extraction

Method SW3520C is a procedure for isolating organic compounds from aqueous samples and is designed for extracting solvents with a density greater than that of the sample.

3.6.3.3.14 Method SW3535A: Solid-Phase Extraction

Method SW3535A is a procedure for isolating organic compounds from aqueous samples using solid-phase extraction media.

3.6.3.3.15 Method SW3540C/SW3541: Soxhlet Extraction

Method SW3540C is a procedure for extracting nonvolatile and semivolatile organic compounds from solids such as soils and sludges. Method SW3541 is an automated Soxhlet extraction. The Soxhlet extraction process ensures intimate contact of the sample matrix with the extraction solvent.

3.6.3.3.16 Method SW3545: Pressurized Fluid Extraction

Method SW3545 is a procedure for extracting water insoluble or slightly water soluble SVOCs from soils, sediments, sludges, and waste solids using elevated temperature and pressure.

3.6.3.3.17 Method SW3550B: Ultrasonic Extraction

Method SW3550B is a procedure for extracting nonvolatile and semivolatile organic compounds from solids such as soils and sludges. The sonication process ensures intimate contact of the sample matrix with the extraction solvent.

3.6.3.3.18 Method SW3585: Waste Dilution for Volatile Organics

Method SW3585 is a procedure describing solvent dilution of a non-aqueous waste sample prior to direct injection analysis.

3.6.3.3.19 Method SW5021: Volatile Organic Compounds in Soils and Other Solid Matrices Using Equilibrium Headspace Analysis

Method SW5021 is a general purpose method for preparing VOCs in soils, sediments, and solid wastes by GC or GC/MS analysis.

3.6.3.3.20 Method SW5030B: Purge and Trap for Volatile Organic Compounds

Method SW5030B describes sample preparation and extraction for the analysis of VOCs. This method is applicable to aqueous samples and soil/sediment extracts.

An inert gas is bubbled through the sample solution at ambient temperature to transfer the volatile components to the vapor phase. The vapor is swept through a sorbent column where the volatile components are trapped. After purging is completed, the sorbent column is heated and backflushed with inert gas to desorb the components onto a GC column.

3.6.3.3.21 Method SW5031: Volatile, Nonpurgeable, Water-Soluble Compounds by Azeotropic Distillation

Method SW5031 is used for separating nonpurgeable water-soluble and VOCs in aqueous or leachates from solid matrices using azeotropic distillation.

3.6.3.3.22 Method SW5032: Volatile Organic Compounds by Vacuum Distillation

Method SW5032 is used to determine VOCs from a variety of matrices using vacuum distillation.

3.6.3.3.23 Method SW5035A: Closed System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples

Method SW5035A describes sample preparation and extraction for the analysis of VOCs in solid matrices. The method involves a heated purge of volatile components followed by analysis on a GC/ MS. Several sample preservation options are given in the method. Analyzing the sample unpreserved within the prescribed 48-hour holding time is the preferred option. If this is not possible, an appropriate preservation option must be chosen. For low-level VOC analysis, the preferred preservation is sodium bisulfate with a 14-day holding time.

3.6.3.3.24 Method 7300: Lead in Air

NIOSH Method 7300 is used to determine amounts of elements (i.e., lead) contained in atmospheric particulates. This method is specific for a particular element and does not distinguish between compounds. NIOSH 7300 is an alternative to methods that require analysis by flame atomic absorption spectroscopy. The analytical procedure for lead is SW6010B.

3.6.3.4 Calibration Procedures and Frequencies

Analytical instruments will be calibrated periodically, per manufacturer requirements, using NIST and/or EPA-traceable standards in accordance with the specified analytical methods.

3.6.4 Definitive Data Analytical Methods

Definitive data are generated using rigorous analytical methods, such as approved EPA reference methods. The data can be generated in a mobile or fixed laboratory. Data are analyte-specific, and both identification and quantitation are confirmed. These methods have standardized QC and documentation requirements. Definitive data are not restricted in their use unless quality problems require data qualification. This section contains brief descriptions of preparation methods. There are subsections for each analytical procedure and a calibration and QC table provided where applicable.

3.6.4.1 Analytical Procedures

A list of Definitive Analytical Methods is presented in Table 3-13. It should be noted that some of the analytical methods used in previous groundwater investigations are not listed on Table 3-13. These analytical methods have been superseded by alternate methods described in this QAPP, and are not planned to be used for future work at Sites 1 & 2. These methods were intentionally not included in the SAP to avoid possible confusion. Analytical methods not included in the SAP which were used for analysis of contaminants during previous investigations include the following:

- E1624 (1,4-dioxane) – superseded by SW8270C–SIM
- E1625C (NDMA) – superseded by E521
- E7196 (hexavalent chromium) – superseded by E7199/E218.6
- SW8260B-SIM (1,2,3-trichloropropane) – superseded by E524.1

In addition to the above, a number of methods previously used for analysis of general minerals have been replaced in the SAP by more recently developed methods, and radiological analyses used during a one-time investigation at Site 1 (Gross Alpha, Tritium, Carbon-14, and Sulfur-35) are not included in the SAP.

A brief description and a calibration and QC table for each method is included in Tables 3-14 to 3-37 in the following subsections. PQLs for the definitive analytical methods addressed herein were previously provided in Tables 3-6, 3-7, 3-8, and 3-9 (Section 3.6.2). Analyte lists for the selected test methods with specific control limits and quantitation limits specified in Tables 3-6, 3-7, 3-8, or 3-9 will be used by default. Variations from the QAPP shall be presented by the Performing Contractor in the project-specific QAPP Addenda. If methods not included in Table 3-13 are to be used, they shall be described by the Performing Contractor in a project-specific QAPP Addendum.

Calibration and QC procedures for each method, including corrective actions and data qualifying criteria, are presented in Tables 3-14 through 3-37 below. In Tables 3-14 through 3-37, the first column designates

the class of analytes that may be determined by the method. The second column lists the QC check. The third column designates the minimum frequency for performing each calibration and QC element. The fourth column designates the acceptance criteria for each calibration and QC element. The last column designates the corrective action in the event that a calibration or QC element does not meet the acceptance criteria. Method SW1311 is used to prepare samples for determining concentrations of organic (semivolatile and volatile) and inorganic constituents that are leachable from waste or other material.

Table 3-13
Definitive Analytical Methods

Analytical Method	Parameter	Applicable Preparation Methods[a]
E300.0	Common anions in water	(see analytical method)
E314.0	Perchlorate anion in water (soil and water)	(see analytical method)
E331.0/332.0	Perchlorate anion in water (soil and water)	(see analytical method)
E521	Low level N-Nitrosodimethylamine (soil and water)	(see analytical method)
E524.1	1,2,3-Trichloropropane (water)	3585, 5021, 5030B, 5031, 5032, 5035A
E529	Low level RDX (soil and water)	(see analytical method)
SW6010B	Trace metals by ICP (soil and water)	3005A, 3010A, 3015, 3050B, 3051
SW6020	Trace metals by ICP-MS (soil and water)	3005A, 3010A, 3015, 3050B, 3051
SW7199/E218.6	Hexavalent chromium (soil and water)	(see analytical method)
SW7470A/ 7471A	Mercury (water)/Mercury (soil)	(see analytical method)
SW8015 (modified)	TPH volatile and extractable (soil and water)	(volatiles) 5030B, 5031, 5035 (extractables) 3510C, 3520C, 3545C, 3541, 3545, 3550B
SW8081A	Organochlorine pesticides (soil and water)	3510C, 3520C, 3540C, 3541, 3545, 3550B, 3535A
SW8082	PCBs (soil and water)	3510C, 3520C, 3540C, 3541, 3535A
SW8141A	Organophosphorus compounds (soil and water)	3510C, 3520C, 3540C, 3541, 3550B,3535A
SW8151A	Chlorinated herbicides (soil and water)	3510C, 3520C, 3540C, 3541, 3550B
SW8260B	Volatile organics (soil and water)	3585, 5021, 5030B, 5031, 5032, 5035A
SW8270C	Semivolatile organics (soil and water)	3510C, 3520C, 3540C, 3541, 3545, 3550B, 3535A
SW8270C SIM	Low level detection of semivolatile organics (i.e., 1,4-dioxane, PAHs, N-Nitrosodimethylamine) (soil and water)	3510C, 3520C
SW8290	Dioxins and furans (soil and water)	(see analytical method)

Analytical Method	Parameter	Applicable Preparation Methods[a]
SW8310	Polynuclear aromatic hydrocarbons (PAHs) (soil and water)	3510C, 3520C, 3540C, 3541, 3550B
SW8330A	Explosives (soil and water)	(see analytical method)
SW9056A	Common anions (water)	(see analytical method)
SW9056A	Common anions (soil)	As per EPA 300.0
Various	General Minerals (soil and water)	(see analytical method)
RSK-175	Gases in water	(see analytical method)
AM20GAX	Hydrogen (water)	(see analytical method)
AM23G	Fatty Acids (water)	(see analytical method)
TO-15	VOCs in gaseous media	(see analytical method)
NIOSH 7400 Method	Asbestos - Air Sample by Phase Contrast Microscopy (PCM)	(see analytical method)
EPA/600/R-93/116	Asbestos Bulk Sample - by Polarized Light Microscopy (PLM)	(see analytical method)
EPA/600/R-93/116	Asbestos - Bulk by Transmission Electron Microscopy (TEM)	(see analytical method)

Notes: a –Refer to analytical method for preparation method indicates "See analytical method".

3.6.4.1.1 Method EPA E300.0: Common Anions in Water and Soil

This method addresses the sequential determination of the anions chloride, fluoride, bromide, nitrate, nitrite, phosphate, and sulfate in aqueous samples. A small volume of aqueous sample is injected into an ion chromatograph to flush and fill a constant volume sample loop. The sample is then injected into a stream of eluent.

The sample is pumped through three different ion exchange columns and into a conductivity detector. The first two columns, a precolumn (guard) column and a separator column, are packed with a low-capacity, strongly basic anion exchanger. Ions are separated into discrete bands based on their affinity for the exchange sites of the resin. The last column is a suppressor column that reduces the anions in the sample to their corresponding acids. The separated anions in their acid form are measured using an electrical-conductivity cell. Anions are identified based on their retention times compared to known standards. Quantitation is accomplished by measuring the peak height or area and comparing it to a calibration curve generated from known standards.

3.6.4.1.2 Method E314.0: Perchlorate

This method addresses the determination of the perchlorate anion in water samples as well as in aqueous extracts of soil samples using ion chromatography (IC).

A large (approximately 1.0 mL) volume of sample is introduced into an IC. Perchlorate is separated and measured using a system composed of an ion chromatographic pump, sample injection valve, guard column, analytical column, suppressor device, and conductivity detector.

The method requires the use of a conductivity detector to monitor sample matrix conductivity and to determine if sample pretreatment is required. Pretreatment must be performed whenever the conductivity exceeds the laboratory-determined Matrix Conductivity Threshold (MCT) and can consist of dilution and/or use of specific pretreatment cartridges or columns designed to remove matrix interferences. The MCT is the matrix conductance where the calculated area to height ratio percent difference ($PD_{A/H}$) for the perchlorate peak exceeds 20 percent.

An analytical batch is a sequence of samples that is analyzed within a 30-hour period and includes no more than 20 field samples. An analytical batch must also include all required QC samples, which do not contribute to the maximum field sample total of 20. The required QC samples include:

- Instrument Performance Check Standard (IPC);
- Laboratory Reagent Blank (LRB);
- Initial Calibration Check Standard (ICCS) (also known as ICV);
- Laboratory Fortified Blank (LFB) (also known as LCS);
- Continuing Calibration Check Standard (CCCS) (also known as CCV);
- End Calibration Check Standard (ECCS) (also known as CCV);
- Laboratory Fortified Sample Matrix (LFM) (also known as MS);
- Duplicate of the LFM (also known as MSD). If no MS/MSD has been designated, a field duplicate or laboratory duplicate may be used;
- If pretreated samples are included in batch, Pretreat LRB, Pretreat LFB, Pretreat LFM (for each pretreated matrix); and

The calibration, QC, corrective action, and data qualifying requirements for method 314.0 are presented in Table 3–14.

Table 3-14 Summary of Calibration and QC Procedures for EPA Method E314.0

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Perchlorate	Multipoint calibration for all analytes (minimum 5 standards are recommended)	Initial calibration prior to sample analysis	*Option 1 linear*- Mean RSD ≤15 percent	Correct problem then repeat initial calibration
			Option 2 linear – least squares regression r > 0.995	

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
			Option 3 non-linear – COD ≥ 0.990 (6 points shall be used for second order, 7 points shall be used for third order)	
	Second-source calibration verification – Quality Control Sample (QCS)	Once per multipoint calibration, upon reestablishing calibration, quarterly	Instrument response within ± 10 percent of expected value	Correct problem then repeat initial calibration
	Instrument Performance Check (IPC)	Daily, before sample analysis	Conductance within 10 percent of original value (original value within ± 10 percent of MCT)	Prepare fresh IPC solution
			$PD_{A/H}$ < 25 percent, instrument response within ± 20 percent of expected response	Redetermine MCT or correct problem and reanalyze IPC
			Retention time shifts < 5 percent, or overall retention time < 80 percent of original recorded value	Correct problem, clean or replace column
	Initial calibration verification (ICCS)	Daily, before sample analysis or when eluent is changed	Instrument response within ± 25 percent of expected value using a standard at or below the RL	Correct problem then repeat initial calibration
	Calibration verification (CCCS/ECCS)	After every 10 samples (CCCS) and at the end of the analysis sequence (ECCS)	Instrument response within ± 15 percent of expected response, alternately using separate mid and high level standards	Correct problem then repeat initial calibration verification and reanalyze all samples since last successful calibration verification
	Method blank (LRB)	One per analytical batch	Perchlorate must be ≤ ½ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	Laboratory fortified blank (LFB)	One LFB per analytical batch following the ICCS	Instrument response within ± 15 percent of expected response	Correct problem then reprep and analyze the LCS and all samples in the affected analytical batch
	Pretreated laboratory reagent blank (LRB)	Required in any analytical batch which includes samples that have been pretreated to reduce the common anion levels	Perchlorate must be ≤ ½ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	Laboratory fortified matrix (LFM) and duplicate	One pair per every 20 project samples per matrix	QC acceptance criteria	None
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	MCT determination	At initial set-up, once per 12-month period	Calculate $PD_{A/H}$ for the perchlorate peak at increasing concentrations of mixed common anion solution The MCT is the matrix conductance where the $PD_{A/H}$ exceeds 20 percent	*Option 1* -least squares regression: plot $PD_{A/H}$ versus matrix conductance, ($r^2 > 0.95$) *Option 2* – Use the conductance level of the highest mixed anion solution which yielded a $PD_{A/H}$ value < 20 percent
	RL verification	At initial set-up, once per 12-month period	Instrument response within ± 30 percent of expected response for a mixed common anion solution containing perchlorate at the RL and conductance within ± 10 percent of the MCT	Lower the MCT by 10 percent and repeat the RL verification
	MDL study	At initial set-up, once per 12-month period	Detection limits established shall be ≤ ½ the RLs	None

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.3 Method 331.0/332.0 – Perchlorate

A high-pressure liquid chromatography (HPLC) method with mass detection is used for determination of ppb and sub-ppb levels of perchlorate in water, soil, and sediment matrices. Aqueous samples can be analyzed directly without any preparatory extraction or undergo cartridge cleanup similar to that in EPA Method 314.0. If sample cleanup is performed, all QC samples such as method blanks, LCSs, MS/MSDs must be treated in a similar manner. Perchlorate in soil samples is extracted with a 10:1 mixture (water to soil). The extract is filtered and analyzed as any other aqueous sample. The liquid chromatograph (LC) is equipped with an ion exchange column to separate perchlorate from other species and an electrospray interface (ESI) operated in the negative ion mode between the LC and the spectrometer system. Perchlorate contains two naturally occurring isotopes of chlorine (Cl^{35} and Cl^{37}) which have a natural abundance ratio of 3.08:1. Quantitation is based on the major ion with the secondary ion and isotopic ratios used for confirmation.

The method employs an ^{18}O-labeled internal standard ($^{35}Cl^{18}O_4^-$, m/z = 107) for quantitation. Tuning may be accomplished using polyethylene glycol (PEG) 400 or other tuning standards which span the masses of interest as recommended by the manufacturer's specifications or other documented source.

Table 3–15 summarizes the QC checks and associated minimum frequencies, acceptance criteria, and corrective actions for HPLC methods. The QC checks include initial and continuing calibration, retention times, and other checks for precision and accuracy. Apply method QC from EPA method E300.0 and follow general data qualifying conventions.

Table 3-15 Summary of Calibration and QC Procedures for EPA Methods 331.0/332.0

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Perchlorate	Mass calibration	Daily, before sample analysis	Tuning standards should span the working range for the analysis. Mass assignments should be within ± 0.3 mass units of target values	Retune instrument and verify.
	Initial multipoint calibration for all analytes (minimum five standards) (ICAL)	Initial calibration prior to sample analysis	One of the options below : *Option 1*: linear – RSD for each analyte < 20% *Option 2*: linear – least squares regression r ≥ 0.995 for each analyte. *Option 3*: non-linear – COD ≥ 0.99 (six points shall be used for second order, seven points shall be used for third order)	Correct problem then repeat initial calibration.
	Second-source calibration verification	Once after each ICAL	All analytes within ± 25% of expected value	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat initial calibration.
	Retention time window position establishment for each analyte and surrogate	Once per ICAL	Position shall be set using the midpoint standard of the initial calibration curve.	N/A
	Retention time window verified for each analyte	Each sample	Relative retention time (RRT) of the analyte within ± 0.06 RRT units of the ICAL (within ± 0.02 RRT units for perchlorate)	Correct problem then reanalyze all samples analyzed since the last retention time check.
	Calibration verification: initial (ICV) and continuing (CCV)	ICV: Daily, before sample analysis, unless ICAL performed on same day CCV: After every 10 samples and at the end of the analysis sequence	All analytes within ± 20% of expected value (% D)	ICV: Correct problem, rerun ICV. If that fails, repeat initial calibration. CCV: Correct problem then repeat CCV. Reanalyze all samples since last successful calibration verification.
	Internal Standards (ISs)	Every sample, spiked sample, standard, and method blank	Retention time ± 30 seconds from retention time of the IS in the ICAL mid-point std. Peak area within ± 50% of area from IS in ICAL mid-point standard	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while the system was malfunctioning is mandatory.

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	^{35}Cl:^{37}Cl isotope ratio (perchlorate only)	Every sample, spiked sample, standard, and method blank	Isotopic ratio between 2.35 – 3.85 (± 25% of theoretical)	Reanalyze. If necessary, reprep sample and repeat analysis.
	Method Blank	One per analytical batch	No analytes detected > ½ RL	Assess data. Correct problem. If necessary, reprep and analyze method blank and all samples processed with the contaminated blank.
	LCS for all analytes	One LCS per analytical batch	Acceptance criteria of the method.	Correct problem then reanalyze. If still out, reprep and reanalyze the LCS and all samples in the affected batch.
	MS/MSD	One MS/MSD per every 20 Air Force project samples per matrix	Acceptance criteria of the method.	Assess data to determine whether there is a matrix effect or analytical error. Analyze LCS for failed target analytes. Potential matrix effects should be communicated to the Performing Contractor so an evaluation can be made with respect to the PQOs.
	Surrogate spike	Every sample, spiked sample, standard, and method blank	Acceptance criteria of the method.	Correct problem then re-extract and reanalyze the affected samples. If matrix effect is verified, discuss in case narrative
	MDL study	At initial setup and subsequently once per 12-month period or quarterly MDL verification checks.	Detection limits established shall be ≤ ½ the RLs. See 40 CFR, Part 136 Appendix B. All analytes must be detected and identified by method-specified criteria for the for the verification check to be valid, or the verification check must produce a response that is at least 3X the instrument noise level and greater than the response in the blanks associated with the MDL study.	Run MDL verification check at higher level and set higher MDL or reconduct MDL study.

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.4 Method E521: N-Nitrosodimethylamine by Solid Phase Extraction (SPE) and Capillary Column GC with Large-volume injection and chemical ionization tandem MS (MS/MS)

N-Nitrosodimethylamine in water samples are analyzed using method E521. This method uses a capillary column GC/MS/MS technique. N-Nitrosodimethylamine is introduced into the GC by injection or other approved method.

Mass calibrate the MS in electron impact (EI) mode using FC-43 or the tuning compound recommended by the MS manufacturer. The recommended manifold temperature is 50 °C, and the recommended trap temperature is 150 °C. On other instruments, the manufacturer's recommendation for instrument temperatures should be followed.

The internal standard (IS) method is used for quantitation of analytes of interest. For quantitation, response factors (RFs) are calculated from the base ion peak of a specific IS added to each calibration standard, blank, QC sample, and sample. Additional calibration information, and the QC, and corrective action requirements for method E521 is presented in Table 3–16.

Table 3-16 Summary of Calibration and QC Procedures for EPA Method E521

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Volatile Organics	Seven-point initial calibration for all analytes	Initial calibration prior to sample analysis	RSD < 30 percent	Correct problem then repeat initial calibration
			option 1 linear-mean RSD for all analytes ≤15 percent with no individual analyte RSD >30 percent	
	Second-source calibration verification	Once per seven-point initial calibration	All analytes within ±25 percent of expected value	Correct problem then repeat initial calibration
	Retention time window calculated for each analyte	Each sample	Relative retention time (RRT) of the analyte within ± 0.06 RRT units of the RRT	Correct problem then reanalyze all samples analyzed since the last retention time check
	Continuing calibration verification	Daily, before sample analysis and after every 12 hours of analysis time	Percent difference ≤ 25 percent	Correct problem then repeat initial calibration
			All calibration analytes within ±20 percent of expected value	

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Internal Standards (ISs)	Each sample	Retention time ±30 seconds from retention time of the IS in the ICAL mid-point std. EICP area within -50 percent to +100 percent of area from IS in ICAL mid-point std.	Inspect mass spectrometer and GC for malfunctions; if system was malfunctioning, mandatory reanalysis of associated samples
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	none
	Surrogate spike	Every sample, spiked sample, standard, and method blank	QC acceptance criteria	Correct problem then reextract and analyze sample
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	None

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.5 Method E524.1: 1,2,3-Trichloropropane by Gas Chromatography/Mass Spectrometry for Water and Soil

Volatile (or purgeable) organics in water samples are analyzed using method E524.1. This method uses a capillary column GC/MS technique. Volatile compounds are introduced into the GC by purge and trap (SW5030B) or other approved method. An inert gas is bubbled through the water samples (or a soil-water slurry for soil samples) to transfer the purgeable organic compounds from the liquid to vapor phase. The vapor is then swept through a sorbent trap where the purgeable organics are trapped. The trap is backflushed and heated to desorb the purgeable organics onto a capillary GC column where they are separated and then detected with an MS.

The mass spectrometer is tuned daily to give an acceptable spectrum for bromofluorobenzene (BFB). The tuning acceptance criteria are given in the following list as an ion abundance for each specified mass:

- Mass 50: 15 percent to 40 percent of mass 95;
- Mass 75: 30 percent to 60 percent of mass 95;
- Mass 95: 100 percent relative abundance (base peak);
- Mass 173: less than 2 percent of mass 174;
- Mass 174: greater than 50 percent of mass 95;
- Mass 175: 5 percent to 9 percent of mass 174;
- Mass 176: greater than 95 percent, but less than 101 percent of mass 174; and
- Mass 177: 5 percent to 9 percent of mass 176.

The internal standard (IS) method is used for quantitation of analytes of interest. For quantitation, RFs are calculated from the base ion peak of a specific IS added to each calibration standard, blank, QC sample, and sample. Additional calibration information, and the QC, and corrective action requirements for method E524.1 is presented in Table 3–17.

Method E524.1 SIM is a mode under the E524.1 method that is used to look for selected ions and has higher sensitivity.

Table 3-17 Summary of Calibration and QC Procedures for EPA Method E524.1 SIM

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Volatile Organics	Five-point initial calibration for all analytes	Initial calibration prior to sample analysis	SPCCs average RF ≥ 0.30[c] and percent RSD for RFs for CCCs ≤ 30 percent and one option below	Correct problem then repeat initial calibration
			option 1 linear-mean RSD for all analytes ≤15 percent with no individual analyte RSD >30 percent	
			option 2 linear – linear least squares regression r ≥ 0.995 for each analyte	
			option 3 non-linear – COD ≥ 0.990 (6 points shall be used for second order, 7 points shall be used for third order)	
	Second-source calibration verification	Once per five-point initial calibration	All analytes within ±25 percent of expected value	Correct problem then repeat initial calibration
	Retention time window calculated for each analyte	Each sample	Relative retention time (RRT) of the analyte within ± 0.06 RRT units of the RRT	Correct problem then reanalyze all samples analyzed since the last retention time check

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Continuing calibration verification	Daily, before sample analysis and after every 12 hours of analysis time	SPCCs average RF ≥ 0.30[c]; and CCCs ≤ 20 percent difference (when using RFs)or drift (when using least squares regression or non-linear calibration)	Correct problem then repeat initial calibration
			All calibration analytes within ±20 percent of expected value	
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Internal Standards (ISs)	Each sample	Retention time ±30 seconds from retention time of the IS in the ICAL mid-point std. EICP area within -50 percent to +100 percent of area from IS in ICAL mid-point std.	Inspect mass spectrometer and GC for malfunctions; if system was malfunctioning, mandatory reanalysis of associated samples
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	none
	Check of mass spectral ion intensities using BFB	Prior to initial calibration and calibration verification	Refer to criteria listed in the method description	Retune instrument and verify
	Surrogate spike	Every sample, spiked sample, standard, and method blank	QC acceptance criteria	Correct problem then reextract and analyze sample
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	None

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.6 Method E529: Explosives by Solid Phase Extraction (SPE) and Capillary Column Has Chromatography /Mass Spectrometry for Water and Soil

Explosives in water and soil samples are analyzed using method E529. This method uses a capillary column GC/MS technique. Explosives are introduced into the GC by purge and trap or other approved

method. The mass spectrometer is tuned daily to give an acceptable spectrum for BFB. The tuning acceptance criteria are given in the following list as an ion abundance for each specified mass:

- Mass 50: 15 percent to 40 percent of mass 95;
- Mass 75: 30 percent to 60 percent of mass 95;
- Mass 95: 100 percent relative abundance (base peak);
- Mass 173: less than 2 percent of mass 174;
- Mass 174: greater than 50 percent of mass 95;
- Mass 175: 5 percent to 9 percent of mass 174;
- Mass 176: greater than 95 percent, but less than 101 percent of mass 174; and
- Mass 177: 5 percent to 9 percent of mass 176.

The internal standard (IS) method is used for quantitation of analytes of interest. For quantitation, RFs are calculated from the base ion peak of a specific IS added to each calibration standard, blank, QC sample, and sample. Additional calibration information, and the QC, and corrective action requirements for method E529 is presented in Table 3–18.

Method E529 SIM is a mode under the E529 method that is used to look for selected ions and has higher sensitivity.

Table 3-18 Summary of Calibration and QC Procedures for EPA Method E529 SIM

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Explosives	Seven-point initial calibration for all analytes	Initial calibration prior to sample analysis	RSD< 30 percent	Correct problem then repeat initial calibration
	Second-source calibration verification	Once per seven-point initial calibration	All analytes within ±25 percent of expected value	Correct problem then repeat initial calibration
	Retention time window calculated for each analyte	Each sample	Relative retention time (RRT) of the analyte within ± 0.06 RRT units of the RRT	Correct problem then reanalyze all samples analyzed since the last retention time check
	Continuing calibration verification	Daily, before sample analysis and after every 12 hours of analysis time	Percent difference ≤ 25 percent	Correct problem then repeat initial calibration
			All calibration analytes within ±20 percent of expected value	

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Internal Standards (ISs)	Each sample	Retention time ±30 seconds from retention time of the IS in the ICAL mid-point std. EICP area within -50 percent to +100 percent of area from IS in ICAL mid-point std.	Inspect mass spectrometer and GC for malfunctions; if system was malfunctioning, mandatory reanalysis of associated samples
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	none
	Surrogate spike	Every sample, spiked sample, standard, and method blank	QC acceptance criteria	Correct problem then reextract and analyze sample
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	None

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.7 Method SW6010B: Trace Elements (Metals) by Inductively Coupled Plasma Atomic Emission Spectroscopy for Water and Soil

Samples are analyzed for trace elements or metals using method SW6010B for water and soils. Analysis for most metals requires digestion of the sample. Following digestion, the trace elements are determined simultaneously or sequentially using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICPES). The calibration, QC, and corrective action requirements are presented in Table 3–19.

Table 3-19 Summary of Calibration and QC Procedures for EPA Method SW6010B

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
ICP Metals	Initial calibration (minimum 1 standard and a blank)	Daily initial calibration prior to sample analysis	If more than one standard is used, correlation coefficient must be ≥ 0.995	If applicable, correct problem and repeat initial calibration
	Initial calibration verification (second source)	Daily after initial calibration	All analytes within ±10 percent of expected value	Correct problem then repeat initial calibration
	Calibration verification (Instrument Check Standard)	After every 10 samples and at the end of the analysis sequence	All analyte(s) within ±10 percent of expected value and RSD of replicate integrations <5 percent	Repeat calibration and reanalyze all samples since last successful calibration
	Calibration blank	After every calibration verification	No analytes detected ≥ RL	Correct problem then analyze calibration blank and previous 10 samples
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Low level calibration check standard (at or below RL)	Once per analytical batch prior to sample analysis unless multi-point (3+) calibration with low std at or below RL is performed	All analyte(s) with ± 50 percent of expected value	Correct problem then reanalyze
	Linear range calibration (high) check standard	Every three months	Analyte within ± 10 percent of expected value	Correct problem then reanalyze or re-set linear range
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
ICP Metals	Interference check solution (ICS)	At the beginning of an analytical run	Within ±20 percent of expected value	Terminate analysis; correct problem; reanalyze ICS; reanalyze all affected samples
	LCS for the analyte	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	Dilution test	Each new sample matrix, at least once per analytical batch (only applicable for analytes with concentrations ≥50X MDL)	Fivefold (1+4) dilution must agree within ±10 percent of the original determination	Perform post digestion spike addition

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Post-digestion spike addition	When dilution test fails or if an analyte's concentration for all samples in a batch is less than 50X MDL	Recovery within 75-125 percent of expected results	Check for instrumental problem then reanalyze post digestion spike addition if appropriate
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	None
	MDL study	Once per 12-month period	Detection limits established shall be ≤ ½ the RLs	None

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.8 Method SW6020: Trace Elements (Metals) by Inductively Coupled Plasma/Mass Spectrometry for Water and Soil

Samples are analyzed for trace elements or metals using method SW6020 for water and soils. Analysis for total (i.e., acid leachable) metals requires digestion of the sample. Following digestion, the trace elements are determined simultaneously or sequentially using Inductively Coupled Plasma/Mass Spectrometry (ICP/MS). The calibration, QC, and corrective action requirements for method SW6020 are presented in Table 3-20.

Table 3-20 Summary of Calibration and QC Procedures for EPA Method SW6020

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
ICP/MS Metals	MS tuning sample	Prior to initial calibration and calibration verification	SW6020 paragraph 5.8	Retune instrument then reanalyze tuning solution
	Initial calibration (minimum 1 standard and a blank)	Daily initial calibration prior to sample analysis	If more than one standard is used, correlation coefficient must be ≥ 0.995	If applicable, correct problem and repeat initial calibration
	Calibration blank	Before beginning a sample run, after every 10 samples and at end of the analysis sequence	No analytes detected ≥ RL	Correct problem then analyze calibration blank and previous 10 samples
	Initial calibration verification (Second source standard)	After initial calibration before beginning a sample run – at a concentration other than used for calibration	All analytes within ±10 percent of expected value	Correct problem then repeat initial calibration
	Continuing calibration verification	After every 10 samples and at the end of the analysis sequence	All analytes within ±10 percent of expected value	Correct problem then repeat calibration and reanalyze all samples since last successful calibration

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Low level calibration check standard (at or below RL)	Once per analytical batch prior to sample analysis unless multi-point (3+) calibration with low std at or below RL is performed	All analyte(s) with ± 50 percent of expected value	Correct problem then reanalyze
	Linear range calibration (high) check standard	Every 3 months	Analyte within ± 10 percent of expected value	Correct problem then reanalyze or re-set linear range
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem reprep and analyze method blank and all samples processed with the contaminated blank
	Interference check solutions (ICS-A and ICS-AB)	At the beginning and end of a analytical run or once during an 12-hour period, whichever is more frequent	ICS-A All non-spiked analytes < RL unless they are a verified trace impurity from one of the spiked analytes ICS-AB Within ±20 percent of true value	Terminate analysis; locate and correct problem; reanalyze ICS; reanalyze all affected samples
	LCS for the analyte	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	Dilution test	Each matrix in a analytical batch (only applicable for analytes with concentrations ≥100X MDL)	Fivefold (1+4) dilution must agree within ±10 percent of the original determination	Perform post digestion spike addition
	Post digestion spike addition	When dilution test fails or if an analyte's concentration for all samples in a batch is less than 100X MDL	Recovery within 75–125 percent of expected results	Dilute the sample; reanalyze post-digestion spike addition
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	None
	Internal Standards (IS)	Every sample	IS intensity within 30-120 percent of intensity of the IS in the initial calibration	Perform corrective action as described in method SW6020
	IDL study	Every 3 months	Detection limits established shall be ≤ ½ the RLs	None
	MDL study	Every 12 months Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	None	None	None

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.9 Method SW7199: Hexavalent Chromium (Ion Chromatography) for Water and Soil

This method for determination of hexavalent chromium is applicable to water samples. Samples containing high anionic species such as sulfide and chloride may cause column overload. Samples containing high levels of organics or sulfides causes rapid reduction of soluble hexavalent chromium to trivalent chromium. The calibration, QC, and corrective action requirements for method SW7199 are presented in Table 3–21.

Table 3-21 Summary of Calibration and QC Procedures for EPA Method SW7199/E218.6

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Hexavalent Chromium	Multipoint calibration curve (minimum three standards and a blank)	Initial calibration prior to sample analysis	Correlation coefficient ≥0.999 for linear regression	Correct problem then repeat initial calibration
	Second-source calibration verification	After each new stock standard preparation	Analytes within ±10% of expected value	Correct problem then repeat initial calibration
	Calibration verification	After every 10 samples and at the end of the analysis sequence	Chromium within ±10% of expected value	Correct problem then repeat initial calibration and reanalyze all samples since last successful calibration
	Method blank	One per analytical batch	No analyte detected > RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS	One LCS per analytical batch	QC acceptance as per the QAPP	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria as per the QAPP	None

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.10 Method SW7470A/SW7471A: Mercury Manual Cold-Vapor Technique for Water and Soil

Water and soil samples are analyzed for mercury using methods SW7470A and SW7471A, respectively. This method is a cold-vapor, flameless atomic absorption (AA) technique based on the absorption of radiation by mercury vapor. Mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an AA spectrophotometer. Mercury concentration is measured as a function of absorbance. The calibration, QC, and corrective action requirements for methods SW7470A and SW7471A are presented in Table 3–22.

Table 3-22 Summary of Calibration and QC Procedures for EPA Method SW7470A/SW7471A

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Mercury	Initial multipoint calibration (minimum 5 standards and a blank)	Daily initial calibration prior to sample analysis	Correlation coefficient ≥0.995 for linear regression	Correct problem then repeat initial calibration
	Second-source calibration check standard	Once per initial daily multipoint calibration	Analyte within ±10 percent of expected value	Correct problem then repeat initial calibration
	Calibration blank	Once per initial daily multipoint calibration	No analyte detected ≥ RL	Correct problem then reanalyze calibration blank and all samples associated with blank
	Calibration verification	After every 10 samples and at the end of the analysis sequence	The analyte within ±20 percent of expected value	Correct problem then repeat calibration and reanalyze all samples since last successful calibration
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for the analyte	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze. If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Dilution test	Each matrix in an analytical batch (only applicable for samples with concentrations ≥25X MDL)	Fivefold (1+4) dilution must agree within ±10 percent of the original determination	None
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	None
	MDL study	Once per 12-month period	Detection limits established shall be ≤ ½ the RLs	None

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.Method 8015 (Modified): -Volatile and Extractable Total Petroleum Hydrocarbons by Gas Chromatography for Water and Soil

Volatile petroleum hydrocarbon components, such as gasoline, jet fuel, and other low molecular weight petroleum products, are analyzed by the direct purge and trap technique described in method SW5030B followed by a modified approach to method SW8015. Extractable TPH components are analyzed by extraction followed by GC analysis.

For volatile TPH, the sample is placed in the purge and trap sparge vessel and analysis is conducted using a GC equipped with a FID.

Extractable TPH components, such as kerosene, diesel, motor oil, and other high molecular weight extractable petroleum products, are typically prepared by method SW3520C or SW3510C for water-based matrices or by method SW3550B for soil/sludge matrices. After the sample is extracted, analysis is accomplished on a GC equipped with a capillary or megabore column and a FID.

Identification and quantitation of TPH components require more analytical judgment than other GC methods. The TPH chromatograms consist of groups of peaks that fall within a noted carbon retention time range (i.e., number of carbon atoms in the molecule). Standard fuel components are used to calibrate the instruments. The total petroleum hydrocarbons results are reported in mg/kg or mg/L based on quantitation of the total area count for the gasoline range organics (i.e., C6-C10) or the diesel range organics (i.e., C10-C28). The retention time window shall be set such that the window encompasses only the C6 through C28 range of organics. The calibration, QC, and corrective action requirements are given in Table 3-23. Second column confirmation is not required.

Table 3-23 Summary of Calibration and QC Procedures for EPA Method 8015B (Modified)

Method	Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
SW8015 (mod)	Volatile and Extractable Total Petroleum Hydrocarbons	Five-point initial calibration for all analytes	Initial calibration prior to sample analysis	linear - mean RSD for all analytes ≤20% with no individual analyte RSD >30%	Correct problem then repeat initial calibration
				linear – least squares regression r ≥ 0.995	
				non-linear – COD ≥ 0.990 (6 points shall be used for second order, 7 points shall be used for third order)	
		Continuing calibration verification	Daily, before sample analysis	All concentration levels of GRO within ±15% of expected value	Correct problem then repeat initial calibration
			After every 10 samples and at the end of the analysis sequence	All concentration levels within ±15% of initial calibration	Correct problem then repeat initial calibration verification and reanalyze all samples since last successful calibration verification
		Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
		Method blank	One per analytical batch	No TPH detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
		LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected batch
		Surrogate spike	Every sample, spiked sample, standard, and method blank	QC acceptance criteria	Correct problem then reextract and analyze sample
		MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	none
		Retention time window	Each initial calibration	GRO – calculate retention time based on	Correct problem then reanalyze all samples

Method	Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
		calculated		2-methylpentane and 1,2,4-trimethylbenzene	analyzed since the last valid retention time check
				DRO - calculate retention time based on C10 and C28 alkanes	
		MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	none

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.11 Method SW8081A: Organochlorine Pesticides by Gas Chromatography for Water and Soil

Organochlorine pesticides in water and soil samples are analyzed using method SW8081A. This analytical method involves the extraction of the samples. The pesticides are then separated and quantified by GC using electron capture detection. The calibration, QC, and corrective action requirements are presented in Table 3–24. Any compounds identified tentatively in the primary analysis, "including those detected at concentrations between the MDL and RL," are confirmed on a second GC column. A second-column confirmation is not required for the analysis of toxaphene or technical chlordane.

Table 3-24 Summary of Calibration and QC Procedures for EPA Method SW8081A

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Organo-chlorine pesticides	Five-point initial calibration for all analytes	Initial calibration prior to sample analysis	Linear - mean RSD for all analytes ≤20 percent with no individual analyte RSD >30 percent	Correct problem then repeat initial calibration
			linear – least squares regression r ≥ 0.995 for each analyte	
			Non-linear – COD ≥ 0.990 (6 points shall be used for second order, 7 points shall be used for third order)	
	Second-source calibration verification for all analytes	Once per five-point initial calibration	All analytes within ±15 percent of expected value	Correct problem then repeat initial calibration

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Retention time window calculated for each analyte	Each initial calibration and calibration verifications	± 3 times standard deviation for each analyte retention time from 72-hour study	Correct problem then reanalyze all samples analyzed since the last retention time check
	Continuing calibration verification	Daily, before sample analysis	All analytes within ±15 percent of expected value	Correct problem then repeat initial calibration
		After every 10 samples and at the end of the analysis sequence	All analytes within ±15 percent of expected value	Correct problem then repeat initial calibration verification and reanalyze all samples since last successful calibration verification
	Breakdown check (Endrin and DDT)	Daily prior to analysis of samples	Degradation ≤15 percent	Repeat breakdown check
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyses of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	Surrogate spike	Every sample, spiked sample, standard, and method blank	QC acceptance criteria	Correct problem then reextract and analyze sample
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	none
	Second-column confirmation (excluding toxaphene and chlordane)	100 percent for all positive results	Same as for initial or primary column analysis	Same as for initial or primary column analysis
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	none
	Results reported between MDL and RL	none	None	none

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyses of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
Organo-chlorine pesticides	Surrogate spike	Every sample, spiked sample, standard, and method blank	QC acceptance criteria	Correct problem then reextract and analyze sample
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	none
	Second-column confirmation (excluding toxaphene and chlordane)	100 percent for all positive results	Same as for initial or primary column analysis	Same as for initial or primary column analysis
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	none

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.12 Method SW8082: Polychlorinated Biphenyls by Gas Chromatography for Water and Soil

PCBs in water and soil samples are analyzed using method SW8082. This analytical method involves the extraction of the samples. The PCBs are then separated and quantified by GC using an electron capture detector or electrolytic conductivity detector. The calibration, QC, and corrective action requirements for method SW8082 are presented in Table 3–25.

For analysis of PCBs, the initial five-point calibration and second source calibration verification standards shall, as a minimum contain a mixture of the Aroclors 1016 and 1260. Retention times shall be set during the initial five-point calibration. The initial and daily calibration verifications may be done using an Aroclor 1016/1260 PCB mixture. Single standards of each of the other five Aroclors are required to aid

the analyst in pattern recognition. Assuming that the Aroclor 1016/1260 standards have been used to validate the linearity of the detector, the single standards of the remaining five Aroclors may be used to determine the response factor (RF) for each Aroclor. The concentrations of the individual Aroclor standards should be at or below the middle of the linear range of the detector. If an Aroclor other than 1016 or 1260 is detected (i.e., qualitatively identified above the MDL based on its pattern), report the result for that Aroclor using the RF from the single Aroclor standard (linear through origin). The LCS and MS/MSD should be spiked using the 1016/1260 mix. A second-column confirmation is not required.

Table 3-25
Summary of Calibration and QC Procedures for EPA Method SW8082

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
PCBs	Five-point initial calibration	Initial calibration prior to sample analysis	Linear - mean RSD for all analytes ≤20 percent	Correct problem then repeat initial calibration
			Linear – least squares regression r ≥ 0.995 for each analyte	
	Second-source calibration verification for PCB 1016/1260 mix	Once per five-point initial calibration	Mix within ±15 percent of expected value	Correct problem then repeat initial calibration
	Retention time window calculated for PCB 1016/1260 mix	Each initial calibration and calibration verifications	± 3 times standard deviation for each quantitation peak retention time from 72-hour study	Correct problem then reanalyze all samples analyzed since the last retention time check
	Continuing calibration verification for PCB 1016/1260 mix	Daily, before sample analysis	Results within ±15 percent of expected value	Correct problem then repeat initial calibration
		After every 10 samples and at the end of the analysis sequence	Results within ±15 percent of expected value	Correct problem then repeat initial calibration verification and reanalyze all samples since last successful calibration verification
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	LCS (1016/1260 mix)	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	Surrogate spike	Every sample, spiked sample, standard, and method blank	QC acceptance criteria	Correct problem then reextract and analyze sample
	MS/MSD (1016/1260 mix)	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	None
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	none

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.13 Method 8141A: Organophosphorus Pesticides by Gas Chromatography for Water and Soil

Method SW8141A is a GC method used to determine the concentrations of various organophosphorus pesticides. This analytical method involves extraction of the samples. An aliquot of the extract is injected into a GC and compounds in the GC effluent are detected with a flame photometric or nitrogen-phosphorus detector. Any compounds identified tentatively in the primary analysis are confirmed on a second GC column. The calibration, QC, and corrective action requirements are given in Table 3-26.

Table 3-26 Summary of Calibration and QC Procedures for EPA Method 8141A

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Organophos-phorus pesticides	Five-point initial calibration for all analytes	Initial calibration prior to sample analysis	linear - mean RSD for all analytes ≤20% with no individual analyte RSD >30%	Correct problem then repeat initial calibration
			linear – least squares regression r ≥ 0.995 for each analyte	
			non-linear – COD ≥ 0.990 (6 points shall be used for second order, 7 points shall be used for third order)	
	Second-source calibration verification	Once per five-point initial calibration	All analytes within ±15% of expected value	Correct problem then repeat initial calibration

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Retention time window calculated for each analyte	Each initial calibration and calibration verifications	± 3 times standard deviation for each analyte retention time from 72-hour study	Correct problem then reanalyze all samples analyzed since the last retention time check
	Continuing calibration verification	Daily, before sample analysis	All analytes within ±15% of expected value	Correct problem then repeat initial calibration
		After every 10 samples and at the end of the analysis sequence	All analytes within ±15% of expected value	Correct problem then repeat initial calibration verification and reanalyze all samples since last successful calibration verification
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria,	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected batch
	Surrogate spike	Every sample, spiked sample, standard, and method blank	QC acceptance criteria,	Correct problem then reextract and analyze sample
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	none
	Second-column confirmation	100% for all positive results	Same as for initial or primary column analysis	Same as for initial or primary column analysis
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	none

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.14 Method SW8151A: Chlorinated Herbicides by Gas Chromatography for Water and Soil

Method SW8151A is a capillary GC method for determining selected chlorinated acid herbicides and related compounds. Samples are extracted then esterified. The esters are determined by GC employing an electron capture detector. Any compounds identified tentatively in the primary analysis are confirmed on a second GC column. The calibration, QC, and corrective action requirements for method SW8151A are presented in Table 3–27.

Table 3-27
Summary of Calibration and QC Procedures for EPA Method SW8151A

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Chlorinated Herbicides	Five-point initial calibration for all analytes	Initial calibration prior to sample analysis	Linear - mean RSD for all analytes ≤20 percent with no individual analyte RSD >30 percent	Correct problem then repeat initial calibration
			Linear – least squares regression r ≥ 0.995 for each analyte	
			Non-linear – COD ≥ 0.990 (6 points shall be used for second order, 7 points shall be used for third order)	
	Second-source calibration verification	Once per five-point initial calibration	All analytes within ±15 percent of expected value	Correct problem then repeat initial calibration
	Retention time window calculated for each analyte	Each initial calibration and calibration verifications	± 3 times standard deviation for each analyte retention time from 72-hour study	Correct problem then reanalyze all samples analyzed since the last retention time check
	Continuing calibration verification	Daily, before sample analysis	All analytes within ±15 percent of expected value	Correct problem then repeat initial calibration
		After every 10 samples and at the end of the analysis sequence	All analytes within ±15 percent of expected value	Correct problem then repeat initial calibration verification and reanalyze all samples since last successful calibration verification
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze, If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	Surrogate spike	Every sample, spiked sample, standard, and method blank	QC acceptance criteria	Correct problem then reextract and analyze sample

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	None
	Second-column confirmation	100 percent for all positive results	Same as for initial or primary column analysis	Same as for initial or primary column analysis
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	None

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.15 Method SW8260B/SW8260B SIM: Volatile Organics by Gas Chromatography/Mass Spectrometry for Water and Soil

Volatile (or purgeable) organics in water and soil samples are analyzed using method SW8260B. This method uses a capillary column GC/MS technique. Volatile compounds are introduced into the GC by purge and trap (SW5030B or SW5035A) or other approved method. An inert gas is bubbled through the water samples (or a soil-water slurry for soil samples) to transfer the purgeable organic compounds from the liquid to vapor phase. The vapor is then swept through a sorbent trap where the purgeable organics are trapped. The trap is backflushed and heated to desorb the purgeable organics onto a capillary GC column where they are separated and then detected with an MS.

The mass spectrometer is tuned daily to give an acceptable spectrum for bromofluorobenzene. The tuning acceptance criteria are given in the following list as an ion abundance for each specified mass:

- Mass 50: 15 percent to 40 percent of mass 95;
- Mass 75: 30 percent to 60 percent of mass 95;
- Mass 95: 100 percent relative abundance (base peak);
- Mass 173: less than 2 percent of mass 174;
- Mass 174: greater than 50 percent of mass 95;
- Mass 175: 5 percent to 9 percent of mass 174;
- Mass 176: greater than 95 percent, but less than 101 percent of mass 174; and
- Mass 177: 5 percent to 9 percent of mass 176.

The internal standard (IS) method is used for quantitation of analytes of interest. For quantitation, RFs are calculated from the base ion peak of a specific IS added to each calibration standard, blank, QC sample, and sample. Additional calibration information, and the QC, and corrective action requirements for method SW8260B are presented in Table 3–28.

Method SW8260 SIM is a mode under the SW8260B method that is used to look for single ions and has higher sensitivity. Method SW8260 SIM has the same QA/QC requirements as those listed in Table 3–28.

Table 3-28 Summary of Calibration and QC Procedures for EPA Method SW8260B/SW8260B SIM

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Volatile Organics	Five-point initial calibration for all analytes	Initial calibration prior to sample analysis	SPCCs average RF ≥ 0.30 and percent RSD for RFs for CCCs ≤ 30 percent and one option below	Correct problem then repeat initial calibration
			option 1 linear-mean RSD for all analytes ≤15 percent with no individual analyte RSD >30 percent	
			option 2 linear – linear least squares regression r ≥ 0.995 for each analyte	
			option 3 non-linear – COD ≥ 0.990 (6 points shall be used for second order, 7 points shall be used for third order)	
	Second-source calibration verification	Once per five-point initial calibration	All analytes within ±25 percent of expected value	Correct problem then repeat initial calibration
	Retention time window calculated for each analyte	Each sample	Relative retention time (RRT) of the analyte within ± 0.06 RRT units of the RRT	Correct problem then reanalyze all samples analyzed since the last retention time check
	Continuing calibration verification	Daily, before sample analysis and after every 12 hours of analysis time	SPCCs average RF ≥ 0.30; and CCCs ≤ 20 percent difference (when using RFs)or drift (when using least squares regression or non-linear calibration)	Correct problem then repeat initial calibration
			All calibration analytes within ±20 percent of expected value	
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Internal Standards (ISs)	Each sample	Retention time ±30 seconds from retention time of the IS in the ICAL mid-point std. EICP area within -50 percent to +100 percent of area from IS in ICAL mid-point std.	Inspect mass spectrometer and GC for malfunctions; if system was malfunctioning, mandatory reanalysis of associated samples

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	none
	Check of mass spectral ion intensities using BFB	Prior to initial calibration and calibration verification	Refer to criteria listed in the method description	Retune instrument and verify
	Surrogate spike	Every sample, spiked sample, standard, and method blank	QC acceptance criteria	Correct problem then reextract and analyze sample
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	None

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.16 Method SW8270/SW8270 SIM: Semivolatile Organics by Gas Chromatography/Mass Spectrometry for Water and Soil

Semivolatile organics (also known as base/neutral and acid extractables) in water and soil samples are analyzed using method SW8270C. This technique determines quantitatively the concentration of a number of SVOCs. Samples are extracted and both base/neutral and acid extracts are then concentrated through evaporation. Compounds of interest are separated and quantified using a capillary column GC/MS.

The MS is tuned every 12 hours to give an acceptable spectrum for decafluorotriphenylphosphine (DFTPP). The tuning acceptance criteria are given in the following list as an ion abundance for each specified mass:

- Mass 96: 5 percent to 9 percent of mass 95;
- Mass 51: 30 percent to 60 percent of mass 198;
- Mass 68: less than 2 percent of mass 69;
- Mass 70: less than 2 percent of mass 69;
- Mass 127: 40 percent to 60 percent of mass 198;
- Mass 197: less than 1 percent of mass 198;
- Mass 198: base peak, 100 percent relative abundance;
- Mass 199: 5 percent to 9 percent of mass 198;
- Mass 275: 10 percent to 30 percent of mass 198;

- Mass 365: greater than 1 percent of mass 198;
- Mass 441: present, but less than mass 443;
- Mass 442: greater than 40 percent of mass 198; and
- Mass 443: 17 percent to 23 percent of mass 442.

The IS method is used for quantitation of analytes of interest. For quantitation, RFs are calculated from the base ion peak of a specific IS that is added to each calibration standard, blank, QC sample, and sample. Additional calibration information, QC, and corrective action requirements for method SW8270C are presented in Table 3–29.

Method SW8270C SIM is a mode under the SW8270C method that is used to analyze water or soil samples for semivolatile organics such as PAHs. The SIM mode allows for low-level detection and quantitation. Method SW8270C SIM has the same QA/QC requirements as those listed in Table 3–29.

Table 3-29
Summary of Calibration and QC Procedures for EPA Method SW8270C and SW8270C SIM

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Semi-Volatile Organics	Five-point initial calibration for all analytes	Initial calibration prior to sample analysis	SPCCs average RF ≥ 0.050 and percent RSD for RFs for CCCs ≤ 30 percent and one option below:	Correct problem then repeat initial calibration
			option 1 linear-mean RSD for all analytes ≤15 percent with no individual analyte RSD >30 percent;	
			option 2 linear – linear least squares regression r > 0.995 for each analyte;	
			option 3 non-linear – COD ≥ 0.990 (6 points shall be used for second order, 7 points shall be used for third order)	
	Second-source calibration verification	Once per five-point initial calibration	All analytes within ±25 percent of expected value	Correct problem then repeat initial calibration
	Retention time window calculated for each analyte	Each sample	Relative retention time (RRT) of the analyte within ± 0.06 RRT units of the RRT	Correct problem then reanalyze all samples analyzed since the last retention time check
	Continuing calibration verification	Daily, before sample analysis and every 12 hours of analysis time	SPCCs average RF ≥ 0.050; and CCCs ≤ 20 percent difference (when using RFs)or drift (when using least squares regression or non-linear calibration)	Correct problem then repeat initial calibration

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
			All calibration analytes within ±20 percent of expected value	
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Internal Standards (ISs)	Each sample	Retention time ±30 seconds from retention time of the IS in the ICAL mid-point std. EICP area within -50 percent to +100 percent of area of IS in ICAL mid-point std.	Inspect mass spectrometer and GC for malfunctions; if system was malfunctioning, mandatory reanalysis of associated samples
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze. If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	Check of mass spectral ion intensities using DFTPP	Prior to initial calibration and calibration verification	Refer to criteria listed in the method description	Retune instrument and verify
	Surrogate spike	Every sample, spiked sample, standard, and method blank	QC acceptance criteria	Correct problem then reextract and analyze sample
	MDL study	Once per 12-month period	Detection limits established shall be ≤ ½ the RLs	None

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.17 Method 8290A: Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans by Gas Chromatography/Mass Spectrometry for Water and Soil

Method SW8290 is used to analyze for polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in water, soil, and waste. This GC/MS method uses matrix-specific extraction, analyte-specific cleanup, and high-resolution capillary column GC/high resolution mass spectrometry techniques to separate and identify the analytes of interest. The sensitivity of the method is dependent on the level of matrix interference. Selected cleanup methods may be used to reduce or eliminate interferences. Target analytes may include all congener classes, tetra- through octa-dioxins and furans. Achieved detection limits vary according to matrix and analyte. Because of the extreme toxicity of these

compounds, the analyst must take appropriate precautions during preparation and analysis to prevent accidental exposure. The calibration, QC, and corrective action requirements are given in Table 3-30.

Table 3-30
Summary of Calibration and QC Procedures for EPA Method 8290A

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Dioxins/ Furans	Mass spectrometer tune	As per method SW8290	As per method SW8290	Retune instrument; verify
	Initial and continuing calibration	As per method SW8290	As per method SW8290	Correct problem then repeat calibration
	Identification/retention times/ion ratios/ signal to noise/ interferences	As per method SW8290	As per method SW8290	Correct problem and rerun
	System performance check	As per method SW8290	As per method SW8290	Correct problem and rerun
	Quality control checks	As per method SW8290	As per method SW8290	Correct problem and rerun
	Internal standard	As per method SW8290	As per method SW8290	Correct problem and rerun
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	none

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.18 Method SW8310: Polynuclear Aromatic Hydrocarbons by HPLC for Water and Soil

Method SW8310 is used to determine the concentration of ppb levels of selected PAHs in groundwater and soils by HPLC. Samples are extracted then analyzed by direct injection. Detection is by ultraviolet and fluorescent detectors. The calibration, QC, and corrective action requirements are given in Table 3-31.

Table 3-31
Summary of Calibration and QC Procedures for EPA Method SW8310

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Polynuclear Aromatic Hydrocarbons	Five-point initial calibration for all analytes	Initial calibration prior to sample analysis	linear - mean RSD of average CF of all analytes ≤20% and average CF of individual analyte <30% or mean RSD for all analytes ≤20% with no individual analyte RSD > 30%	Correct problem then repeat initial calibration

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
			linear – least squares regression r > 0.995 for each analyte	
			non-linear – COD ≥ 0.990 (6 points shall be used for second order, 7 points shall be used for third order)	
	Second-source calibration verification	Once per five-point initial calibration	All analytes within ±15% of expected value	Correct problem then repeat initial calibration
	Retention time window calculated for each analyte	Each initial calibration and calibration verifications	± 3 times standard deviation for each analyte retention time from 72-hour study	Correct problem then reanalyze all samples analyzed since the last retention time check
	Continuing calibration verification	Daily, before sample analysis	All analytes within ±15% of expected value	Correct problem then repeat initial calibration
		After every 10 samples and at the end of the analysis sequence	All analytes within ±15% of expected value	Correct problem then repeat initial calibration verification and reanalyze all samples since last successful calibration verification

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.19 Method SW8330A: Explosive Residues by HPLC for Water and Soil

Method SW8330 provides HPLC conditions for the detection of ppb levels of certain explosive residues in a water, soil, and sediment matrix. Prior to using this method, appropriate sample preparation techniques must be used.

Two low-level preparatory methods exist, salting out and solid phase extraction (SPE). In the salting-out method, aqueous samples of low concentration are extracted by a salting-out extraction procedure with no evaporation. SPE (Method SW3535A) is a procedure for isolating organic compounds from aqueous samples using solid-phase extraction media. SPE is the preferred method due to the increased accuracy and precision it gives over salting out. An aliquot of the extract is separated on a C-18 reverse-phase column, determined at 254 nanometers (nm), and confirmed on a cyanide reverse-phase column.

In the high-level direct injection method, aqueous samples of higher concentration can be diluted, filtered, separated on a C-18 reverse-phase column, determined at 254 nm, and confirmed on a cyanide reverse-phase column.

Soil and sediment samples are extracted in an ultrasonic bath and filtered before chromatography. The calibration, QC, and corrective action requirements are given in Table 3-32.

Table 3-32
Summary of Calibration and QC Procedures for EPA Method SW8330A

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Explosives	Five-point initial calibration for all analytes	Initial calibration prior to sample analysis	linear - mean RSD of average CF of all analytes ≤20% and average CF of individual analyte <30% or mean RSD for all analytes ≤20% with no individual analyte RSD > 30%	Correct problem then repeat initial calibration
			linear – least squares regression r ≥ 0.995 for each analyte	
			non-linear – COD ≥ 0.990 (6 points shall be used for second order, 7 points shall be used for third order)	
	Second-source calibration verification	Once per five-point initial calibration	All analytes within ±15% of expected value	Correct problem then repeat initial calibration
	Retention time window calculated for each analyte	Each initial calibration and calibration verifications	± 3 times standard deviation for each analyte retention time from 72-hour study	Correct problem then reanalyze all samples analyzed since the last retention time check
	Continuing calibration verification	Daily, before sample analysis	All analytes within ±15% of expected value	Correct problem then repeat initial calibration
		After every 10 samples and at the end of the analysis sequence	All analytes within ±15% of expected value	Correct problem then repeat initial calibration verification and reanalyze all samples since last successful calibration verification
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected batch
	Surrogate spike	Every sample, spiked sample, standard, and method blank	QC acceptance criteria	Correct problem then reextract and analyze sample
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	none
	Second Column Confirmation	100% for all positive results	Same as for initial or primary analysis	Same as for initial or primary analysis
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	none

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.20 Method RSK 175: Gases (Volatile Organics) by Gas Chromatography/Flame Ionization Detector in Water

Soil gases in water are sampled and analyzed using method RSK-175. This method uses a high resolution GC coupled with an FID.

The IS method is used for quantitation of analytes of interest. For quantitation, RFs are calculated from the area under the curve of a specific IS added to each calibration standard, blank, QC sample, and sample. The calibration, QC, and corrective action requirements are given in Table 3-33.

Table 3-33 Summary of Calibration and QC Procedures for EPA Method RSK 175

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Volatile Organics	Initial multipoint calibration minimum 3 standards	Initial calibration prior to sample analysis	%RSD for all calibration analytes ≤ 30% or linear regression correlation coefficient r≥ 0.995	Correct problem then repeat initial calibration
	Second-source calibration verification	Once per initial calibration	All analytes within ±25% of expected value	Correct problem then repeat initial calibration
	Calibration verification (one point)	Daily, before sample analysis and every 12 hours of analysis time	All calibration analytes within ±25% of expected value	Correct problem then repeat initial calibration

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
		Prior to initial calibration and calibration verification	Refer to criteria listed in the method description	Retune instrument and verify
	ISs	Each Sample.	Retention time ±30 seconds from retention time of the mid-point std. in the ICAL. EICP area within -50% to +100% of ICAL mid-point std.	Inspect GC/FID for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	none

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.21 Method AM20GAx: Gases in Water by Gas Chromatography

Method AM20GAx is used to determine the concentration of biodegradation indicator gases in vapor samples. Method AM20GAx is used to determine the dissolved concentration of hydrogen. The sample gas is analyzed with a gas chromatograph capable of simultaneous analysis of all of the target analytes from a single gas sample. A single injection of gas from integral, simultaneously filled sample loops is used to assure consistent injection volume. The permanent gases are analyzed using a thermal conductivity detector (TCD). The light hydrocarbons are analyzed using a flame ionization detector (FID). Hydrogen is analyzed using a reduction gas detector (RGD). The data are transferred to a microcomputer, converted to digital format, stored, and processed using a chromatography data system. The calibration, QC, and corrective action requirements are given in Table 3-34.

Table 3-34 Summary of Calibration and QC Procedures for AM20GAx

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Hydrogen	Initial multipoint calibration minimum 3 standards	Initial calibration prior to sample analysis	%RSD for hydrogen calibration ≤ 30% or linear regression correlation coefficient r≥ 0.995	Correct problem then repeat initial calibration
	Second-source calibration verification	Once per initial calibration	hydrogen within ±25% of expected value	Correct problem then repeat initial calibration
	Calibration verification (one point)	Daily, before sample analysis and every 12 hours of analysis time	hydrogen calibration within ±25% of expected value	Correct problem then repeat initial calibration
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for hydrogen that did not meet criteria
	Check of mass spectral ion intensities using BFB	Prior to initial calibration and calibration verification	Refer to criteria listed in the method description	Retune instrument and verify
	ISs	Each Sample.	Retention time ±30 seconds from retention time of the mid-point std. in the ICAL. EICP area within -50% to +100% of ICAL mid-point std.	Inspect mass spectrometer and GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning
	Method blank	One per analytical batch	No hydrogen detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for hydrogen	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	none

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.22 Method AM23G: Volatile Fatty Acids by Ion Chromatography in Water

This method determines low level volatile fatty acids in groundwater. Volatile fatty acids are not a contaminant but a metabolic by-product and measurement of their concentration can aid remedial effort.

The method used for this procedure is a modification of SW846-9056 in that this method uses an IC, a hydroxide eluent, an anion-exchange separation column, a hydronium based suppressor column and an electrical conductivity detector. The quality control requirements of SW846-9056 are inappropriate for this method due to inherent presence of matrix interference even in laboratory prepared samples. The quality control requirements of SW846-8000 are used for this method.

Samples are pretreated to remove potential interference. The pretreated samples are then spiked with a mix of compounds that serve as preservatives and internal retention time markers. Samples are then analyzed by ion exchange in an IC. In the alkaline solutions of the IC, the acids ionize to their conjugate anions. The anions are separated on an ion chromatograph and chemically converted to their acid form in an anion self-regenerating suppressor (ARSR). The volatile fatty acids pass through an electrical conductivity detector. The instrument responds by producing peaks that correspond to the individual VFA concentration. The calibration, QC, and corrective action requirements are given in Table 3-35.

Table 3-35 Summary of Calibration and QC Procedures for AM23G

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Volatile Fatty Acids	Multipoint calibration for all analytes (minimum 3 standards and one calibration blank)	Initial calibration prior to sample analysis	Correlation coefficient ≥0.995 for linear regression	Correct problem then repeat initial calibration
	Second-source calibration verification	Once per multipoint calibration	All analytes within ±10% of expected value	Correct problem then repeat initial calibration
	Retention time window calculated for each analyte	Each initial calibration and calibration verifications	± 3 times standard deviation for each analyte retention time over 8 hour period	Correct problem then reanalyze all samples analyzed since the last retention time check
	Initial calibration verification	Daily, before sample analysis or when eluent is changed	All analytes within ±10% of expected value	Correct problem then repeat initial calibration
	Calibration verification	After every 10 samples and at the end of the analysis sequence	Instrument response within ±10% of expected value	Correct problem then repeat initial calibration verification and reanalyze all samples since last successful calibration verification

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected batch
	Duplicate	One per every 10 samples	%D ≤10%	
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	none
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	none

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.23 Method 9056: Common Anions Ion Chromatography in Soil and Water

This method addresses the sequential determination of the anions chloride, fluoride, bromide, nitrate, nitrite, phosphate, and sulfate in aqueous samples, aqueous extracts of solids, and the collection solutions from the bomb combustion of solid waste samples.

A small volume of aqueous sample is injected into an ion chromatograph to flush and fill a constant volume sample loop. The sample is then injected into a stream of eluent.

The sample is pumped through three different ion exchange columns and into a conductivity detector. The first two columns, a precolumn (guard) column and a separator column, are packed with a low-capacity, strongly basic anion exchanger. Ions are separated into discrete bands based on their affinity for the exchange sites of the resin. The last column is a suppressor column that reduces the anions in the sample to their corresponding acids. The separated anions in their acid form are measured using an electrical-conductivity cell. Anions are identified based on their retention times compared to known standards. Quantitation is accomplished by measuring the peak height or area and comparing it to a calibration curve generated from known standards.

The calibration, QC, and corrective action requirements are given in Table 3-36.

Table 3-36 Summary of Calibration and QC Procedures for EPA Method 9056A

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Common anions	Multipoint calibration for all analytes (minimum 3 standards and one calibration blank)	Initial calibration prior to sample analysis	Correlation coefficient ≥0.995 for linear regression	Correct problem then repeat initial calibration
	Second-source calibration verification	Once per multipoint calibration	All analytes within ±10% of expected value	Correct problem then repeat initial calibration
	Retention time window calculated for each analyte	Each initial calibration and calibration verifications	± 3 times standard deviation for each analyte retention time over 8 hour period	Correct problem then reanalyze all samples analyzed since the last retention time check
	Initial calibration verification	Daily, before sample analysis or when eluent is changed	All analytes within ±10% of expected value	Correct problem then repeat initial calibration
	Calibration verification	After every 10 samples and at the end of the analysis sequence	Instrument response within ±10% of expected value	Correct problem then repeat initial calibration verification and reanalyze all samples since last successful calibration verification
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyzeIf still out, reprep and reanalyze the LCS and all samples in the affected batch
	Duplicate	One per every 10 samples	%D ≤10%	
	MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria	none
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	none

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.24 Method TO-15: Volatile Organics (Polar and Non-Polar) by Gas Chromatography/Mass Spectrometry

Volatile organics (polar and non-polar) in air are sampled and analyzed using method TO-15. This method uses a high resolution GC coupled to one or more appropriate detectors (i.e. a mass-selective detector).

Calibration—The mass spectrometer is tuned daily to give an acceptable spectrum for BFB. The tuning acceptance criteria are given in the following list as an ion abundance for each specified mass:

- Mass 50: 15 percent to 40 percent of mass 95;
- Mass 75: 30 percent to 60 percent of mass 95;
- Mass 95: base peak, 100 percent relative abundance;
- Mass 96: 5 percent to 9 percent of mass 95;
- Mass 173: less than 2 percent of mass 174;
- Mass 174: greater than 50 percent of mass 95;
- Mass 175: 5 percent to 9 percent of mass 174;
- Mass 176: greater than 95 percent, but less than 101 percent of mass 174; and
- Mass 177: 5 percent to 9 percent of mass 176.

The IS method is used for quantitation of analytes of interest. For quantitation, RFs are calculated from the base ion peak of a specific IS added to each calibration standard, blank, QC sample, and sample. The calibration, QC, and corrective action requirements are given in Table 3–37.

Table 3-37 Summary of Calibration and QC Procedures for EPA Method TO-15

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
Volatile organics	Initial multipoint calibration (minimum 3 standards and humid zero air)	Initial calibration prior to sample analysis	%RSD for all calibration analytes ≤ 30%	Correct problem then repeat initial calibration
	Second-source calibration verification	Once per three-point initial calibration	All analytes within ±25% of expected value	Correct problem then repeat initial calibration
	Calibration verification (one point)	Daily, before sample analysis and every 12 hours of analysis time	All calibration analytes within ±25% of expected value	Correct problem then repeat initial calibration

Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria
	Check of mass spectral ion intensities using BFB	Prior to initial calibration and calibration verification	Refer to criteria listed in the method description	Retune instrument and verify
	ISs	Immediately after or during data acquisition for the calibration verification standard.	Retention time ±30 seconds from retention time of the mid-point std. in the ICAL. EICP area within -50% to +100% of ICAL mid-point std.	Inspect mass spectrometer and GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning
	Method blank	One per analytical batch	No analytes detected ≥ RL	Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank
Volatile organics	LCS for all analytes	One LCS per analytical batch	QC acceptance criteria	Correct problem then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected analytical batch
	MDL study	Once per 12 month period	Detection limits established shall be ≤ ½ the RLs	None

Notes: a - All corrective actions associated with Site project work shall be documented, and all records shall be maintained by the laboratory.

3.6.4.1.25 Air Sample by Phase Contrast Microscopy (PCM) of Asbestos

The analysis includes testing of air sample for asbestos and other fibers by phase contrast microscopy (PCM). It is used primarily for estimating asbestos concentrations in air. It is used to show compliance with limits set by NIOSH, OSHA, and other regulatory agencies. The method does not differentiate between asbestos and other fibers and can also be used to estimate the airborne concentration of other, non-asbestos materials such as fibrous glass. Fibers less than 0.25 microns in diameter will not be detected with this method.

Asbestos analysis does not include the usual QC criteria found in other environmental analyses. There are no method blanks or multilevel calibrations performed for asbestos analysis. There are two QC elements that are common for asbestos testing: 1) documenting that the oil used for the microscope mounts is free from asbestos contamination; and 2) counting asbestos fibers on a reference standard slide.

Duplicate analyses can be used to indicate precision. Analysis of both the parent and duplicate sample must be performed by the same analysts for QC purposes.

3.6.4.1.26 Polarized Light Microscopy (PLM) of Asbestos

This method is the widely utilized for standard analysis of bulk materials for asbestos content. The analyst first pulverizes the sample and prepares microscope slides of bulk materials. Using a polarized light microscope (PLM), the analyst then tests optical properties of the sample components, giving both the asbestos types and estimated percentages in the sample material.

Asbestos analysis does not contain the usual QC criteria found in other environmental analyses. There are no method blanks or multilevel calibration performed for asbestos analysis. There are two QC elements that are common for asbestos testing 1) documenting oil purity that is free from asbestos contamination and 2) counting asbestos fibers on a reference standard slide. Duplicate analysis can be used to indicate precision. Analysis of both the parent and duplicate sample must be performed by the same analysts for QC purposes.

3.6.4.1.27 Transmission Electron Microscopy (TEM) of Asbestos

Asbestos analysis is performed using high resolution transmission electron microscopy (TEM). Samples are prepared by gravimetric reduction. Test results are derived from the weight of asbestos fibers in the residue.

Asbestos analysis does not contain the usual QC criteria found in other environmental analyses. There are no method blanks or multilevel calibration performed for asbestos analysis. There are two QC elements that are common for asbestos testing 1) analysis of an unopened filter to confirm that the filter is free from asbestos contamination (air samples only); and 2) evaluation of a reference sample by multiple analysts to establish accuracy and precision. Duplicate analysis can also be used to indicate precision. Analysis of both the parent and duplicate sample must be performed by the same analysts for QC purposes.

3.6.5 Low Level Analysis of Emergent Chemicals

There are certain chemical compounds that have emerged as contaminants of concern which have low-level detection requirements. Most of these compounds are target analytes in established EPA methods, but the usual detection limits are not low enough for regulatory purposes. Therefore, modified methods and/or low level specific drinking water methods are used for these emergent chemicals.

There are currently five emergent chemicals addressed in this QAPP; they are listed below with the analytical methods that give a low reporting limit.

- Perchlorate Anion: Analytical method EPA 314.0/314.1 gives a 4.0 microgram per liter (µg/L) RL; method EPA 331.0/332.0 gives a 0.7 µg/L RL.
- N-Nitrosodimethylamine: Analytical method EPA 8270 SIM gives a 0.04 µg/L RL; method.EPA E521 gives a low level RL of 0.002 µg/L.
- RDX: Analytical method E529 gives a low level-RL of 0.2 µg/L.
- 1,2,3-Trichloropropane: Analytical method EPA Method E524.1 SIM gives a low-level RL of 0.005 µg/L.
- 1,4-Dioxane: Modified method SW8270C with SIM quantitation gives a low level-RL of 2 µg/L. Special extraction protocols are used to minimize analyte loss.
- Hexavalent Chromium: Analytical method SW7199 gives a RL of 1 µg/L; method EPA 218.6 gives a low level RL of 0.3 µg/L.

To achieve low level detection limits for emergent chemicals in soil, it is necessary to use modified versions of the corresponding drinking water methods. For example, Method 314.0, which is used for analysis of perchlorate in water, can be modified for analysis of perchlorate in soil by using water extraction of a soil sample for analyses. In this case, the method would be considered 314.0 modified. Documentation of the modified drinking water method will be needed to establish the analytical protocol for the soil matrix.

Method 521 for NDMA will be modified for soil analysis to obtain low level detection limits. In this case, the soil extraction procedure provided in method SW8270C will be used to modify the drinking water method. This modification is required because NDMA is a target analyte in method SW8270C.

3.7 INTERNAL QUALITY CONTROL CHECKS

3.7.1 Field Activities Quality Control

QC procedures associated with sample collection are an integral part of each sampling methodology. These procedures are designed to ensure the collection of representative samples that are free of external contamination. The following field QA/QC procedures will be used during sample collection:

- TBs will accompany each cooler of samples sent to the laboratory for VOC analysis. TBs are prepared at the laboratory by filling sample containers with Reagent Grade Type II water. The TBs are shipped to the Performing Contractor and then carried to the sampling site by the field sampling crews. The TBs are then returned to the laboratory with the environmental samples and analyzed for VOCs. TBs are never opened until received by the laboratory.
- Ambient condition blanks will be collected when the ambient site conditions have a potential to contaminate the environmental samples (e.g., when sampling is occurring downwind of a busy road or runway). Ambient condition blanks are prepared at the sampling site by pouring deionized water into sample containers, and allowing the sample containers to stand open for 30 minutes. Ambient condition blanks are analyzed for VOCs.
- EBs will be collected every day that reusable sampling equipment is used. EBs are prepared by pouring deionized water into the sampling equipment, and then transferring the water into sample containers. EBs are analyzed for the same analytes as the associated environmental samples.

- One disposable bailer EB will be collected for each case of 12 precleaned disposable bailers. Disposable bailer EBs are prepared by pouring deionized water into a disposable bailer, and then transferring the water into sample containers. Disposable bailer EBs are analyzed for the same analytes as all associated environmental samples. Disposable bailer EBs are assigned a field identification number that identifies the case number the EB is associated with. The case number associated with all environmental samples collected with disposal bailers is recorded in the field logs and stored in the data management system so that disposable bailer EBs can be associated with the correct environmental samples.
- Duplicate water samples will be collected at a frequency of one for every 10 environmental samples. Duplicate water samples are two samples collected at one sampling location during the same sampling event.
- Replicate soil samples will be collected at a frequency of one for every 10 environmental samples. Replicate soil samples are two sequential sample liners or two sample jars filled with soil from the same location during the same sampling event.
- Sampling apparatus will be thoroughly cleaned between each sampling event to prevent cross-contamination of the samples. Details of the decontamination procedures of sampling apparatus are provided in Section 2.5.13.

3.7.2 Laboratory Analysis Quality Control

The control limits for QC analytes in the LCSs are those considered free from matrix effects. The LCS control limits will be applied to the MS/MSDs for acceptance.

3.7.2.1 Analytical Batch

The batch is the basic unit of frequency for the analysis of the QC samples, which control and have dominion over the related environmental sample results. The QC samples must be unambiguously linked and permanently attached to the batch. The QC samples must also be unique to the batch and cannot be implicated, used, or transferred to any other batch. Two types of analytical batches can be identified: the preparation batch and instrument batch.

An analytical batch is a number of samples (20 or less) that are similar in composition and are extracted or digested at the same time and with the same lot of reagents. For methods that do not have a separate extraction (e.g., volatile analyses by purge and trap), the analytical batch is a number of samples (20 or less) that are similar in composition and analyzed sequentially within a calibration period.

Analytical methods that have a separate preparation batch, where the samples are uniquely associated with the preparation batch, may be analyzed across several instrument batches to obtain valid results. EPA Method SW8270 is an example of a method where this type of batch is used. Since the QC resides in the preparation batch, the instrument batch does not affect the method QC sample associations. After the samples (environmental and QC) are extracted, 40 days are allowed for analysis of the batch, which must also be analyzed inside a compliant instrument batch.

For analytical methods that do not have a separate preparation batch, where the method itself has inseparably linked the preparation and instrument analysis, the instrument batch becomes the defining batch. EPA Method SW8260B is an example of a method where this type of batch is used. All valid samples (environmental and QC) that are unique to the batch are also unique to the 12-hour instrument tune (mass calibration) criterion. Therefore, the VOC GC/MS batch is 12 hours long and all samples related to the batch must be analyzed within the same 12 hours.

3.7.2.2 Laboratory or Method Blank

The laboratory will use a method blank to monitor the batch for interferences and contamination from glassware, reagents, and other potential laboratory-generated contaminants. The laboratory blank is taken through the entire sample preparation process, and is included with each batch of extractions/digestion preparation.

3.7.2.3 Laboratory Control Sample

LCSs are defined as blank soil or reagent water spiked with a known amount of analyte. The spiking solution contains all the analytes of interest. The LCS is used to evaluate laboratory precision and accuracy. The LCS is analyte-free water for aqueous analyses or a choice of clean silica sand, sodium sulfate, or glass beads 1 millimeter or less in diameter for soil spiked with all analytes listed for the method in Tables 3-6, 3-7, 3-8, or 3-9. Each analyte in the LCS shall be spiked at a level less than or equal to the midpoint of the calibration curve for each analyte. (The midpoint is defined as the median point in the curve, not the middle of the range). The LCS shall be carried through the complete sample preparation and analysis procedure.

The LCS is used to evaluate each analytical batch and to determine if the method is in control. The LCS cannot be used as a calibration verification sample.

One LCS shall be included in every analytical batch. If more than one LCS is analyzed in an analytical batch, results from all LCSs analyzed shall be reported. A QC failure of an analyte in any of the LCSs shall require appropriate corrective action including qualification of the failed analyte in all of the samples as required.

The performance of the LCS is evaluated against the QC acceptance limits. Whenever an analyte in a LCS is outside the acceptance limit, corrective action shall be taken. After the system problems have been resolved and system control has been reestablished, all samples in the analytical batch shall be reanalyzed for the out-of-control analyte(s). When an analyte in a LCS exceeds the upper or lower control limit and

no corrective action is performed or the corrective action was ineffective, the appropriate validation flag shall be applied to all affected results.

3.7.2.4 Matrix Spike/Matrix Spike Duplicate Samples

The MS/MSD Field QC samples are specified by the sampling personnel and noted on the CoC record. The MS/MSD will be analyzed at a frequency of 5 percent for each type of sample matrix. The matrix spiking solutions for organic compounds are prepared from the same source as the calibration standards. Inorganic matrix spikes are prepared with analytes of interest at an appropriate concentration. The MS/MSD analytes for organic and inorganic QC samples are the complete target list. The LCS control limits will also apply to MS/MSD samples.

The MS/MSDs are prepared as aliquots of sample spiked with known concentrations of all analytes listed for the method in Tables 3-6, 3-7, 3-8 or 3-9. The spiking occurs prior to sample preparation and analysis. Each analyte in the MS and MSD shall be spiked at a level less than or equal to the midpoint of the calibration curve for each analyte. The MS/MSD shall be designated on the CoC record.

The MS/MSD is used to document the bias of a method due to sample matrix. Thus, for soil samples, laboratories may use the same container for the parent sample, the MS sample, and the MSD sample (except for volatile organic analyses), if there is enough sample. The Performing Contractor should select the samples for MS/MSDs. The sample replicates will be generated in the field and will be used by the laboratory to prepare the appropriate MS/MSDs. The MS/MSD results and flags must be associated with or related to samples that are collected from the same site and matrix from which the MS/MSD set were collected. The Performing Contractor should document the unique sample set that an individual MS/MSD pair is associated with. Commonly, MS/MSD pairs are associated with other samples by site; however, other factors, such as soil type, must be carefully considered when making these associations.

A site-specific MS/MSD should be indicated for each medium, e.g., any different soil, water, or sediment for each site during each sampling event, which should not exceed 5 working days in one week. Project managers should designate the MS/MSDs and determine if they are site-specific based on the project requirements. A minimum of one MS and one MSD shall be designated by the project manager for each site and analyzed with every batch of samples in a batch of up to 20 field samples (i.e., collect up to 20 field samples followed by 2 additional samples designated as MS and MSD). More than one MS/MSD pair may be submitted as part of the sample group of environmental samples, however, project managers must coordinate with the laboratory providing analytical services for most cost-effective sampling.

The performance of the MS and MSD is evaluated against the QC acceptance limits for the method provided in Tables 3-6, 3-7, 3-8, or 3-9. If either the MS or the MSD is outside the QC acceptance limits, the analytes in all related samples shall be qualified in accordance with data flagging criteria.

3.7.2.5 Surrogate Compounds

Surrogates are used to evaluate laboratory accuracy, method performance, and extraction efficiency. Surrogates are organic compounds that are similar to the target analyte(s) in chemical composition and behavior in the analytical process, but that are not normally found in environmental samples. Surrogates shall be added to environmental samples, controls, and blanks, in accordance with the method requirements.

For GC and GC/MS analyses, the analytical process includes the addition, subsequent detection, and recovery calculations of surrogate spiking compounds. Surrogate compounds are added to every sample at the beginning of the sample preparation, and the surrogate recovery is used to monitor sample preparation and the possibility of matrix interference. Method-specific surrogates are used in both matrix and laboratory control samples. Surrogate failure thought to be due to matrix interference must be confirmed by reanalysis. Suitable surrogates will have the following qualities:

- Be compounds not requested for analysis;
- Be compounds that do not interfere with the determination of the analytes of interest;
- Be chemically similar to the analytes of interest; and
- Exhibit similar responses to the analytes of interest.

Whenever a surrogate recovery is outside the acceptance limit, corrective action must be performed. After the system problems have been resolved and system control has been reestablished, re-prepare and reanalyze the sample. If corrective actions are not performed or are ineffective, the appropriate validation flag shall be applied to the sample results.

3.7.2.6 Internal Standards

ISs are used to accurately quantify data analyte concentrations, to verify extraction efficiency, and verify overall system performance.

Internal standards are measured amounts of certain compounds added after preparation or extraction of a sample.

Internal standards are used in an IS calibration method to correct sample results affected by column injection losses, purging losses, or viscosity effects.

Internal standards shall be added to environmental samples, controls, and blanks, in accordance with the method requirements.

When the IS results are outside of the acceptance limits, corrective actions shall be performed. After the system problems have been resolved and system control has been reestablished, all samples analyzed while the system was malfunctioning shall be reanalyzed. If corrective actions are not performed or are ineffective, the appropriate validation flag shall be applied to the sample results.

3.7.2.7 Performance Evaluation Samples

Periodically, during any sampling round, EPA or commercially available performance testing evaluation samples may be forwarded to the laboratory as part of the Performing Contractor's performance evaluation program. The samples will be blind sample to the laboratory and will cover all methods used for project samples.

Analysis of PE samples shall also be used to provide additional information for assessing the accuracy of the analytical data being produced. PE samples are sample spiked with known amounts of target analytes, and are analyzed like normal environmental samples to verify the accuracy of the preparation and analytical procedures.

There are three general types of PE samples: (1) PE samples ordered by the Performing Contractor and submitted to the subcontractor laboratory disguised as regular project samples; (2) PE samples ordered by the subcontractor laboratory from an outside vendor; and (3) PE samples prepared by the QC department of the subcontractor laboratory.

3.7.2.8 Retention Time Windows

Retention time windows are used in GC and HPLC analyses for qualitative identification of analytes. They are calculated from replicate analyses of a standard on multiple days. The procedure and calculation method are given in SW-846 method 8000B.

When the retention time is outside of the acceptance limits, corrective action shall be performed. After the system problems have been resolved and system control has been reestablished, reanalyze all samples analyzed since the last acceptable retention time check. If corrective actions are not performed, the appropriate validation flag shall be applied to the sample results.

For GC and HPLC methods, the daily retention times of each analyte in the method are checked from the calibration verification standards for that day or the analytical batch. If the daily retention time of an analyte falls within the established absolute retention time window, the daily window is calculated based

on that day's retention time and using the +/- 3 Standard Deviation (SD) used in establishing the absolute retention time window.

3.7.2.9 Interference Check Sample

The ICS, used only in ICP analyses, contains both interfering and analyte elements of known concentrations. The ICS is used to verify background and inter-element correction factors.

The ICS is analyzed at the beginning of an analytical batch for SW6010, and at the beginning of an analytical batch or once every 12-hour period, whichever is more frequent for SW6020.

When the interference check sample results are outside of the acceptance limits stated in the method, corrective action shall be performed. After the system problems have been resolved and system control has been reestablished, reanalyze the ICS. If the ICS result is acceptable, reanalyze all affected samples. If corrective action is not performed or the corrective action was ineffective, the appropriate validation flag shall be applied to all affected results.

3.7.2.10 Method Blank

The method blank is used to document contamination resulting from the analytical processes.

A method blank is an analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank shall be carried through the complete sample preparation and analytical procedure. A method blank shall be included in every analytical batch.

The presence of analytes in a method blank at concentrations equal to or greater than the RL indicates a need for corrective action. Corrective action shall be performed to eliminate the source of contamination prior to proceeding with analysis. After the source of contamination has been eliminated, all samples containing the analyte(s) found in the method blank above the RL shall be re-prepared and reanalyzed. No analytical data shall be corrected for the presence of analytes in blanks. When an analyte is detected in the method blank and in the associated samples, and corrective actions are not performed or are ineffective, the appropriate validation flag shall be applied to the sample results.

3.7.2.11 Establishment of Control Limits

The laboratory will monitor the percent spike recovery in LCSs, MS/MSDs, and the surrogate recoveries in all samples where surrogates are appropriate. The RPD between MS and MSD or sample and duplicate recoveries, depending on the method, will also be monitored. From these results, in-house control limits will be calculated.

Control limits are automatically monitored through the LIMS system, using an Access-based control charting program and, at a minimum are updated annually. When control limits are updated, hardcopy forms will be distributed to the RPMs.

3.8 QUALITY CONTROL PROCEDURES

3.8.1 Holding Time Compliance

All sample preparation and analysis shall be completed within the method-required holding times. The holding time for a sample begins at the time of sample collection. Some methods have more than one holding time requirement (e.g., methods SW8081A, SW8270C). The preparation holding time is calculated from the time the sample is collected to the time the sample preparation process is completed, as described in the applicable method, prior to any necessary extract cleanup and/or volume reduction procedures. If no separate preparation (e.g., extraction) is required, the analysis holding time is calculated from the time the sample is collected to the time all analytical runs are completed, including dilutions, second column confirmations, and any required reanalysis. In methods requiring separate sample preparation prior to analysis, the analysis holding time is calculated from the time of preparation completion to the time of completion of all analytical runs, including dilutions, second column confirmations, and any required reanalysis.

If holding times are exceeded and the analyses are performed, the results shall be qualified in accordance with data flagging criteria.

3.8.2 Analyte Confirmation

Quantitative confirmation of results at or above the MDL for samples analyzed by GC or HPLC shall be required, and shall be completed within the method-required holding times. For GC methods, a second column is used for confirmation. For HPLC methods, a second column or a different detector will be used. The result from the primary column/detector is the result that shall be reported. If holding times are exceeded and the analyses are performed, the results shall be qualified in accordance with data flagging criteria.

The confirmation column or detector must be calibrated and quality controlled like the primary column or detector. If one result is significantly higher (e.g., >40%), the chromatograms should be evaluated to see if an obviously overlapping peak is causing an erroneously high result. If no overlapping peaks are noted, the baseline parameters established by the instrument data system (or operator) during peak integration should be evaluated. If no anomalies are noted, review the chromatographic conditions. If there is no evidence of chromatographic problems, report the higher result. This approach is conservative relative to

protection of the environment. The data user should be advised of the disparity between the results on the two columns. The case narrative must explain the actions taken and the rationale for selecting a result.

3.8.3 Control Charts

Control charts are used to track the performance of laboratory control sample recoveries over time. All analytes spiked into the LCS should be tracked via control charts. These charts are useful in identifying trends and problems in an analytical method. Updating these charts annually and reviewing them for possible trends that could compromise data quality is recommended. These charts can also be used to benchmark a laboratory's performance against regulatory requirements to determine possible areas for improvement.

Standard materials, including second source materials, used in calibration and to prepare samples shall be traceable to NIST, EPA, American Association of Laboratory Accreditation (A2LA), or from another equivalent approved source, if available. If an NIST, EPA, or A2LA standard material is not available, the standard material proposed for use shall be included in an addendum to the QAPP and approved before use. The standard materials shall be current, and managed according to the following expiration policy.

- The expiration dates for ampules of solutions shall not exceed the manufacturer's expiration date or 1 year from the date of receipt, whichever comes first.
- Expiration dates for laboratory-prepared stock and diluted standards shall be no later than the expiration date of the stock solution or material or the date calculated from the holding time allowed by the applicable analytical method, whichever comes first.
- Expiration dates for pure chemicals shall be established by the laboratory and be based on chemical stability, possibility of contamination, and environmental and storage conditions.
- Expired standard materials shall be either revalidated prior to use or discarded.

Revalidation may be performed through assignment of a true value and error window statistically derived from replicate analyses of the material as compared to an unexpired standard. The laboratory shall label standard and QC materials with expiration dates.

A second source standard is used to independently confirm initial calibration. A second source standard is a standard purchased from a vendor other than the vendor supplying the material used in the initial calibration standards. The second source material can be used for the calibration verification standard or for the LCS (but shall be used for one of the two). Two different lot numbers from the same vendor do not constitute a second source.

3.8.4 Instrument Calibration Requirements

Analytical instruments shall be calibrated in accordance with the analytical methods. All analytes reported shall be present in the initial and calibration verification standards, and these calibrations shall meet

acceptance criteria (Sections 3.6.3 and 3.6.4). The initial calibration acceptance criteria for each method are specified in the respective tables included in Section 3.6.4. Results outside the calibration range are unsuitable for quantitative work and will only give an estimate of the true concentration. For methods SW6010 and SW6020, results shall be within the working range determined by linear range studies. Records of standard preparation and instrument calibration shall be maintained. Records shall unambiguously trace the preparation of standards and their use in calibration and quantitation of sample results. Calibration standards shall be traceable to standard materials.

The initial calibration must include a minimum number of standard concentrations required by the method including a standard at or below the corresponding RL. The requirements for each method are specified in the respective tables. If a standard at or below the RLs could not be included as part of the initial calibration curve, then a RL verification must be done after the initial calibration.

Instrument calibration shall be checked using all of the analytes (or an approved subset of analytes) listed in the QC acceptance criteria table. This applies equally to multiresponse analytes. The initial calibration acceptance criteria for each method are specified in the respective tables. The initial calibration shall be checked at the frequency specified by in the method using materials prepared independently of the calibration standards. Multipoint calibrations shall contain the minimum number of calibration points specified in the method with all points used for the calibration being contiguous. If more than the minimum number of standards is analyzed for the initial calibration, all of the standards analyzed shall be included in the initial calibration.

If the highest concentration for an analyte exceeds the linearity for that analyte, the laboratory may delete the highest concentration point and recalculate the acceptance with all the remaining points. All results for field samples shall be reported only within the calibration linearity range. No middle data point in the calibration curve shall be excluded in the calculation of the acceptance of the linearity of the curve.

3.8.5 Supplies and Consumables

The laboratory shall inspect supplies and consumables prior to their use in analysis. The materials description in the methods of analysis shall be used as a guideline for establishing the acceptance criteria for these materials. Purity of reagents shall be monitored by analysis of LCSs. An inventory and storage system for these materials shall assure use before manufacturers' expiration dates and storage under safe and chemically compatible conditions.

3.9 LABORATORY AUDITS AND PERFORMANCE EVALUATION PROGRAMS

Technical systems and performance audits shall be performed as independent assessments of sample collection and analysis procedures. Audit results will be used to evaluate the ability of an analytical subcontractor to (1) produce data that fulfill the objectives established for the program, (2) comply with the QC criteria, and (3) identify any areas requiring corrective action. The systems audit is a qualitative review of the overall sampling or measurement system, while the performance audit is a quantitative assessment of a measurement system. Full data validation is also a quantitative check of the analytical process, where all documentation and calculations are evaluated and verified.

3.9.1 Technical Systems Audits

A technical systems audit is an on-site, qualitative review of the sampling or analytical system to ensure that the activity is being performed in compliance with the SAP specifications. Sampling and field procedures, and the analytical laboratories shall be audited by the Performing Contractor at the beginning of the project. In addition, a laboratory systems audit may be performed by the client if previous audit reports indicate corrective actions are outstanding, a recent audit has not been conducted, or quality concerns have arisen based upon the use of that laboratory for other projects. Results from the laboratory systems audit will be used to assess the Performing Contractor's oversight, and to review laboratory operation, ensure that technical procedures and documentation are in place, ensure equipment is operating to provide data that fulfill the project objectives, and to ensure outstanding corrective actions have been addressed.

Critical items for a laboratory or field systems audit include (1) sample custody procedures, (2) calibration procedures and documentation, (3) completeness of data forms, notebooks, and other reporting requirements, (4) data review and validation procedures, (5) data storage, filing, and record keeping procedures, (6) QC procedures, tolerances, and documentation, (7) operating conditions of facilities and equipment, (8) documentation of training and maintenance activities, (9) systems and operations overview, and (10) security of laboratory automated systems.

Critical items for a sampling systems audit include (1) calibration procedures and documentation for field equipment, (2) documentation in field logbooks and sampling data sheets, (3) organization and minimization of potential contamination sources while in the field, (4) proper sample collection, storage, and transportation procedures, and (5) compliance with established CoC and transfer procedures.

After each on-site audit, a debriefing session will be held for all participants to discuss the preliminary audit results. The auditor will then complete the audit evaluation and submit an audit report including observations of the deficiencies and the necessary recommendations for corrective actions to the

Performing Contractor. Compliance with the specifications presented in the SAP will be noted and noncompliance or deviations shall be addressed in writing by the Performing Contractor to the client with corrective actions and a time frame for implementation of the corrective actions. Follow-up audits will be performed prior to completion of the project to ensure corrective actions have been taken.

3.9.2 Project-Specific Performance Evaluation Audits

Performance audits quantitatively assess the data produced by a measurement system. A performance audit involves submitting project-specific PE samples for analysis for some or all analytical methods used in the project. The Performing Contractor shall submit project-specific PE samples at a frequency consistent with the project DQOs. The project-specific PE samples are selected to reflect the expected range of concentrations for the sampling program. The performance audit answers questions about whether the measurement system is operating within control limits and whether the data produced meet the analytical QA specifications.

The project-specific PE samples are made to look as similar to field samples as possible and are submitted as part of a field sample shipment so the laboratory is unable to distinguish between them and project samples. This approach ensures unbiased sample analysis and reporting by the laboratory.

The critical elements for review of PE results include (1) correct identification and quantitation of the PE sample analytes, (2) accurate and complete reporting of the results, and (3) measurement system operation within established control limits for precision and accuracy.

The concentrations reported for the PE samples shall be compared to the known or expected concentrations spiked in the samples. The percent recovery shall be calculated and the results assessed according to the accuracy criteria for the LCS presented in Section 3.6. If the accuracy criteria are not met, the cause of the discrepancy shall be investigated and a second PE sample shall be submitted. The Performing Contractor shall notify the project staff, client, and agencies of the situation at the earliest possible time and the Performing Contractor shall keep the client up to date regarding corrective actions and subsequent PE sample results.

3.9.3 Raw Data/Magnetic Tape Audits

Magnetic tape audits involve examining the electronic media used by the analytical laboratory and by the Performing Contractor to collect, analyze, report, and store data. These audits are used to assess the authenticity of the data generated, and assess the implementation of good automated laboratory practices. The client may perform magnetic tape audits of the laboratories or of the Performing Contractor when warranted by project PE results, on-site audit results, or by other state/federal investigations.

3.9.4 Performance Evaluation Samples

All laboratories shall participate in the EPA PE Water Supply and Water Pollution Studies programs or equivalent programs for state certifications. Satisfactory performance in these non-project-specific PE programs also demonstrate proficiency in methods used to analyze samples. The laboratory shall document the corrective actions to unacceptable PE results to demonstrate resolution of the problems.

3.9.5 LIMS Assessment

The Performing Contractor will assess the efficacy of the laboratory subcontractor LIMS system for consistency and correlation. The QA that the LIMS is performing correctly is determined by auditing the EDD output from the LIMS and reconciling EDD output with the analytical instrumentation output.

3.10 PREVENTIVE MAINTENANCE

3.10.1 Maintenance Responsibilities

The subcontractor laboratory should maintain service contracts for the ICP spectrometers. All instruments and equipment must receive routine preventive maintenance, and be recorded in instrument-specific maintenance logbooks. Routine maintenance ensures that the equipment is operating under optimum conditions, reducing the possibility of instrument malfunction.

3.10.2 Maintenance Schedules

Preventive maintenance procedures including lubrication, source cleaning, and detector cleaning (and the frequency of such maintenance) must be performed according to the procedures recommended in the manufacturer's instrument user manual.

Chromatographic carrier gas purification traps, injector liners, and injector septa shall be regularly cleaned or replaced. Precision and accuracy data shall be examined for trends and to determine evidence of instrument malfunction. Maintenance must be performed when the instrument begins to degrade as evidenced by the degradation of peak resolution, decreased sensitivity, or failure to meet one or more of the quality control criteria. Instrument logbooks containing maintenance and repair records must be kept in the laboratories at all times.

3.10.3 Spare Parts

The laboratories shall maintain adequate supplies of spare parts such as GC columns, syringes, septa, injection port liners, and electronic parts to minimize potential down-time.

If an equipment malfunction cannot be readily resolved by laboratory personnel, service shall be obtained from an in-house electronics technician and, if the malfunction remains unresolved, the instrument vendor

or manufacturer. Should instrument failure preclude completion of analyses within contract requirements (i.e., holding times), the laboratory will contact the Performing Contractor to determine alternative strategies.

3.10.4 Maintenance Records

Maintenance and repair of major field and laboratory equipment shall be recorded in field or laboratory logbooks. These records shall document the serial numbers of the equipment, the person performing the maintenance or repairs, the date of the repair, the procedures used during the repair, and proof of successful repair prior to the use of the equipment.

3.11 CORRECTIVE ACTION

3.11.1 Field Activities

Corrective action procedures for field activities are described in the FSP.

3.11.2 Laboratory Activities

Problems requiring corrective action in the laboratory shall be documented by the use of a corrective action report. The QA coordinator or any other laboratory member can initiate the corrective action request in the event QC results exceed acceptability limits, or upon identification of some other laboratory problem.

The type and level of corrective action for laboratory activities will depend on the degree of nonconformity. Corrective action may be initiated and carried out by nonsupervisory staff, but final approval and data review by management is necessary before reporting any information. All potentially affected data must be thoroughly reviewed for acceptance or rejection.

When errors, deficiencies, or out-of-control situations arise, the QA program systematically implements "corrective actions" to resolve the problem and restore proper functioning to the analytical system.

Laboratory personnel are alerted that corrective actions may be necessary if the following are observed with respect to analytical results:

- QC data are outside the acceptable window for precision and accuracy determination;
- QC samples such as the method blank or the laboratory control sample contain contamination above previously described acceptable levels;
- Undesirable trends are detected in spike recoveries or in the RPDs between the QC sample and appropriate duplicate sample;
- Unusual changes occur in detection limits;

- Deficiencies are detected by the QA/QC Department during internal or external audits of the laboratory and/or deficiencies are detected from the results of performance evaluation samples submitted by the Performing Contractor; and
- Client inquiries concern the quality of laboratory-generated results.

Corrective action procedures can usually be handled by the chemist, who reviews the preparation and extraction procedures for errors and checks the instrument calibration, instrument sensitivity, and ancillary equipment associated with the instrument. If the problem persists, or cannot be identified after all possible sources of errors are investigated, the matter is then referred to the supervisor and the QA Manager in the form of a corrective action report (Appendix C). The corrective action report is utilized for documenting the suggested corrective need and the return to control. Additional documentation to support the return to control is located in the associated instrument analysis logbook and the instrument-specific maintenance logbook. Once resolved, the corrective action report is completed describing the corrective action procedure. This report is maintained in a project file. A copy of the completed corrective action report is forwarded to the Performing Contractor's Program Manager and the Project QA/QC Manager.

Recommended holding times for samples are monitored closely. If a sample is analyzed outside a holding time, the corrective action report is used to report any holding time violations. The QA Manager and/or Program Manager will immediately notify the Performing Contractor's Project QA/QC Manager of the holding time violation by phone, followed up by a hard copy of the completed corrective action report by both facsimile and first-class mail. Samples may be re-collected if holding times are exceeded prior to either extraction or analysis of the environmental sample at no additional cost to the client.

3.11.2.1 Corrective Action System

A system for issuing, tracking, and documenting completion of formal Recommendations for Corrective Action (RCAs) shall exist for addressing significant and systematic problems. RCAs are issued only by the Laboratory QA Manager, or a designee in a specific QA role. Each RCA addresses a specific problem or deficiency, usually identified during QA audits of laboratory or project operations. An RCA requires a written response from the party to whom the RCA was issued. A summary of unresolved RCAs is included in the monthly QA report to management. The report lists all RCAs that have been issued, the manager responsible for the work area, and the current status of each RCA. An RCA requires verification by the QA group that the corrective action has been implemented before the RCA is considered to be resolved. In the event there is no response to an RCA within 30 days, or if the proposed corrective action is disputed, the recommendation and/or conflict is pursued to successively higher management levels until the issue is resolved.

3.12 QUALITY ASSURANCE REPORTS

Effective management of field sampling and analytical effort requires timely assessment and review of field and laboratory activities. Such assessment and review will require effective interaction and feedback between the Performing Contractor's field sampling team, the Program Manager, the Project QA/QC Officer, and the QA Manager of the laboratory. Specific QA report procedures and contents are summarized below.

Sampling and analysis field operations will be reviewed by staff members responsible for the activity to determine if the sampling QC requirements are being fulfilled. The laboratory QA Manager is responsible for keeping the Performing Contractor's Program Manager and the Project QA/QC Manager up to date regarding the status of their respective tasks. This procedure ensures that solutions are developed and implemented as quickly as possible.

The QA Manager will include the following elements in a report detailing the status of the system's data quality:

- Activities and general program status;
- Calibration and QC problems;
- Unscheduled maintenance activities;
- Corrective actions;
- Status of any unresolved problems;
- Assessment and summary of data completeness; and
- Significant QA/QC problems and recommended and/or implemented solutions.

The QA Auditor will prepare audit reports following each performance and system audit. These reports will address the audit results and provide a qualitative assessment of overall system performance. They will be submitted to the QA Manager and the Laboratory Director, and to the Performing Contractor's Program Manager and Project QA/QC Managers.

3.13 DATA REDUCTION, VALIDATION, AND REPORTING

The data reduction, review, reporting, and validation procedures described in this section will ensure that (1) complete documentation is maintained, (2) transcription and data reduction errors are minimized, (3) the data are reviewed and documented, and (4) the reported results are qualified if necessary. Laboratory data reduction and verification procedures are required to ensure the overall objectives of analysis and reporting meet method and project specifications.

3.13.1 Performing Contractor

The Performing Contractor will monitor all aspects of data gathering as part of the Sites 1 & 2 program. This will help to ensure that the DQOs are achieved. Figure 3-1 illustrates how the Performing Contractor will manage the data collected from both field operations and laboratory-generated results. Basically, the laboratory submits an EDD containing each Sample Delivery Group (SDG) as a separate computer data file. Each SDG should have data for all environmental results and field QC, as well as all associated lab QC data (Matrix Spikes, Method Blanks, Blank Spikes), and Surrogates for QA/QC review. The laboratory must submit the EDD according to general guidelines established by the Performing Contractor. This data shall be placed in the master project database for subsequent analysis and tabulation.

3.13.2 Laboratory

Data storage and documentation will be maintained using logbooks, data sheets, and computer files that will be kept at the laboratory. All computer-generated raw data are stored on magnetic tape, or other media, and will be maintained along with all paper copies for not less than 5 years.

3.13.3 Data Reduction

Data reduction calculations are part of laboratory SOPs.

3.13.4 Data Quality Assessment

3.13.4.1 Laboratory

General responsibilities for data quality assessment are summarized in Table 3-38. All sample analyses are reported through the LIMS system. The analyst is responsible for the first level of data review. Notes are maintained by the analyst and submitted with each data package.

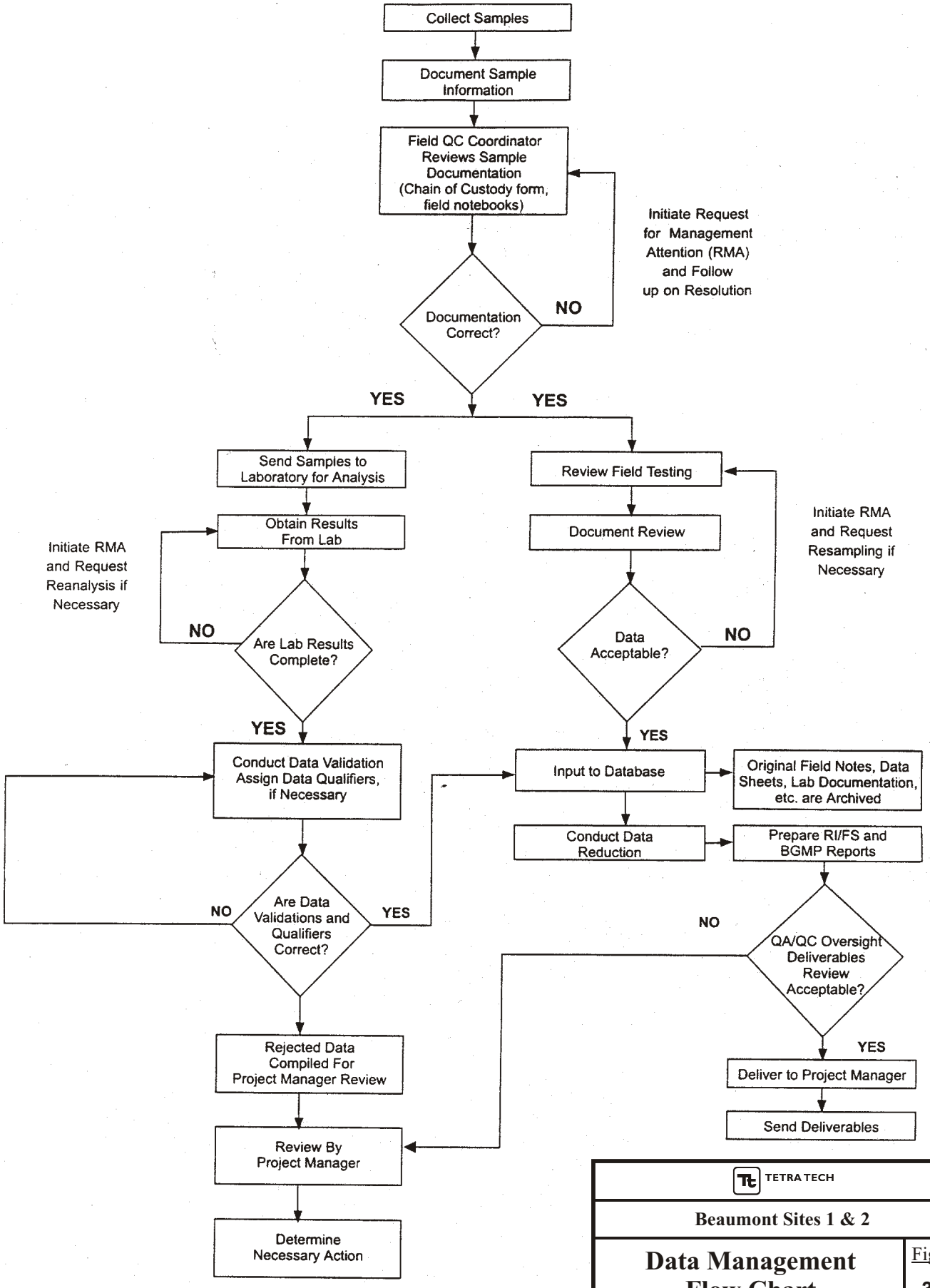
Control charts are generated automatically through an Access program designed to receive data collected in the LIMS for all methods and analytes. The analyst initiates a discrepancy report, if warranted.

The laboratory supervisor oversees the daily analytical activities of their respective assigned areas. Narrative notes and QC information provided by the analyst are reviewed by the supervisor or peer chemist. The final results are reported through the LIMS and/or a full data package that includes raw data and forms. All final results are reviewed by a laboratory supervisor.

Initial and continuing calibration curves and any discrepancies are reviewed by the supervisor. The supervisor is responsible for ensuring contractual and technical compliance for samples collected at the Site.

The supervisor reviews and approves the case narrative. The supervisor may be asked to confer with the Performing Contractor's Project QA/QC Managers regarding technical issues.

X:\GIS\LOCKHEED 23521-0601\FIG 3-1.CDR



TETRA TECH

Beaumont Sites 1 & 2

Data Management Flow Chart

Figure 3-1

All discrepancies in the initial and calibration verification control criteria are to be reviewed by the LQAM. The LQAM is responsible for ensuring contractual and technical compliance for samples received. The LQAM reviews and approves the case narrative, conducts contractual compliance review of at least 10 percent of the data packages, reviews items in the data package such as calculations, determines if both QC and method criteria have been met, and checks that the proper forms have been used and the control criteria have been adequately described. The LQAM may be asked to confer with the Performing Contractor QA/QC Manager regarding technical issues.

The LPM has final data review and validation responsibilities. The LPM ensures that the final data deliverable is prepared and that permanent data packages are properly maintained. The LPM also reviews the data package for completeness and quality and reviews the narrative for accuracy. The LPM also serves as a liaison between the laboratory and the Performing Contractor. Final data packages, complete with cover letter, will be sent to the Performing Contractor by the LPM.

If, at any point during data review, a condition adverse to quality is identified, a discrepancy report may be initiated to return the data to a satisfactory status. The situation is analyzed for both incidental conditions as well as chronic trends that have affected the quality of the data being generated. The impact of the condition is evaluated and, if deemed to have no adverse effect on the quality of the data, the investigation is closed with written narrative to support the decision. If the condition is deemed to cause adverse effects to the quality of the data, the relevant manager is notified and the following steps are taken:

- the cause of the adverse effect is determined;
- any impacts to the data are evaluated;
- corrective actions are taken to preclude a recurrence of the adverse effect;
- the adverse condition as well as the steps taken to alleviate this condition are documented and reported to the appropriate manager; and
- the implementation of the corrective action is verified.

Once the corrective action has been determined to be effective, the case is closed out with written narrative documenting all steps taken. If the corrective action is determined to not be effective, a re-evaluation of the corrective action process must occur. The re-evaluation of the corrective action process should include at a minimum the supervisor, the LQAM, and the LPM. The corrective action process may be repeated and/or an alternate corrective action may be implemented. This process will continue until the system is demonstrated to be back in control.

Table 3-38
Analytical Data Review Process

Role	Responsibilities
Analyst	Sample analysis entry and data generation (when not performed through LIMS) Data review - first level (bench) Control charting Written narrative notes Initiate discrepancy reports Provide copies of log books, as necessary
Section Supervisor	Oversee daily analytical activities Review control chart comments Validate data Review analyst notes Supervise contractual and technical compliance Review quality control daily (calibrations, etc.) Sign-off for case narrative Ensure program compliance Review discrepancies requiring manager resolution Technical conference calls with client Ensure technical validity of data
Laboratory Project Manager or Designee	Sample analysis entry and data generation Written narrative notes Initiate corrective action reports Provide copies of log books, as necessary Oversee daily analytical activities Review control chart comments Review analyst notes Supervise contractual and technical compliance Review quality control daily (calibrations, etc.) Sign-off for case narrative Ensure program compliance Review discrepancies requiring manager resolution Technical conference calls with client Ensure technical validity of data Generate forms package Review and validate final data Prepare package and paginate Generate electronic deliverables Maintain data package files Validate data Review narratives for accuracy Review packages for completeness and quality Prepare cover letter Collate organic and inorganic packages Client/laboratory liaison Deliver package to client
Laboratory Quality Assurance Manager	10 percent contractual compliance review (data packages) - Custody when required - Calculations - Methods criteria - QC criteria - Forms - Control charting Client communication involving QA/QC issues

3.13.4.2 Performing Contractor

The Performing Contractor shall review the entire definitive data report package, and with the field records, apply the final data qualifiers for the definitive data. The laboratory shall apply data qualifying flags to each environmental field QC sample, i.e., ambient blanks, equipment blanks, trip blanks, MS samples, and MSD samples. The Performing Contractor shall review the field QC samples and field logs, and shall then appropriately flag any of the associated samples identified with the field QC sample. Each MS sample shall only be qualified by the laboratory, while the Performing Contractor shall apply the final qualifier for a matrix effect to all samples collected from the same site as the parent sample or all samples showing the same lithologic characteristics as the MS/MSD.

The Performing Contractor shall (1) determine if the DQOs have been met, and (2) calculate the data completeness for the project. These results shall be included in the data package deliverable. Contractual requirements for payment of laboratory services are beyond the scope of this document and may be different than the data validation requirements. In addition to the validation described above, it may be necessary to also validate the data by other appropriate guidelines.

3.13.4.2.1 Data Verification by Performing Contractor

Data verification is defined as "confirmation by examination and provision of objective evidence that specified requirements have been fulfilled" (EPA, 2002). The Performing Contractor's project QA/QC manager shall review the entire definitive data report package and apply the final data qualifiers. Initially, the Performing Contractor must review the flags applied by the laboratory for accuracy defining the qualifiers and general flagging conventions. The Performing Contractor may use various checklists during the verification process to document all the verification activities. However, these checklists should not be included as part of the data packages. All changes to the data or flags must be explained in the Data Verification Report, and the QA summary section of the technical reports.

In the case of matrix interference, the laboratory will follow the guidelines described in following section.

3.13.4.2.2 Data Validation Rationale

The analyses of environmental samples are conducted under approved U.S. EPA methods. Since the analytical data were obtained by following the U.S. EPA approved method criteria, the data are evaluated by using the U.S. EPA approved validation methods described in the National Functional Guidelines.

The National Functional Guidelines were written for use with the Contract Laboratory Program (CLP) methods as outlined in the CLP Statement of Work (SOW). The SOW contains methods for volatile and semivolatile GC/MS analysis, two-column GC pesticide analysis, and ICP metal analysis. These methods

do not differ significantly in the application of the basic quality control parameters from those found in the corresponding SW846 methods for volatile, semivolatile, pesticide, and ICP metals analyses (hereafter referred to as the SW methods). The target compounds in the CLP are a subset of the SW846 target compounds.

Since the CLP methods and the SW846 methods have similar QC instructions, the National Functional Guidelines are usable for the SW methods. When methods that are not SW methods are used, the individual QC entities appropriate for the analysis are used to control and evaluate the method. Interpretive judgments are sometimes required for complex data. After several years of sampling the same wells and analyzing the samples by the same methods, the database of historical results is useful for applying professional judgment to data validation. In an effort to give unambiguous quality control information, the National Functional Guidelines shall be used as the primary guidance documents for validation purposes. This system of validation has been in place and has been used since the beginning of the monitoring program. Using the National Functional Guidelines for data validation maintains consistency of the data sets. Validation activities will be performed according to the following subsections, and if requested, the following documents:

- USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, EPA-540/R-04-004, 2004.
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review, EPA 540/R-08-01, 2008.

These two documents are hereinafter collectively referred to as the National Functional Guidelines.

3.13.4.2.3 Data Validation Theory and Matrix Effects

The practice of data validation in the environmental organic chemistry field has been the subject of debate for many years. Determining the validity of environmental data results when matrix effects are suspected is not an exact science, and professional judgment concerning matrix effects is used to help guide the data to its best logical interpretation and evaluation.

The overall QC of environmental sample analysis can be divided into two main categories: “method QC” and “instrument QC.” Both types of QC operate independently to validate the data and qualify the results.

Instrument QC parameters are often well defined and well understood and are based on the tangible physical laws of analytical instrumentation. Instrument QC parameters have to do with (but are not limited to) the calibration, chromatography, and detection aspects of environmental data analysis. Instrument QC parameters are considered independent from a sample's matrix and/or matrix effects.

Conversely, method QC parameters do not yield results that are as well defined, since they are based in part on problems associated with the intangible and/or unknown effects of the sample matrix. Method QC parameters have to do with (but are not limited to) the spiking, extraction, and spike recovery aspects of environmental data analysis. Method QC parameters are considered dependent on a sample's matrix and/or matrix effects.

When evaluating environmental data results with pronounced or unknown matrix effects, a conservative approach to the validation is required. The method QC parameters are rigidly applied and validations are conferred to entire data sets based on one sample's bias.

3.13.4.2.4 Validation Qualifiers

The definitions for validation qualifiers used to qualify analytical data are provided below.

B: The sample result is less than 5 times (10 times for common organic laboratory contaminants) the blank contamination. The result is considered not to have originated from the environmental sample, because cross-contamination is suspected.

J: The analyte was positively identified and the result is usable; however, the analyte concentration is an estimated value.

R: The sample result is rejected and not usable for any purpose. The presence or absence of the analyte cannot be verified.

U: The analyte was not detected above the method detection limit (MDL).

UJ: The analyte was not detected above the MDL; however, the MDL is uncertain and may be elevated above normal levels.

Y: Confirmation column results indicate a non-detect for the target analyte.

3.13.4.2.5 Qualifier Descriptors

The qualifier descriptors are used to denote the cause for qualification of data.

a: The analyte was found in the method blank.

b: The surrogate spike recovery was outside quality control criteria.

c: The MS and/or MSD recoveries were outside control limits.

d: The laboratory control sample recovery was outside control limits.

e: A holding time violation occurred.

f: The duplicate/replicate sample's relative percent difference (RPD) was outside the control limit.

g: The data met prescribed criteria as detailed in the QAPP.

h: The method requires a confirmation result, but none was performed.

k: The analyte was found in a field blank.

l: The second column confirmation result indicates the analyte was not confirmed.

n: The laboratory case narrative indicated a QC problem.

p: Professional judgment determined the data should be qualified.

q: The analyte detection was below the PQL.

r: The result is above the instrument's calibration range.

t: The temperature was outside acceptance criteria.

3.13.4.2.6 Organic Validation Guidelines

Sample Preservation

Variances from the temperature preservation will result in the following data qualifiers.

- Samples with temperatures in excess of six degrees Celsius but less than or equal to 12 degrees Celsius are qualified J for detected analytes and UJ for non-detects.
- Samples in gross excess (>12 degrees) of the temperature criteria are qualified J for detected analytes and non-detects are qualified R.
- The descriptor t is used to indicate sample temperature qualification.

Holding Times

Violation of method-specific holding times will result in the following data qualifiers.

- For VOA samples, analysis after 14 days (7 days if not pH preserved) from collection are qualified J for detected analytes and UJ for non-detects.
- For semivolatile (SV) samples, water samples extracted after 7 days (14 days for soil) are qualified J for detected analytes and UJ for non-detects. Samples analyzed after 40 days from extraction are also qualified J for detected analytes and UJ for non-detects.
- If holding times are grossly exceeded (greater than 2 times the normal holding time), then positive results are qualified J and non detects are qualified R.
- The descriptor e is used to denote holding time violations.

Blanks

Blank contamination identified during sample handling preparation and/or analysis will result in the following data qualifiers.

- Analytes found in associated environmental samples at or below 5 times (10 times common organic analytes) of the method or field blank analyte concentrations are qualified B.
- The descriptor a is used to indicate method blank contamination.
- The descriptor k is used to indicate field blank contamination.

Surrogates

Surrogates detected outside of the specified limits will result in the following data qualifiers.

- For VOC (GC/MS) samples, there are three cases. Any one surrogate failure will cause qualification.
  - Case #1: Recovery above upper limit, then J qualify detected analytes. Do not qualify non detected analytes.
  - Case #2: Recovery between lower limit and 10 percent, then J for detected analytes and UJ for non-detects.
  - Case #3: Recovery below 10 percent, then J positive results and R non detects.
- For SVOCs (GC/MS) samples, there are four cases. Except for case four, two surrogate failures (within each fraction) will cause fraction specific qualification.
  - Case #1: Recovery above upper limit, then J detected analytes only.
  - Case #2: Recovery between lower limit and 10 percent, then J for detected analytes and UJ for non-detects.
  - Case #3: Recovery of one surrogate above upper limit and one surrogate below the lower limit but above 10 percent, then qualify as in case #2.
  - Case #4: Any one surrogate below 10 percent, then J positive results and R non detects.
- For SVOCs (GC) samples.
  - Case #1: Recovery above upper limit, then J only positive results. Non-detects are not qualified.
  - Case #2: Recovery between lower limit and 10 percent, then J positive results. Non-detects are qualified UJ.
  - Case #3: Recovery below 10 percent, then J positive results and R non-detects.
- The descriptor b is used to indicate surrogate failure qualification.

Laboratory Control Sample

Constituents detected in control samples outside of the specified limits will result in the following data qualifiers.

- For LCS qualifications, the specific analytes spiked into the LCS sample must always be qualified. All target analytes are spiked into the LCS.
- For all methods requiring LCS recoveries there are 2 cases.

  - Case #1: LCS recovery is above upper limit, then J detected analytes only. Do not qualify non detects.
  - Case #2: LCS recovery is below lower limit then J positive results and R non detects.
- The descriptor d is used to indicate LCS qualification.

Matrix Spike/Matrix Spike Duplicates

Each specific MS or MSD spiking analyte that fails recovery criteria produces qualification of the matching analyte in the associated environmental samples. Where both the MS and MSD fail criteria, qualification is based on the least compliant recovery. Constituents detected in control samples outside of the specified limits will result in the following data qualifiers.

- If the MS and/or MSD recovery exceed the upper control limit, then J detected compounds only. Do not qualify non-detected compounds.
- If the MS and/or MSD recovery falls below the lower limit then J detected compounds and UJ non-detects.
- The descriptor c is used to indicate MS/MSD qualification based on the percent recovery of the spiked analytes.
- MS/MSD RPDs are calculated from the analyte concentrations of the MS and MSD. If the RPD is outside the control limit, the precision is in question, and the accuracy is compromised.
- RPD outside the control limit, then qualify the related sample results with J for detected compounds and UJ non-detects.
- The descriptor f is used to indicate RPD failure.

Second Column Confirmation

For certain GC or HPLC methods, second column/detector confirmation is required for detected analytes. Refer to the relevant QAPP for method and analyte specific requirements.

Second column results are used to confirm the actual presence or absence of a target analyte. U.S. EPA guidelines state "If the qualitative criteria for both columns were not met, all target compounds that are reported detected should be considered non-detected." Therefore, any compound detection on only one column is not considered a target compound hit.

- For the situation where a compound was detected on the primary column and not detected on the confirmation column, consider the value reported to be not detected. Qualify the result with Y and use the l descriptor.
- In the case of a detection on the primary column where the required second column confirmation was not performed, then qualify the result with R and use the h descriptor.

Field Duplicate Samples

Field duplicate samples are collected to assess the precision of the sample collection and laboratory analytical process. As a rule, both the sample and its duplicate result must be at or above the PQL in order to calculate a meaningful RPD and if both results are below the PQL, the RPD is not calculated.

However, if one result is below the PQL (assume zero for a non-detect) and the other result significantly above (10 times) the PQL a RPD is calculated. If the RPD is outside the control limit, the precision is in question, and the accuracy is compromised. The qualification resulting from the sample and its duplicate non-compliant RPD apply only to the sample and it's duplicate and is analyte specific.

- If the RPD is outside the control limit, then qualify the sample and its duplicate with J for detected compounds and UJ non-detects.
- The descriptor f is used to indicate RPD failure.

3.13.4.2.7 Inorganic Validation Guidelines

Sample Preservation

Variances from the temperature preservation will result in the following data qualifiers.

- Samples with temperatures in excess of 6 degrees Celsius but less than or equal to 12 degrees Celsius are qualified J for detected analytes and UJ for non-detects.
- Samples in gross excess (more than 12 degrees) of the temperature criteria are qualified J for detected analytes and non-detects are qualified R.
- The descriptor t is used to indicate sample temperature qualification.

Holding Times

Violation of method-specific holding times will result in the following data qualifiers.

- Holding times for inorganic compounds vary from 24 hours for analyses such as chromium VI and pH to six months for ICP metals. Results produced from analyses performed beyond the holding time are qualified as estimated J for detected values and UJ for nondetects.
- If holding times are grossly exceeded (greater than 2 times the normal holding time), then positive results are qualified J and non detects are qualified R.
- The descriptor e is used to denote holding time violations.

Blanks

Blank contamination identified during sample handling preparation and/or analysis will result in the following data qualifiers.

- Analytes found in associated environmental samples at or below 5 times the blank analyte contamination are qualified B.
- Analytes qualified for laboratory blank contamination are denoted with a descriptor a.
- Analytes qualified for equipment blank contamination are denoted with a descriptor k.

Laboratory Control Sample

Constituents detected in control samples outside of the specified limits will result in the following data qualifiers.

- For LCS qualifications, the specific analytes spiked into the LCS sample must always be qualified. All target analytes are spiked into the LCS.
- LCS recovery is above upper limit then J detected analytes only. Do not qualify non-detects.
- LCS recovery is below lower limit then J positive results and R non-detects.
- Analytes qualified for LCS failure are denoted with a descriptor d.

Matrix Spike/Matrix Spike Duplicate

Each specific MS or MSD spiking analyte that fails recovery criteria produces qualification of the matching analyte in the associated environmental samples. Where both the MS and MSD fail criteria, qualification is based on the least compliant recovery. Constituents detected in control samples outside of the specified limits will result in the following data qualifiers.

- MS/MSD recovery results are not used for qualification if the analyte concentration in the environmental sample used for the MS/MSD exceeds the spike concentration by a factor of 4 or more.
- If the MS and/or MSD recovery exceed the upper control limit, then J detected compounds only. Do not qualify non-detected compounds.
- If the MS and/or MSD recovery falls below the lower limit then J detected compounds and UJ non-detects.
- The descriptor c is used to indicate MS/MSD qualification based on the percent recovery of the spiked analytes.
- MS/MSD RPDs are calculated from the analyte concentrations of the MS and MSD. If the RPD is outside the control limit, the precision is in question, and the accuracy is compromised.
- MS/MSD RPD results are not used for qualification if the analyte concentration in the environmental sample used for the MS/MSD exceeds the spike concentration by a factor of 4 or more.
- RPD outside the control limit, then qualify the related sample results with J for detected compounds and UJ non-detects.
- The descriptor f is used to indicate RPD failure.

Field Duplicate Samples

Field duplicate samples are collected to assess the precision of the sample collection and laboratory analytical process. As a rule, both the sample and its duplicate result must be at or above the PQL in order to calculate a meaningful RPD and if both results are below the PQL, the RPD is not calculated. However, if one result is below the PQL (assume zero for a non-detect) and the other result significantly above (10 times) the PQL a RPD is calculated. If the RPD is outside the control limit, the precision is in question, and the accuracy is compromised. The qualification resulting from the sample and its duplicate non-compliant RPD apply only to the sample and it's duplicate and is analyte specific.

- If the RPD is outside the control limit, then qualify the sample and its duplicate with J for detected compounds and UJ non-detects.
- The descriptor f is used to indicate RPD failure.

3.13.5 Summary of Data Quality Objectives and Compliance

3.13.5.1 Data Quality Objectives

DQOs are qualitative and quantitative statements developed by data users to specify the quality of data from field and laboratory data collection activities. These DQOs must be carefully designed to support specific decisions or regulatory actions. The DQOs describe data which are needed, why the data are needed, and how the data will be used to address the problem being investigated. DQOs also establish numeric limits for the data to allow the data user to determine whether the data collected are of sufficient quality for use in their intended application.

The usability of the data collected during an investigation depends on its quality. A number of factors relate to the quality of data, and sample collection methods are as important to consider as methods used for sample analysis. Following standard operating procedures for both sample collection and analysis reduces sampling and analytical error. Complete CoC documentation and adherence to required sample preservation techniques, holding times and proper shipment methods ensure sample integrity. Obtaining valid and comparable data also requires adequate QA/QC procedures and documentation, as well as established detection and control limits.

Quantitation limits are based on the extent to which the field equipment, laboratory equipment, or analytical process can provide accurate measurements of consistent quality for specific constituents in field samples. The quantitation limit for a given analysis will vary depending on instrument sensitivity and matrix effects.

3.13.5.2 Precision, Accuracy, Completeness, and Comparability

The effectiveness of a QA program is measured by the quality of data generated by the laboratory. Data quality is judged in terms of its precision, accuracy, completeness, and comparability. These terms are described as follows:

Accuracy

Accuracy is the degree of agreement of a measurement or average of measurements with an accepted reference or "true" value, and is a measure of bias in the system. The accuracy of a measurement system is impacted by the errors introduced through the sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analytical techniques.

The laboratory accuracy of the measurement data will be assessed and controlled for this program. Results for blanks, matrix spikes, LCS, and surrogates will be the primary indicators of accuracy. These

results will be used to control accuracy by requiring that they meet specified criteria. As spiked samples are analyzed, spike recoveries will be calculated and compared to pre established acceptance limits.

Acceptance limits are based upon previously established laboratory performance for similar samples. In this approach, the control limits reflect the minimum and maximum recoveries expected for individual measurements for a control system. Recoveries outside the established limits indicate some assignable cause, other than normal measurement error, and possible need for corrective action. This includes recalibration of the instrument, reanalysis of the QC sample, reanalysis of the samples in the batch, or flagging the data as suspect if the problems cannot be resolved. For contaminated samples, recovery of matrix spikes may depend on sample homogeneity, matrix interference, and dilution requirements for quantification.

Precision

Precision is a measure of agreement among individual measurements of the same property under prescribed similar conditions. When control limits are established for accuracy, it automatically identifies the precision of the method. In the analysis of samples in a preparation batch, if the recoveries of analytes in the LCS are within the control limits, then the precision is also within limits.

Precision is also determined from duplicate sample analysis and MS/MSD analysis. The precision is quantified by the RPD value calculated from the duplicate results.

Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under correct, normal conditions.

Successful analyses are defined as those where the samples arrived at the laboratory intact, properly preserved, in sufficient quantity to perform the requested analyses, and accompanied by a completed CoC record. Furthermore, the sample must be analyzed within the specified holding time and in such a manner that analytical QC criteria described in this document are met.

Factors that adversely affect completeness include:

- Receipt of samples in broken containers;
- Receipt of samples in which CoC or sample integrity is compromised in some way;
- Samples received with insufficient volume to perform initial analyses or repeat analyses, if initial efforts do not meet QC acceptance criteria;
- Improperly preserved samples; and
- Samples held in the field or laboratory longer than expected, thereby jeopardizing holding time requirements.

Completeness for the entire project also involves completeness of field and laboratory documentation, whether all samples and analyses specified in the SAP have been processed, and whether the procedures specified in the SAP, Work Plan, and laboratory SOPs have been implemented.

Comparability

Comparability expresses the confidence with which one data set can be compared to another data set measuring the same property. Comparability is ensured through the use of established and approved sample collection techniques and analytical methods, consistency in the basis of analysis (wet or dry weight, volume, etc.), consistency in reporting units, and analysis of standard reference materials.

3.13.5.3 Selected Definitions/Criteria of Terms

3.13.5.3.1 Holding Times

The U.S. Environmental Protection Agency (U.S. EPA) has established maximum time intervals (holding times) between the collection and extraction, and extraction and analysis, of samples. All compliant results must be obtained within holding times or the results are considered deficient. Samples analyzed outside of holding times must be qualified.

3.13.5.3.2 Laboratory and Field Blanks

Laboratory and field blanks are samples used to determine if environmental sample results may be positively biased by laboratory or field contamination. Laboratory blank results indicate contamination due to laboratory operations only, while field blank results indicate contamination from field and/or laboratory operations. Laboratory blanks that have contaminants in concentrations above the PQL indicate a need for corrective action.

3.13.5.3.3 Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Matrix spike samples are environmental samples that are spiked with known concentrations of target analytes. The recovery of the target analytes is used to evaluate the effects of the sample matrix. Matrix effects are considered site specific. One MS/MSD sample is analyzed for each project, or every 20 environmental samples, whichever is more frequent. The matrix spike duplicate results may be compared to the matrix spike results in order to determine precision.

3.13.5.3.4 Laboratory Control Sample (LCS)

The LCS determines if the analytical system is in control and consists of reagent grade (analyte-free) water spiked with known concentrations of target analytes. Results from the LCS are considered free of any matrix effects and analyte recoveries outside control limits are used to qualify data.

3.13.5.3.5 Surrogates

For most methods, surrogate compounds are added to every sample at the beginning of sample preparation and are used to monitor the analytical process and give information concerning matrix effects. Surrogate recoveries are the single most useful QC entity for evaluating environmental analytical data. The ubiquitous use of surrogates in the analytical methods has afforded a large database of results from which useful correlated information can be extracted. Surrogates are chemically similar to target analytes and their recovery within control limits indicates the process is in control. Surrogates are the primary indicators of matrix effects.

3.13.5.3.6 Second Column Confirmation

All organic analysis that results in analyte detection should be confirmed in order to have confidence in the result. In the case of gas chromatography/mass spectrometry (GC/MS) analysis, analyte peaks at the correct retention time are confirmed by the mass spectra. For GC or HPLC analysis, a second analytical column and/or a second detector is used for to confirm the presence of the analyte. Unless an analyte is confirmed, its presence cannot be proved.

3.13.5.3.7 Temperature Blanks

Temperature blanks are placed in coolers with environmental samples in order to determine the temperature of the samples when they arrive at the lab. Temperature blanks typically consist of water in a container similar to the sample containers. Upon receipt at the lab, the temperature blanks are opened and a thermometer is inserted directly into the liquid. Alternatively, the temperature of the samples is measured using an infrared thermometer. The criterion is 4 degrees Celsius, plus or minus 2 degrees. Samples that arrive at the laboratory shortly after sample collection (less than 4 hours) may not have sufficient time for temperature equilibration. In these cases, samples may exceed the upper temperature limit of 6 degrees Celsius, but must be below ambient temperatures.

3.13.5.3.8 Field Audits

Field audits are a way of determining whether the sampling procedures used by the field crew follow standard operating procedures. The techniques used to collect the samples are analyzed to determine if the samples are being collected correctly.

3.13.5.3.9 Sample Delivery Group (SDG)

The SDG is a laboratory defined collection of sample results together with the corresponding quality control results. These results are organized under a unique group heading. The laboratory determines the method of grouping the sample results under an SDG and each SDG may contain samples collected at

various times and with different matrix types. Generally, each SDG consists of the results for a group of samples received by the laboratory on a single day.

3.13.5.3.10 Data Gaps

Data gaps may be generated by both field sampling activities and laboratory data problems. Field activities that may produce data gaps include difficulty accessing the sampling location, which results in no sample being collected, or damage and subsequent loss of samples before they reach the laboratory. Laboratory QC errors resulting in data that must be qualified as rejected will also leave data gaps in the analytical results. If necessary, data gaps may be closed quickly by resampling and reanalysis. If the results are not time critical, the gap may be closed during the next quarter of sampling.

3.13.6 Data Reporting

Results for soil and sediment samples shall be reported on a dry weight basis. Sample specific PQLs and MDLs should also be reported on a dry weight basis and should be adjusted for dilutions.

Determination of Percent Solids is required for soil and sediment samples in order to report results on a dry weight basis. Percent solids is determined by weighing the sample prior to drying it, then reweighing it after drying and applying the following equation:

$$\frac{1-(\text{Initial Weight - Dried Weight})}{\text{Initial Weight}} \text{ x } 100 = \% \text{ solids}$$

The percent solids determination is used to calculate results for soil samples on a dry weight basis using the following equation:

$$\frac{\text{result of analysis on wet weight basis}}{\% \text{ solids}} = \text{result of analysis on dry weight basis}$$

All soil and sediment results and MDLs shall be reported on a dry weight basis.

For soil and sediment samples, method recommended amounts should be weighed from each sample for analytical purposes. If the laboratory encounters special situations where deviation from the above rule is deemed necessary, the laboratory should contact the Performing Contractor to obtain variance. Samples for analysis and for moisture determination may be weighed from the same container on the same day.

3.13.6.1 Hard Copy Submittals

Hardcopy data reporting package requirements for screening data and definitive data are outlined below. The data reporting requirements and formats may be modified based on project DQOs. Modifications to

reporting requirements shall be specified in the project specific QAPP addenda. All hard copy submittals will be signed by the Laboratory Director certifying that the data provided therein is correct and is suitable for its intended use. Each data package must stand alone analytically and must not rely on other data packages for QC completeness.

3.13.6.1.1 Screening Data Package

Final hard copy screening data packages from the laboratory will include at least the following elements:

- A copy of the signed CoC form showing the date and time the sample was received;
- A cross-reference of field sample number to laboratory sample number;
- A cross-reference to identify applicable laboratory QC samples with the field samples;
- A cross-reference to identify each batch to the QC samples;
- A glossary to define the symbols and terms used in the laboratory report;
- Sample collection, extraction, and analysis dates;
- Sample receiving temperature;
- A list of detection limits;
- A list of practical quantitation limits;
- Instrument identification number for the tests performed; and
- Instrument calibration summary data to verify that initial and continuing calibration criteria are in control.

Depending on the DQOs for a project, the screening data package may include a QA/QC summary report, providing data on method blanks, surrogate recoveries, LCSs, MS/MSDs, and any other QA/QC samples (e.g., GC/MS tune) relevant to all initial, diluted, or reanalyzed samples. The QA/QC report will also contain a narrative that details all elements relevant to the sample results. The narrative will discuss each element; whether the element was acceptable or not and why; if outside acceptance criteria, the value and the criteria will be noted; corrective action taken; and the effect any problems had on the quality of the data.

3.13.6.1.2 Definitive Data Packages

Final hard copy reports from the laboratory will include at least the following elements:

- A copy of the signed CoC form showing the date and time the sample was received;
- A cross-reference of field sample number to laboratory sample number;
- A cross-reference to identify applicable laboratory QC samples with the field samples;
- A cross-reference to identify each batch to the QC samples;
- A glossary to define the symbols and terms used in the laboratory report;
- Sample collection, extraction, and analysis dates;
- Sample receiving temperature;
- A list of detection limits;

- A list of practical quantitation limits;
- Instrument identification number for the tests performed;
- For second column/detector confirmation samples, a data or analytical results summary will also be reported;
- Instrument calibration summary data to verify that initial and continuing calibration criteria are in control;
- Environmental sample results reported with at least two significant figures; and
- The analytical results for all detected and non-detected QAPP target analytes.

Depending on the DQOs for a project, the definitive data package will include a QA/QC summary report, providing data on method blanks, surrogate recoveries, LCSs, MS/MSDs, and any other QA/QC samples (e.g., GC/MS tune) relevant to all initial, diluted, or reanalyzed samples. The QA/QC report will also contain a narrative that details all elements relevant to the sample results for both inorganic and organic analyses. The narrative will discuss each element; whether the element was acceptable or not and why; if outside acceptance criteria, the value and the criteria will be noted; corrective action taken; and the effect any problems had on the quality of the data.

Results of all initial, diluted, and reanalyzed sample analyses for all methods as explained below:

1. The initial results are the undiluted or least diluted and most QC compliant sample analysis.
2. The diluted results are those results related to the initial sample analysis which, by virtue of a calibration range exceedance, caused the diluted analysis to be performed. All analytes reported in the initial results will be reported in the diluted results. All dilutions should be analyzed within holding times.
3. The reanalyzed sample results are those results usually related to corrective action procedures. The most common situations are surrogate recovery and IS area failures. If surrogate results or IS areas are outside control limits (high or low) the analysis is considered out of analytical control. The corrective action is to re-prepare and reanalyze the sample. Upon reanalysis, if the results are inside control limits, the laboratory reports only the in control results. However, if results are outside control limits in the reanalysis, then both sample results must be reported to document the corrective action attempt.

At the direction of the Performing Contractor, the laboratory will provide hardcopy data packages equal to a full raw data deliverable data package.

3.13.6.2 Electronic Submittals

Laboratory services providers will report all data in electronic and hard copy format. The electronic data will be reported as EDDs in a format specified by the Performing Contractor. Hard copy data will be reported in the Data Package format and using summary forms. If the laboratory cannot generate summary forms, the following elements which comprise a minimum data package, will be delivered:

- A copy of the signed CoC record showing the date and time the sample was received;

- A cross-reference of field sample number to laboratory sample number;
- A cross-reference to identify applicable laboratory QC samples with the field samples;
- A cross-reference to identify each batch to the QC samples;
- A glossary to define the symbols and terms used in the laboratory report;
- Sample collection, extraction, and analysis dates;
- Sample receiving temperature;
- A list of detection limits;
- A list of practical quantitation limits;
- Instrument identification number for the tests performed;
- Environmental sample results reported with at least two significant figures;
- The analytical results for all detected and non-detected QAPP target analytes;

For second column/detector confirmation samples, a data or analytical results summary will also be reported.

A QA/QC summary report, providing data on method blanks, surrogate recoveries, LCSs, MS/MSDs, and any other QA/QC samples (e.g., GC/MS tune) relevant to all initial, diluted, or reanalyzed samples will be provided. The QA/QC report will also contain a narrative that details all elements relevant to the sample results for both inorganic and organic analyses. The narrative will discuss each element; whether the element was acceptable or not and why; if outside acceptance criteria, the value and the criteria will be noted; corrective action taken; and the effect any problems had on the quality of the data;

The results of all initial, diluted, and reanalyzed sample analyses for will follow the guidelines presented above for the EDDs.

3.13.6.3 Formatting Conformance with Agencies

In determining EDD format, the Performing Contractor must be aware that EDDs should conform to the formatting requirements of other agencies. The Statement of Work will specify the project electronic formatting requirements. Project-specific QAPP addenda will further identify electronic requirements to support such as regulatory agency databases. For example, the RWQCB requires submittal of selected investigative data including laboratory analytical data and survey coordinates to Geotracker. It is the responsibility of the Performing Contractor to ensure that work is conducted in conformance with Geotracker requirements for all UST sites.

3.13.6.3.1 Formatting Conformance with Performing Contractor

Data generated during sampling activities will be incorporated into an electronic database. A geographic information system (GIS) is utilized as a tool to aid in the graphical presentation and interpretation of physical and analytical data collected during sampling activities. The Performing Contractor shall provide

the laboratory with an SOP for data generation that includes instructions regarding data review for consistency and status, and maintenance of magnetically stored data to ensure integrity. Electronic laboratory data are delivered to the Performing Contractor in EDDs and formats for use with GIS data.

Hard copy data reports will be provided to the client in various formats depending on contract and end user requirements.

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5.0 ACRONYMS

%	percent
%R	percent recovery
°C	degrees Celsius
µm	micrometer (micron)
µg/kg	microgram per kilogram
µg/L	microgram per liter
A2LA	American Association of Laboratory Accreditation
AA	atomic absorption
APHA	American Public Health Association
API	American Petroleum Institute
ARCH	air rotary-casing hammer
ASTM	American Society of Testing and Materials
BFB	bromofluorobenzene
bgs	below ground surface
BPA	burn pit area
CCCS	continuing calibration check standard (also known as CCV)
CFR	Code of Federal Regulations
CGI	combustible gas indicator
cis-1,2-DCE	cis-1,2-dichloroethene
CLP	Contract Laboratory Program
COD	coefficient of determination
CPT	cone penetrometer test
CoC	Chain–of–Custody
COPC	chemical of potential concern
1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethene
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DFTPP	decafluorotriphenylphosphine
DHS	California Department of Health Services
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DOT	Department of Transportation
DP	direct push
DPE	dual-phase extraction
DQI	data quality indicator
DQO	data quality objective

DTSC	California Department of Toxic Substances Control
DWNL	drinking water notification level
DWR	California Department of Water Resources
EB	equipment blank
EC	electrical conductivity
ECCS	end calibration check standard (also known as CCV)
EDD	electronic data deliverable
EICP	extracted ion chromatography profile
EM	electromagnetic
EPA	United States Environmental Protection Agency
Fe^{+2}	ferrous iron
FID	flame ionization detector
FSP	Field Sampling Plan
GC/MS	gas chromatography/mass spectrometry
GCR	Grand Central Rocket Company
GFAA	graphite furnace atomic absorption
GIS	geographic information system
gpm	gallons per minute
GPR	ground penetrating radar
GPS	global positioning system
HASP	Health and Safety Plan
HPLC	high pressure liquid chromatography
HSA	hollow stem auger
IC	ion chromatography
ICAL	initial calibration standard
ICCS	initial calibration check standard (also known as ICV)
ICP	inductively coupled plasma emission spectroscopy
ICP/MS	inductively coupled plasma emission spectroscopy/ mass spectrometry
ICPES	inductively coupled plasma atomic emission spectroscopy
ICS	interference check solution
I.D.	internal diameter
IDW	investigation–derived wastes
IPC	instrument performance check standard
IS	internal standard
IUOE	International Union of Operating Engineers
K	hydraulic conductivity
LAC	Lockheed Aircraft Corporation
LC	liquid chromatography
LCS	laboratory control sample
LFM	laboratory fortified sample matrix (also known as MS)
LIMS	Laboratory Information Management System

LMC	Lockheed Martin Corporation
LNAPL	light non-aqueous phase liquid
LPC	Lockheed Propulsion Company
LPM	Laboratory Project Manager
LQAM	Laboratory Quality Assurance Manager
LRB	laboratory reagent blank
LSM	Large Solid Motor
MCL	maximum contaminant level
MCT	matrix conductivity threshold
MDL	method detection limit
MEC	munitions and explosives of concern
ml	milliliter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MSL	mean sea level
MS/ MSD	matrix spike/matrix spike duplicate
N/A	not applicable
NAD	North American Datum
NAVD	North American Vertical Datum
NCR	nonconformance report
NIST	National Institute of Standards and Technology
nm	nanometer
NSF	National Sanitary Foundation
NTU	nephelometric turbidity unit
O.D.	outside diameter
ORP	oxidation-reduction potential
OVA	organic vapor analyzer
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
$PD_{A/H}$	area to height ratio percent difference
PE	performance evaluation
P.E.	Professional Engineer
P.G.	Professional Geologist
PHSM	Project Health and Safety Manager
PID	photo-ionization detector
POC	point of contact
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
ppmv	parts per million by volume
PQL	practical quantitation limit

PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
R&D	research and development
RCA	recommendation for corrective action
RCDEH	Riverside County Department of Environmental Health
RCRA	Resource Conservation and Recovery Act
RDX	Royal demolition explosive
RF	response factor
RI/FS	Remedial Investigation/Feasibility Study
RL	laboratory reporting limit
RMPA	Rocket Motor Production Area
RPD	relative percent difference
RSD	relative standard deviation
RSK	Richard S. Kerr
RWQCB	California Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SARWPCB	Santa Ana River Basin Regional Water Pollution Control Board
SIM	selected ion monitoring
SPE	solid-phase extraction
SOP	Standard Operating Procedure
SOW	Statement of Work
SPT	Standard Penetration Test
SRAM	Short Range Attack Missile
SSHO	Site Safety and Health Officer
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
T	well transmissivity
TB	trip blank
1,1,1-TCA	1,1,1-trichloroethane
TCE	trichloroethene
TCLP	toxicity characteristic leaching procedure
Tetra Tech	Tetra Tech, Inc.
TNT	trinitrotoluene
TPH	total petroleum hydrocarbons
UDMH	unsymmetrical dimethylhydrazine
USA	Underground Service Alert
USCS	Unified Soil Classification System
UST	underground storage tank

UV-VIS	ultraviolet-visible
VOA	volatile organic analysis
VOC	volatile organic compound
WDA	Waste Discharge Area

REPORT BODY AND APPENDICES A-C ON CD ON THIS DIVIDER