FINAL

SITE OPERATIONS PLAN

SOILS REMEDIATION OF AREA 2 OF SWMU 11
DUGWAY PROVING GROUND
DUGWAY, UTAH

CONTRACT NUMBER: W9123824C0005

Prepared for

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APPROVALS

SITE OPERATIONS PLAN

for the

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DUGWAY, UTAH

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TABLE OF CONTENTS

SECTION **PAGE**

1.0 INTRODUCTION 1-1
1.1 SCOPE 1-1
1.2 PLANNING DOCUMENTS 1-1
2.0 SITE BACKGROUND 2-1
2.1 CURRENT SITE CONDITIONS 2-1
2.2 SURROUNDING PROPERTIES 2-2
2.3 NATURE AND EXTENT OF CONTAMINATION 2-2
3.0 PRE-MOBILIZATION ACTIVITIES 3-1
3.1 SITE-SPECIFIC PROJECT PLANS 3-1
3.1.1 CQCP 3-1
3.1.2 APP/SSHP/RPP 3-1
3.1.3 UFP-QAPP 3-2
3.1.4 Project Management Plan 3-2
3.2 WASTE PROFILE 3-2
3.3 PERMITTING AND NOTIFICATION 3-2
3.4 HEALTH AND SAFETY MEETINGS 3-3
3.5 PRE-MOBILIZATION SURVEYS 3-3
3.5.1 Field Team and Equipment 3-3
3.5.2 Baseline Topographic Survey 3-3
3.5.3 Baseline Air Monitoring 3-3
3.5.4 Baseline Gamma Walkover Survey 3-3
3.5.5 Backfill Sampling 3-4
4.0 FIELD WORK 4-1
4.1 MOBILIZATION 4-1
4.1.1 Field Team 4-1
4.1.2 Equipment 4-1
4.2 SITE PREPARATION ACTIVITIES 4-2
4.2.1 Field Observations and Photographic Documentation 4-2
4.2.2 Material Handling and Storage Areas 4-2
4.2.3 Temporary Fencing 4-2
4.2.4 Traffic Control 4-2

TABLE OF CONTENTS (CONTINUED)

SECTION **PAGE**

4.2.5 Erosion & Sedimentation Controls 4-3
4.3 REMEDIATION 4-3
4.3.1 EXCAVATION 4-4
4.3.2 Water Management 4-6
4.3.3 WASTE PACKAGING & TRANSFER TO STAGING AREA 4-6
4.3.4 WASTE TRANSPORTATION AND DISPOSAL 4-7
4.3.5 SPILL PREVENTION AND CONTROL 4-7
4.4 AIR MONITORING 4-8
4.4.1 Perimeter and Remediation Zone Air Monitoring 4-8
4.4.2 Personnel Air Monitoring 4-8
4.4.3 Meteorological Monitoring 4-8
4.5 EQUIPMENT DECONTAMINATION 4-8
4.6 SITE RESTORATION 4-9
4.6.1 Backfilling Methods and Equipment 4-9
4.6.2 Backfill Materials 4-10
4.7 DECONTAMINATION AND RELEASE OF EQUIPMENT AND TOOLS 4-10
4.8 DEMOBILIZATION 4-11
5.0 CONSTRUCTION QUALITY CONTROL 5-1
6.0 REGULATORY COMPLIANCE 6-1
6.1 ARARS CONSIDERED IN DETERMINING REMEDIAL ALTERNATIVE 6-1
6.2 BACKGROUND REQUIREMENTS FOR THE EXECUTION OF REMOVAL ACTION 6-2
6.2.1 Permitting 6-2
6.2.2 Statutory Authorities 6-2
6.2.3 Federal Regulatory Agencies 6-3
6.2.4 State Regulatory Agencies 6-4
6.3 SUMMARY OF APPLICABLE REQUIREMENTS AND STANDARDS 6-4
7.0 REPORTING REQUIREMENTS 7-1
8.0 REFERENCES 8-1

LIST OF TABLES

Table 6-1. Potential Regulatory Requirements for the DPG SWMU-11 Site..... 6-5
Table 6-2. Applicable USACE Guidance Documents for DPG SWMU-11 Site..... 6-16

LIST OF FIGURES

Figure 1-1 Site Location
Figure 1-2 Construction Site Layout
Figure 4-1 Erosion and Sedimentation Controls/Construction Diagrams
Figure 4-2 Gross Excavation Plan
Figure 4-3 Excavation Detail
Figure 4-4 Waste Transportation Haul Route
Figure 4-5 Restoration Plan

LIST OF APPENDICES

Appendix A Uniform Federal Policy for Quality Assurance Project Plans

LIST OF ACRONYMS/ABBREVIATIONS

APP	Accident Prevention Plan
ARARs	Applicable or Relevant and Appropriate Requirements
Army	US Army
^{214}Bi	bismuth-214
bgs	below ground surface
BZ	breathing zone
Cabrera	Cabrera Services Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm	centimeters
CQCP	Contractor Quality Control Plan
^{137}Cs	cesium-137
CWA	Clean Water Act
CY	cubic yards
DOD	Department of Defense
DOT	Department of Transportation
DPG	Dugway Proving Ground
DQOs	daily quality objectives
EM	Engineering Manual
ENVECO	ENVECO Environmental Solutions LLC
EPA	Environmental Protection Agency
ES	EnergySolutions LLC
FS	Feasibility Study
FSS	final status surveys
ft	feet
GWS	gamma walkover survey
IDW	investigation-derived waste
IL	investigation level
LLW	Low level waste
LV	low volume
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MoU	memorandum of understanding
m/s	meters per second
^{94}Nb	niobium-94
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OP	operating procedure
OSHA	Occupational Safety and Health Administration
^{214}Pb	lead-214
pCi/g	picocuries per gram
PHP	Principal Health Physicist
PP	Proposed Plan
PPE	Personal Protective Equipment
PM	Project Manager
RAO	Remedial Action Objective
^{226}Ra	radium-226
RBA	reference background area
RCRA	Resource Conservation and Recovery Act
RCT	Radiation Control Technician
RFI	RCRA Facility Investigation

LIST OF ACRONYMS/ABBREVIATIONS (CONTINUED)

ROC	radionuclide of concern
ROD	Record of Decision
RPP	Radiation Protection Plan
SARA	Superfund Amendments and Reauthorization Act
Site	Area 2 of Solid Waste Management Unit-11
SOP	Site Operations Plan
^{90}Sr	strontium-90
SRSO	Site Radiation Safety Officer
SSHP	Site-Specific Safety & Health Plan
SU	survey unit
SWMU	Solid Waste Management Unit
SWPPP	Stormwater Pollution Prevention Plan
UDEQ	Utah Department of Environmental Quality
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
USACE	United States Army Corps of Engineers
USC	U.S. Code

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1.0 INTRODUCTION

Cabrera Services Inc. (Cabrera) has developed this Site Operations Plan (SOP) to describe the means and methods for performing soils remediation at Area 2 of Solid Waste Management Unit (SWMU)-11, hereafter referred to as "the Site," within the Dugway Proving Ground (DPG) in Dugway, Utah under Contract number W9123824C0005 with the US Army Corps of Engineers (USACE) Sacramento District. The DPG site location is displayed in Figure 1-1, and the proposed construction layout of the Site is displayed in Figure 1-2.

Cabrera is an EnergySolutions company and shares a common parent company with EnergySolutions, LLC (ES). The radioactive waste disposal scope of work described in this plan will be performed by ES under an intercompany agreement with Cabrera. For consistency, "Cabrera" will be used throughout this SOP to refer to the contractor performing the remediation and "ES" will be used to refer to the radioactive waste disposal facility at Clive, Utah, unless otherwise specified.

1.1 SCOPE

The major components of the selected remedy for the SWMU-11 include:

- Excavating approximately 572 cubic yards (CY) from both TR-5 and TR-6 to a depth of approximately 7 feet (ft) below ground surface (bgs) to meet the Remedial Action Objective (RAO).
- Establishing perimeter dust control measures, air monitoring and contamination control measures to monitor and control the discharge of surface water runoff and airborne dust from the excavation areas to local conveyances. This will be conducted for health and safety purposes during excavation.
- To ensure the excavation was completed to meet unrestricted (i.e., residential) standards (i.e., unlimited use/unrestricted exposure), confirmation surveys and soil sampling for radionuclides and a magnetometer survey will be performed to ensure all radiologically impacted materials and debris have been removed.
- Backfilling with clean soil, contoured to promote surface water runoff in accordance with Section 4.6 of this SOP.

Cabrera will be required to meet the RAO, as stated in the Record of Decision (ROD) (US Army Environmental Command [AEC], 2021), to demonstrate completion of the contract:

- Prevent direct contact to or external exposure from surface and subsurface soil and debris (i.e., metal tubes) contaminated with Radium-226 (^{226}Ra), Strontium-90 (^{90}Sr), Bismuth-214 (^{214}Bi), Niobium-94 (^{94}Nb), Lead-214 (^{214}Pb), and Cesium-137 (^{137}Cs) by human receptors, with consideration to current and reasonably anticipated future land uses. The radiological criterion for unrestricted release is a dose limit of 25 millirem per year.
- Reduce the potential for migration of soil contaminated with ^{226}Ra, ^{90}Sr, ^{214}Bi, ^{94}Nb, ^{214}Pb, and ^{137}Cs to areas beyond the trenches (i.e., buffer zones surrounding the trenches, air, and groundwater).

1.2 PLANNING DOCUMENTS

In addition to this SOP, the other planning documents that will govern this work are as follows:

- Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) (provided in Appendix A);

- Accident Prevention Plan (APP), including a Site-Specific Safety and Health Plan (SSHP) and Radiation Protection Plan (RPP) (Cabrera, 2024a);
- Project Management Plan (Cabrera, 2024b); and
- Contractor Quality Control Plan (CQCP) (Cabrera, 2024c).

2.0 SITE BACKGROUND

In the DPG Resource Conservation and Recovery Act (RCRA) Facility Application, Area 2 of SWMU-11 was one of seven reported radioactive landfills. Historic records regarding radiological materials handling were summarized in the 2009 Phase II RCRA Facility Investigation (RFI) (Parsons, 2009). Specific records regarding radiological materials disposed at SWMU-11 are limited. The East Granite Holding Area (i.e., SWMU-11) is not identified in available literature as being associated with the testing of radiological munitions conducted at DPG in the 1950s and 1960s. Historical inspection records indicate that buried wastes in the SWMU-11 area consisted primarily of "contaminated rags and papers." Inspection records from the U.S. Atomic Energy Commission indicate that low-level radioactive waste materials were repackaged for sea disposal in the Able Area. Waste from this activity may have also been disposed at the DPG burial area corresponding to SWMU-11 after the sea disposal program was discontinued. Available documentation states that operation of the DPG radioactive waste disposal facility was discontinued in the early 1960s and that materials were transferred offsite during 1962 (NRC, 2001). Historical records indicate that the latest potential use of the SWMU-11 area for radiation-related operations was 1977. By extension, the last potential opportunity for radiological material to be added to trenches TR-5 and TR-6 would also be 1977.

Radioactive waste materials from laboratory activities in other areas of DPG were stored in a CONEX container at SWMU-11 to protect individual storage containers from the elements. Materials stored in the CONEX container included Tritium and Carbon-14. In March 1980, contaminated glassware was removed from the CONEX by the DPG radiation safety officer and disposed at an off-site location.

During the 2005 Phase II RFI, no waste remained in the CONEX container (Parsons, 2009). The CONEX container was determined to be radiologically clear and was removed in 2017 (Marsh, 2017).

2.1 CURRENT SITE CONDITIONS

The Feasibility Study (FS) (North Wind, 2020) evaluated human and ecological receptors and exposure routes, established RAOs, developed Applicable or Relevant and Appropriate Requirements (ARARs), and evaluated six remedial alternatives to address site-related contaminants that pose an unacceptable risk to human health or the environment. As presented in the ROD (AEC, 2021), the conceptual site model provides an evaluation of human and ecological receptors and exposure routes and RAOs were established based on the known current conditions and the potential risks to human receptors identified during the FS.

The Proposed Plan (PP) presented the findings of the FS (North Wind, 2020). The PP identified the Preferred Alternative for addressing radiologically impacted soil and debris at Area 2 of SWMU-11 as Alternative 4 – Excavation, Disposal, and Backfilling. Alternative 4 meets the threshold criteria (i.e., overall protection of human health and the environment and compliance with ARARs) and provides the best balance of tradeoffs among the six alternatives with respect to balancing and modifying criteria (i.e., long- and short-term effectiveness; reduction of toxicity, mobility, volume, and mass of contamination; implementability; and cost).

The U.S. Army (Army) selected Alternative 4 (Excavation, Disposal, and Backfilling) as the preferred remedy for Area 2 of SWMU-11. Excavation, Disposal, and Backfilling represents the best balance of tradeoffs between balancing and modifying criteria and will be protective of human health and the environment and will comply with ARARs.

2.2 SURROUNDING PROPERTIES

The DPG facility is bordered to the northeast by the Cedar Mountains and to the north-northwest by Wendover Air Force Range. DPG currently serves as the Army's designated Major Range Test Facility for chemical and biological defense. SWMU-11, also known as DPG-011 and the East Granite Holding Area, is located in the remote southwest portion of DPG and covers approximately 3.4 acres within a small canyon on the east side of Granite Mountain. SWMU-11 is divided into two distinct areas: Area 1 and Area 2. Area 1 of SWMU11 was previously evaluated and closed under the RCRA and corrective action requirements of the Utah Department of Environmental Quality (UDEQ) Division of Waste Management and Radiation Control. The focus of this PWS, Area 2 (0.86 acres) of SWMU-11 is a radiological disposal area of concern and consists of two trenches, TR-5 and TR-6, and the area adjacent to the trenches.

2.3 NATURE AND EXTENT OF CONTAMINATION

The various DERP soil sampling efforts identified soils in the SWMU-11 with elevated levels of ^{26}Ra, ^{214}Pb, ^{214}Bi, ^{90}Sr, ^{94}Nb, and ^{137}Cs. Maximum detected concentrations within the excavation locations included 3,040 picocuries per gram (pCi/g) for ^{226}Ra, 2,200 pCi/g for ^{214}Pb, 2,100 pCi/g for ^{214}Bi, 19.2 pCi/g for ^{90}Sr, 8.9 pCi/g for ^{94}Nb. ^{137}Cs was not detected in Area 2 but is likely associated with metallic debris in TR-6.

3.0 PRE-MOBILIZATION ACTIVITIES

This section describes project-related tasks that will be completed prior to full field mobilization for remediation.

3.1 SITE-SPECIFIC PROJECT PLANS

Site-specific project planning documents (project work plans) have been developed and are incorporated into this SOP by reference. All of the project work plans have been prepared in accordance with the Scope of Work (SOW). These documents, including this SOP, may be updated periodically as necessary based on the scheduled review process and potential changes encountered in the field. Major revisions will be reviewed and approved by the USACE and appropriate stakeholders, as required, and directed by the USACE. The most current approved revision for each document will be maintained on site. A summary of the supporting project work plans is provided below.

3.1.1 CQCP

The CQCP (Cabrera, 2024c) provides procedures to assure that work activities comply with the SOW, this SOP supporting project work plans and USACE quality control (QC) requirements. The plan is structured to cover general requirements, including purpose, scope, organization and use of the documents; project plans; site background and scope of work; QC program organization, personnel qualifications and training; letters of authority; inspection phases; record-keeping; and deficiency management reporting; project records and documentation; construction testing; definable features of work and references.

3.1.2 APP/SSHP/RPP

The APP (Cabrera, 2024a) has been prepared to cover each APP element in Appendix A of Engineering Manual (EM) 385-1-1 (USACE, 2014) and meets the Hazardous Waste Operations and Emergency Response requirements set forth by the Occupational Safety and Health Administration (OSHA) in the Code of Federal Regulations (CFR) Part 20, Sections 1910.120 and 1926.65 (OSHA, 2011). The Site Safety and Health Plan (SSHP) attached to the APP (Appendix A) covers each of the SSHP elements in Section 33.B.02 of EM 385-1-1.

This APP establishes site-specific safety and health procedures, practices, and equipment to be implemented and used to protect personnel, as well as the local community and the environment, from potential occupational safety and health hazards during execution of Cabrera's SOW. This APP is considered a working document and may be modified during fieldwork based upon review of additional information regarding unexpected site conditions and/or implementation issues.

Field activities shall be performed in accordance with policies and procedures in Cabrera's Occupational Health & Safety Management System (Cabrera, 2021); other applicable site health and safety (H&S) regulations; OSHA requirements; and, other applicable Federal, State, and local statutes. Onsite personnel shall follow the health and safety guidelines specified in the APP, be alert to potential changes in site hazards, and exercise reasonable caution at all times.

The SSHP includes Activity Hazard Analyses prepared in accordance with page 8, Figure 1-2 of Engineer Manual (EM) 385-1-1 Safety and Health Requirements (USACE, 2014), and includes a RPP to address radioactive materials encountered at the Site in accordance with USACE publication EM 385-1-80, Radiation Protection Manual (USACE, 2013). The SSHP also includes an Emergency Response and Notification Plan for potential spills/releases (chemical and radiological) for both on-site activities and off-site transportation.

3.1.3 UFP-QAPP

The UFP-QAPP (Appendix A) establishes the project quality assurance plan for sampling, measurement, and analytical requirements associated with site remediation activities. It describes applicable data quality objectives, analytical methods and measurements, QA/QC protocols, and data assessment procedures for evaluating and identifying any data limitations. It contains technical detail and direction for field and laboratory personnel to understand project sample analysis, QC and data reporting requirements, analytical methods, required detection limits, QC requirements, and data validation and reporting requirements. The UFP-QAPP will contain a Final Status Survey (FSS) Plan, which is prepared in accordance with the guidance contained in the Multi-Agency Radiation Survey and Site Investigation Manual (NRC, 2000). The FSS will be performed prior to backfilling to demonstrate the attainment of remedials goals.

3.1.4 PROJECT MANAGEMENT PLAN

The Project Management Plan (Cabrera, 2024b) establishes the means and methods for managing the project, and includes the schedule, Milestone Payment Schedule, Submittal Register, general technical approach, resources, and communication required for the planning, execution, and completion of the project.

3.2 WASTE PROFILE

Cabrera will work with ES to establish the initial draft waste profile for the project. Cabrera will use historical analytical data from previous investigations to complete the profile and will answer any outstanding questions on the profile with the ES point of contact. The draft waste profile will then be sent to USACE and the AEC for review and comment prior to finalization. It is possible that the waste profile will require revisions based on analytical data collected during this investigation. If this is necessary, then Cabrera will notify USACE/AEC and follow the same process to prepare, review, and submit a revised profile.

3.3 PERMITTING AND NOTIFICATION

The ROD (AEC, 2021) presents the Army Selected Remedy for Area 2 of SWMU-11 at DPG, Dugway, Utah. Records indicate Area 2 was never licensed by the NRC. During 2016, the Department of Defense (DoD) and the NRC finalized a memorandum of understanding (MoU) for the coordination of response actions for DoD sites containing radioactive material that are not licensed by the NRC (NRC-DoD MoU, 2016). The Remedy was selected pursuant to the MoU and in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, and to the extent practical, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) – 40 Code of Federal Regulations (CFR) Part 300, and the U.S. Environmental Protection Agency (EPA) Remedial Investigations (RI)/ FS Guidance 540/G-89/004 (EPA, 1988).

Paragraph 30 of the MoU states that when DoD's radiological remediation activities are conducted by service providers, DoD will verify that its service providers use NRC's guidance (i.e., NUREG-1556, Vol. 18, Rev. 1 [NRC, 2017]) to determine whether an NRC or Agreement State license is required in order to conduct its activities. The first step in this process is to determine whether the waste is licensed under the Atomic Energy Act (AEA) of 1954. As stated in the previous paragraph, this material was never licensed by the AEA or by NRC. Furthermore, all activities on this project are being performed under the DoD's authority under CERCLA. Therefore, Cabrera will not invoke its Mobile NRC license #39-35044-01 to perform the remediation work but will conduct its work in accordance with the procedures approved under this license. The DoD will also provide

written clarification that the remediation activities will be conducted under the DoD's CERCLA authority. Mobile NRC license #39-35044-01 procedures are included in Attachment A of the RPP (Cabrera, 2024a).

The intermodal containers (IMCs) being used to package and ship low activity radioactive waste will be mobilized to the project as "Rad Empty," meaning that the outside of the containers will comply with the contamination limits in U.S. Department of Transportation (DOT) regulation 49 CFR 173.443, but the inside surfaces of the containers may contain residual radioactivity. Therefore, Cabrera will seek reciprocity of its Mobile NRC license #39-35044-01 with the State of Utah to invoke its license during the opening, lining, and loading of IMCs. Waste packaging is described in detail in Section 4.3.3.

A dig permit and utility locating survey is not required prior to performing intrusive work at DPG due to previous investigations in the same location.

A Stormwater Pollution Prevention Plan (SWPPP) and permit is required if a project causes a land disturbance of greater than 1 acre. This is not expected; therefore, a SWPPP is not required.

3.4 HEALTH AND SAFETY MEETINGS

Daily tailgate safety meetings will be held before starting work. Field staff, including subcontractors, will attend these meetings and sign a tailgate safety meeting form. The meetings will be held by the Site Safety and Health Officer (SSHO), or his or her qualified designee, and will cover various safety issues. Any subcontractor, inspector, agency, or USACE/USAF personnel that visit the site during the course of the day will be required to review and sign the tailgate form prior to entering the work site.

3.5 PRE-MOBILIZATION SURVEYS

3.5.1 FIELD TEAM AND EQUIPMENT

The field team for pre-mobilization surveys will consist of the SSHO, Contractor Quality Control Systems Manager (CQCSM), Site Radiation Safety Officer (SRSO), and Environmental Sampler/Radiation Control Technician (RCT). Equipment will consist of a generator to power on-site instrumentation and air monitors and radiological instrumentation.

3.5.2 BASELINE TOPOGRAPHIC SURVEY

A subcontractor, with Cabrera oversight, will perform an existing conditions land survey in accordance with the SOW, prior to full mobilization for remediation. The existing conditions land survey, which will identify surface topography and key Site features, is planned for summer 2024. The existing conditions survey will encompass approximately 2 acres.

3.5.3 BASELINE AIR MONITORING

Pre-remediation baseline air monitoring, consisting of one low-volume air sampler running for approximately 8 hours, will be performed to establish ambient air concentrations prior to the start of site remediation activities. Air monitoring will be performed as discussed in the RPP (Cabrera, 2024a). Filters will be counted using on-site instrumentation for total alpha and beta activity.

3.5.4 BASELINE GAMMA WALKOVER SURVEY

A gamma walkover survey (GWS) will be conducted in all site areas, such as the Support Zone (SZ), including parking and trailer areas, haul roads, etc., the Contamination Reduction Zone (CRZ), and the Exclusion Zone (EZ) (the trench areas) to document baseline conditions. GWS will

be performed and displayed as discussed in the UFP-QAPP (Appendix A). The figures showing the completed GWS will be submitted to USACE for review.

3.5.5 BACKFILL SAMPLING

A grab sample will be collected from the on-site backfill source to ensure it is suitable for use during site improvements and restoration. Sampling and analysis at the off-site laboratory will be conducted as described in the UFP-QAPP (Appendix A). Results will be sent to USACE and AEC for review prior to use. Subsequent backfill sampling will consist of one sample per 75 CY of fill material.

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4.0 FIELD WORK

This section describes the specific field work activities and procedures.

4.1 MOBILIZATION

Mobilization activities will include travel to the Site by field personnel, and delivery and setup of equipment, materials, a trailer, and instrumentation. There will be two separate mobilizations to perform field work (not including the mobilization to perform Pre-Mobilization Surveys described in Section 3.4). The purpose of the first mobilization is to prepare the site for remediation, perform site improvements, excavate contaminated soil and debris from the trenches, load and transport IMCs, perform final status surveys (FSS) at the limits of excavation, and secure the excavation before leaving the Site awaiting analytical results from the FSS samples. The purpose of the second mobilization is to mobilize the personnel and equipment required to backfill and restore the site after receiving approval from USACE/AEC.

The personnel and equipment required for each mobilization are described in the following subsection.

4.1.1 FIELD TEAM

For the first mobilization, in addition to the SSHO, CQCSM, SRSO, Environmental Sampler/RCT, Cabrera will mobilize a Site Superintendent, Waste Manager, and RCT to join the project team. Our team subcontractor ENVECO Environmental Solutions, LLC (ENVECO) will provide one Senior Heavy Equipment Operator/Foreman, one Senior Heavy Equipment Operator, one Junior Heavy Equipment Operator, and one Sr. Environmental Technician/Laborer to the field team. We will mobilize and stage a CONEX box office and perimeter/work area air monitors powered with 5 kilowatt gas generators. We will also mobilize a 50,000-pound excavator to load approved on-site fill into a 26-ton off-road dump truck to conduct haul road improvements. The excavator will also be used to remediate the trench soils and load directly into IMCs. The excavator will either be fitted with a bucket scale or we will mobilize a truck scale to ensure loaded IMCs meet DOT public road weight limits. A 30,000-pound dozer will be used to perform site improvements.

For the second mobilization, the full field team described above will mobilize to the Site. We will mobilize the excavator and dump truck to transport fill to the Site, and the dozer will be used to backfill the trenches.

Other equipment used during the first and second field mobilizations includes a water truck for dust suppression, a skid steer with bucket/trencher attachments used for miscellaneous earthwork, and diesel/gas fuel tanks. The diesel tank will be a 500-gallon tank with secondary containment and a spill kit, or a truck-mounted tank on the back of a pickup truck.

4.1.2 EQUIPMENT

Excavation will be completed in the manner described in Section 4.3.1 using the following equipment:

- Large tracked excavator (50,000 pounds) with a bucket scale, or equivalent, located within the EZ will excavate soil and directly load IMCs.
- Medium tracked excavator (30,000 pounds) to load dump trucks with backfill from on-site source.
- Off-road dump truck (25 CY) to transport backfill to site for improvements and to backfill

excavations

- Wide-track low ground pressure (LGP) dozer (95-105 horsepower) to make site improvements, backfill with machine compaction, and grading.
- Water truck (2,000 gallon) for dust suppression
- Tracked skid steer (28,000 pounds) with forks and trencher attachments for silt fence installation and miscellaneous earthwork
- IMCs (25.4 CY size) with aluminum lids will be mobilized to the Site to containerize radioactive wastes from the remediation. Approximately 15 IMCs will be used in rotation during the project.

4.2 SITE PREPARATION ACTIVITIES

Site preparation activities are discussed in the following subsections.

4.2.1 FIELD OBSERVATIONS AND PHOTOGRAPHIC DOCUMENTATION

Field observations will be recorded daily in the project logbooks and daily reports. Photographs of the site will be collected daily during field operations. Electronic versions of the photographs will be sorted by date and accompanied by a Project Photographic Log providing the date, location, and a description of the activities shown in each photo will be developed and kept in the electronic project file.

4.2.2 MATERIAL HANDLING AND STORAGE AREAS

Radioactive waste will be minimized by compliance with contamination control work practices combined with survey practices. Radiological areas and postings are further described in the RPP (Cabrera, 2024a). If investigation derived waste is generated during project survey activities, then this waste will be managed along with other low activity radioactive waste as described in Section 4.3.3.

4.2.3 TEMPORARY FENCING

Temporary fencing will be installed around the trench areas prior to the start of excavation. The fencing will be high visibility orange fencing at least 42 inches high and secured to steel fence posts and will also include radiation rope and appropriate postings (i.e., Radiologically Controlled Area, etc.). The fencing will demarcate the exclusion zone (EZ) from the contamination reduction zone and will limit access to open excavations. The approximate location of the temporary fencing and EZ are displayed in Figure 1-2. Details regarding the installation of the fencing are provided in Figure 4-1.

4.2.4 TRAFFIC CONTROL

Parking for visitors and field supervisory personnel will be located in the Trailer Support Zone. Remediation personnel will park in the designated area depicted in Figure 1-2. In general, access will be restricted to the main portion of the Site once remediation activities are initiated. Visitors will be directed to the office trailers for sign-in and escort into the work area if approved by USACE and Site Superintendent. Access to the main portion of the Site after hours will not be permitted. Access to the SZ will be restricted after hours, with site trailers locked during non-working hours.

4.2.5 EROSION & SEDIMENTATION CONTROLS

Erosion & sedimentation (E&S) controls will be installed prior to initiating earthwork and maintained for the duration of excavation and site restoration activities. Given the flat grade of the site, the installation of widespread E&S controls is not planned. The following E&S controls and procedures will be implemented at the Site:

- Temporary upgradient diversion dikes will be installed for each excavation to divert storm water at the locations shown in Figure 1-2. The design of these diversion dikes are provided in Figure 4-1. Berms or pumping will only be implemented if the primary techniques are unsuccessful, as determined by the Site Superintendent.

- Silt fence will be installed and maintained downgradient of the layback soil stockpile area to minimize the potential for surface migration of contaminated storm water runoff.

- Trucks entering and leaving the Site will avoid direct tire contact with contaminated soil to prevent tracking soil off site. If potential contact with truck tires becomes a concern, then a rumble strip will be provided to shake off excess dirt before the trucks leave the EZ.

- E&S control measures will be monitored during all phases of the cleanup to prevent the surface migration of contaminated storm water runoff. The inspection of control measures will occur on a daily basis to ensure that control and preventive measures are in operation to prevent pollution of the environment. Corrective action will be taken if the operability of a control measure is in question. Inspections and corrective action will be documented in daily QC reports (DQCRs).

- Inspections will be made after each rainfall and daily during extensive periods of rainfall. Silt accumulated in erosion control structures will be removed as necessary. Silt fences will be inspected daily, and any damaged silt fence will be repaired or replaced. E&S controls will be removed upon the completion of backfilling.

Any site-specific control measures different from those described herein will be discussed with USACE prior to implementation. The approximate location of the E&S controls described above are depicted in Figure 1-2. Typical details for the controls to be implemented are provided on Figure 4-1. Wastewater will be managed as discussed in Section 4.3.2.

4.2.6 HAND EXCAVATION AND DRUM SHIPMENT

After mobilization to the Site, an RCT will utilize the on-site GPS unit to physically mark the trench locations with marking paint (or equivalent). A laborer will use a shovel to fill a 55-gallon drum with surficial waste material from Trench TR-5. The drum will be released from the EZ and surveyed for release as described in Section 4.3.3.2. The Waste Manager will generate the waste manifests for AEC review/signature as described in Section 4.3.3.3. The Waste Manager, or designee, will transport the drum to ES. ES will collect their own sample from this container to confirm WAC compliance. Upon receipt of analytical results, ES will dispose of the waste and notify the Cabrera Project Manager that the remaining low activity radioactive waste from the Site can be shipped to ES for disposal.

4.3 REMEDIATION

Remediation operations (i.e., excavation, waste packaging, and transportation and off-site disposal of contaminated soil and debris) will be under the day-to-day management of the Site Superintendent. The major tasks for remediation include:

- Excavation of contaminated soil and debris to pre-determined depths;
- Direct loading/packaging of excavated and sized wastes into IMCs, performing a surface contamination survey (i.e., smear sampling and counting) to demonstrate the absence of removable radiological contamination on the IMC exterior, and conducting a radiological survey to determine the dose rate associated with the shipment and demonstrate compliance with the requirements of U.S. Department of Transportation (DOT) regulations 49 CFR 173.436;
- Transportation of IMCs to the ES facility after visual inspection, radiological surveying for evidence of residual radioactive contamination, and receipt of approved signed waste manifests;
- Providing a safe excavation for RCTs and the magnetometer surveyor to complete FSS and magnetometer surveys of remediated areas, respectively;
- Backfilling, machine compaction and site restoration following USACE approval of FSS results;
- Decontamination and free-release operations;
- Establishment and maintenance of the Site coordinate system and land surveying;
- Budget, cost and schedule tracking;
- Regulatory compliance monitoring; and
- QC inspections and records maintenance by the CQCSM.

Detailed descriptions of personnel, equipment and processes/methods that will be used to complete this remediation are described below.

4.3.1 EXCAVATION

Soil exceeding project cleanup goals (derived concentration guideline levels [DCGLs]) will be excavated from Areas designated by USACE as shown in Figure 4-2. An FSS will verify the limits of excavations meet project DCGLs. Personnel, equipment and processes/methods for conducting the FSS are described in the UFP-QAPP (Appendix A).

4.3.1.1 Excavation Procedure

Empty IMCs will be delivered and staged adjacent to the excavation for loading (IMCs will first be inspected, surveyed, and lined in Section 4.3.3.1). Upon acceptance, surveys, and lining of the IMC, contaminated material will be directly loaded into the IMC.

Excavation will begin with the non-impacted layback soils around the trench boundaries (approximately 90 CY total from Trenches TR-5 and TR-6). Excavations will be sloped at a ratio of 1.5:1 to a depth of 3-ft to allow for personnel to safely enter the excavations (see Figure 4-3). This material will be removed first and staged on a 100’ x 100’ piece of 12-oz non-woven geotextile fabric and covered using poly sheeting with sandbags. Samples will be collected of this

material to determine its suitability for use as additional borrow material. This material will be sampled as described in the UFP-QAPP (Appendix A) and sent off-site to GEL Laboratories for radiological and chemical analysis. The sample results will be evaluated as discussed in Section 4.6.2.1 to determine if the layback soils are suitable for use as backfill. If the results do not meet the requirements for use as backfill, then the layback soils will be loaded into IMCs as described in this section.

After the layback soils are excavated, the excavation of contaminated materials will begin with Trench TR-6 due to the lead-time required to sample and analyze the material inside the expected drum carcasses for waste characterization purposes. The excavator will be fitted with a grading bucket and a calibrated bucket scale. Each bucket will be weighed so that the total acceptable weight of each IMC is not exceeded. The 50,000-pound excavator will excavate Trench TR-6 to the pre-determined excavation limits presented in Figure 4-3 without entering the excavation and tracking through the contaminated material. Contaminated soil and debris will be directly loaded into IMCs to avoid double-handling.

When the drum carcasses are located, they will be exhumed intact if possible, and loaded into a second IMC that is staged next to the excavation. If there is material present inside the drums, then it will be sampled as described in the UFP-QAPP (Appendix A) and sent off-site to GEL Laboratories for TCLP analysis for arsenic.

Approximately 190 bank CY (BCY) will be removed from Trench TR-6, and approximately 11.3 BCY will be loaded into each IMC (17 tons at an assumed conversion factor of 1.5 BCY per ton). Therefore, approximately 17 IMCs will be filled from contaminated soils/debris from Trench TR-6, not including the IMC used to contain the drum carcasses and their contents. If the sample results from the drums confirm that the material is non-hazardous, then soil will be loaded into the IMC and it will be prepared for shipment off-site as described in Section 4.3.4. If the sample results from the drum contents confirm that the material is hazardous for arsenic, then USACE will be notified, and the Waste Manager will work with ES to revise the waste profile and arrange for treatment of the waste prior to disposal.

When the limits of the excavation presented in Figure 4-3 have been reached, an RCT will conduct post-excavation GWS to identify any potential outliers. If GWS reveals gamma activity above the action level, then USACE will be notified. Either a sample will be collected and sent off-site for radiological analysis or USACE will authorize further excavation to remove the contaminated material. After Cabrera's Principal Health Physicist (PHP) determines that the GWS results are likely to meet the RAO, the GWS results will be submitted to USACE/AEC for review. A magnetometer survey will then be completed to detect any potential remaining metal debris using a Geonics EM-38B magnetometer, or equivalent. The CQCSM will perform a visual inspection to confirm there is no debris remaining inside the trench. After these inspections/ surveys are completed, the land surveyor will perform a civil survey to document the final excavation dimensions, mark the FSS sample locations, and calculate the soil removed. RCTs will then collect FSS samples as described in the UFP-QAPP (Appendix A) and sent off-site to GEL Laboratories for radiological analysis. The PM will then notify USACE and AEC that the trench is ready for inspection.

Excavation and FSS of Trench TR-5 will be performed as described above after TR-6 excavation is completed. Approximately 263 BCY will be removed from Trench TR-5, and approximately 11.3 BCY will be loaded into each IMC. Therefore, approximately 24 IMCs will be filled from contaminated soils/debris from Trench TR-5.

Excavations will remain open to allow for the FSS to be completed, samples to be analyzed off-

site, and USACE to review FSS results and authorize backfilling the excavations. During this time, Cabrera will temporarily demobilize personnel and equipment as described in Section 4.8. Cabrera will backfill the excavations and complete site restoration as described in Section 4.6 following USACE approval.

4.3.2 WATER MANAGEMENT

The generation of wastewater is not anticipated on this project. Groundwater is at a depth of 60 feet below ground surface (source) and the soils consist of permeable sand, silt and gravel causing stormwater to rapidly infiltrate into the vadose zone. Excavator tracks will be kept out of contaminated soils inside the EZ, and dry decontamination activities will be used to avoid the generation of wastewater. If wastewater is generated during excavation, it will be collected and pumped into a 500-gallon poly tank for storage. The water will be sampled and analyzed as discussed in the UFP-QAPP (Appendix A) for radiological, chemical, and metals analyses. The results will be used to generate a waste profile and facilitate off-site disposal.

4.3.3 WASTE PACKAGING & TRANSFER TO STAGING AREA

4.3.3.1 Intermodal Containers

Contaminated material will be loaded directly into 25.4-cubic yard (or similar) size IMCs lined with 6-millimeter plastic and equipped with aluminum hard-lids will be placed using a rolloff truck adjacent to the excavation(s). These IMCs will be US DOT-compliant shipping containers and can serve as standalone shipping units of radiological waste, conforming to the "strong-tight" definition of 49 CFR 17.427. Specifications for the IMCs and liners will be provided to USACE when the transportation vendor is selected on a future date.

4.3.3.2 Radiological Survey of IMC

A surface contamination survey (i.e., smear sampling and counting) will be performed to ensure compliance with 49 CFR 173.441, 49 CFR 173.443, and the RPP (Cabrera, 2024a). Any exterior areas of radioactivity that exceed release criteria will be decontaminated prior to release for off-site transport.

A dose rate survey will also be performed for each IMC to demonstrate compliance with the 49 CFR 173.436 and the RPP (Cabrera, 2024a). IMCs will be released for transport to ES following review/approval of the surface contamination and dose rate surveys by the Site RSO, preparation of shipping documents by the Waste Manager, and USACE approval/signature of shipping documents.

Details of the radiological survey of the IMC's exterior are described in the RPP (Cabrera, 2024a). It is unlikely that residual contamination on the IMC's exterior will exceed the criteria in the RPP (Cabrera, 2024a). However, the exterior of the IMC will be decontaminated and the survey repeated in the event free release limits are exceeded. Decontamination will consist of broom sweeping and using cloth to wipe down the containment sack exterior. Decontamination materials (brooms, rags, etc.) as well as spent personal protective equipment (PPE) will be sized as necessary and placed inside the IMCs for transport and off-site disposal as contaminated waste.

4.3.3.3 Transport to On-Site Waste Staging Area

Loaded IMCs will be properly manifested and a final inspection will be performed prior to being released from the Site. Manifests weights will be established using the weights measured by the certified bucket scale, or other approved method (i.e., truck scale). The Waste Manager will create

manifests consisting of manifests (i.e., US NRC 540/541 Forms), print each, and provide them to the on-site AEC representative for review and signature. Once signed, the forms will be scanned on-site and provided to the truck driver, who will then be authorized to leave the Site and transport the waste using the designated haul route displayed in Figure 4-4.

4.3.4 WASTE TRANSPORTATION AND DISPOSAL

Contaminated wastes will be packaged and labeled in accordance with the US DOT Hazardous Materials Regulations (49 CFR Parts 171 through 180). Cabrera's Waste Manager will coordinate preparation and approval of required paperwork, coordinate logistics with the subcontract transporters and ES, and track shipments and disposal, and obtain waste acceptance and disposal certificates. Records will be provided to the CQCSM for inclusion in DQCRs as appropriate as well as project files.

A surface contamination survey (i.e., smear sampling and counting) will be performed to ensure compliance with 49 CFR 173.441,49 CFR 173.443, and the RPP (Cabrera, 2024a). Any exterior areas of radioactivity that exceed release criteria will be decontaminated prior to release for off-site transport.

A dose rate survey will also be performed for each IMC to demonstrate compliance with the 49 CFR 173.436 and the RPP (Cabrera, 2024a). IMCs will be released for transport to ES following review/approval of the surface contamination and dose rate surveys by the Site RSO, preparation of shipping documents by the Waste Manager, and USACE approval/signature of shipping documents. Manifests and shipping instructions will be completed ahead of time and provided to the USACE/AEC for review. Cabrera will coordinate waste shipments with USACE/AEC, including obtaining the appropriate AEC signature on shipping documents.

IMCs will be transported using trucks to ES. After the shipments are disposed, certificates of disposal (CODs) will be sent by ES to the Waste Manager, and these CODs will be included in an appendix of the Remedial Action Completion Report (RACR).

4.3.5 SPILL PREVENTION AND CONTROL

Procedures and responsibilities for spill prevention, response activities and cleanup associated with the remediation and waste transportation at the Site are presented in the SSHP. This section briefly identifies the potential sources of spills during remediation, and the methods that will be implemented to prevent spills, limit impact to the environment in the event of a spill and protect personnel and the public from exposure or injury.

4.3.5.1 Potential Spill Sources and Prevention

Given the relatively short duration of the remediation activity, on-site storage of petroleum products or hazardous materials will be minimal. Gasoline will be stored in USACE-approved Type II metal containers of five gallons or less. Fuel oil (diesel) for refueling heavy equipment is anticipated to be stored on site but may also be brought on site daily by ENVECO personnel using a US DOT-compliant fuel tank mounted on the back of a pickup truck. The refueling truck driver will be required to continuously monitor refueling operations without leaving the area. A Cabrera employee will also monitor all refueling operations. Refueling will occur over a drip pan to minimize the potential for small spills. No waste oil or hydraulic fluid will be stored on site.

The use of solvents or hazardous materials is not anticipated for this project. Decontamination activities on site will use water and commercially available, biodegradable cleaners (i.e., Simple

Green™). Potentially-contaminated water pumped from excavation areas will be transferred to an on-site poly tank, which will be located within a lined area for secondary containment.

4.3.5.2 Spill Response

A spill kit with a capacity to respond to a release of 50 gallons or less will be maintained on site. A local spill response contractor will be identified and contacted prior to mobilization to provide on-call spill response and control services for any spills larger than 50 gallons. Spills will be reported to USACE and AEC in accordance with procedures in the SSHP.

4.4 AIR MONITORING

The remediation team will perform three types of air monitoring: perimeter, remediation-zone, and personnel air monitoring. Meteorological monitoring will also be performed as discussed below. A detailed description air monitoring is included in the SSHP and RPP (Cabrera, 2024a).

4.4.1 PERIMETER AND REMEDIATION ZONE AIR MONITORING

Perimeter and remediation zone air monitoring will be completed using 10-100 liter per minute low volume air samplers (LVs) that will be staged in weather-tight containers positioned in up to three locations around the excavation area. One LV will be located upwind and one to two will be located downwind of the excavation area. The LVs will be powered by portable generators and operate throughout the day during excavation operations. A cellulose filter will be installed in the LV and collected and counted at the end of each workday for gross indications of radioactivity. The results of the air sample analysis will be available within 72 hours (to provide for radon decay) to allow the Site RSO to determine if additional dust suppression measures are needed. If there are any exceedances of the concentration limits in the RPP, then USACE will be notified. Additional details on air monitoring are provided in the RPP (Cabrera, 2024a).

4.4.2 PERSONNEL AIR MONITORING

Personnel entering excavation area EZs will be fitted with zero to 0.5 liters per minute personal breathing zone air samplers (BZs) that will operated in similar manners as the LV remediation area monitors. Personnel will be assigned BZ and will be required to maintain their operation throughout the day, notifying the SRSO or SSHO if problems occur with the equipment operation. The results of the BZ cellulose filter counts will be available within 72 hours (to provide for radon decay) to allow the SSHO and SRSO to determine if additional dust suppression measures and/or PPE are needed. If there are any exceedances of the concentration limits in the RPP, then USACE will be notified. Additional details on air monitoring are provided in the RPP (Cabrera, 2024a).

4.4.3 METEOROLOGICAL MONITORING

We install and utilize a Davis Instruments Wireless Weather Station, or equivalent, near the office trailer to analyze weather data (wind, temp, etc.) to allow the SSHO to direct or suspend operations and model potential contaminants of concern dispersion. Weather will be documented on a daily basis in the DQCR, including any delays due to adverse weather conditions.

4.5 EQUIPMENT DECONTAMINATION

Equipment involved in remediation will be decontaminated before moving it between excavation areas or off-site demobilization. Equipment involved in remediation will initially be decontaminated at the excavation area by removing all loose soil from buckets, tracks and the undercarriage using shovels, brooms and brushes. Additional decon procedures (e.g., the use of

low-pressure wash) will only be used as a last resort, based on a determination made by the SRSO and Cabrera's Corporate RSO/PHP in consultation with the Cabrera PM.

A release survey will be completed at the excavation area prior to transport the equipment to the next work location on site. Construction equipment involved in remediation will also be transported to the on-site decon pad for a final, thorough decontamination prior to its demobilization off site.

A post-remedial GWS will be performed of all support areas, including haul roads and the support zone, prior to demobilization. The post-remedial GWS will identify any anomalous activity that is different from the baseline GWS. If there are any anomalies identified, the PHP will notify the PM and USACE for further direction. It is likely that a sample will be collected of the material and the sample will be sent to the off-site laboratory for radiological analysis as described in the UFP-QAPP (Appendix A).

Small tools and other equipment (i.e., field meters, etc.) will be wrapped in plastic prior to being moved between contaminated areas of the Site and will be decontaminated prior to being moved to uncontaminated areas of the Site or off-site.

All equipment will be decontaminated and surveyed in accordance with procedures established the RPP.

As much equipment as possible will be dedicated for single use for the duration of the project, and will remain within EZs on site until decontaminated, surveyed and verified in conformance with free release limits.

4.6 SITE RESTORATION

This section identifies methods, equipment, and materials for backfilling remediation excavations at the Site and other support zone areas on the site as needed. Deviations from this section will not be implemented without prior review and consent of the USACE Contracting Officer's Representative (COR). Areas for backfilling and site restoration will be as directed by the COR.

4.6.1 BACKFILLING METHODS AND EQUIPMENT

Site restoration will be performed following remediation, FSS verifying that cleanup goals (DCGLs) have been met at the limits of excavation, USACE approval of FSS survey results and land surveying the limits of excavation. If there is standing water in the excavation(s) when we return to the Site after the excavations meet the RAOs, then the water will be pumped out of the excavations prior to commencing backfilling and released to the ground.

Backfill material will consist of suitable materials that are sampled, analyzed, and accepted by the USACE in accordance with the UFP-QAPP (Appendix A) prior to being brought to the Site. Backfill materials will meet the specifications in the PWS and not contain contaminants, substantial roots and other organic matter, trash, debris, snow, ice, frozen materials, or other undesirable material. The maximum particle size within the backfill will be less than 6 inches. The anticipated source of backfill with be the North Granite Gravel Pit within the DPG. The gravel pit location is shown in Figure 1-1.

Backfill will be delivered to the Site in offroad dump trucks that will deposit the materials adjacent to excavation areas to facilitate efficient backfilling utilizing equipment. If needed, and upon acceptance of source and analytical results, the backfill materials may be mobilized to the Site and stockpiled in an area outside of the EZs to facilitate efficient backfilling utilizing equipment. The location(s) of potential borrow source stockpiles on-site will be determined in the field by the SM

and USACE personnel. Material will be placed, graded, and machine-compacted in 18-inch lifts using a wide-track (LGP dozer (95-105 horsepower) dozer. Machine compaction will consist of three passes of construction equipment over the backfilled filled areas.

Site restoration will commence with backfilling excavations to match surrounding grades as displayed in Figure 4-5. Site restoration will also include repairing Site areas damaged or disturbed during remediation activities, such as the haul roads or support areas (e.g., ruts from tracks or tires). The proposed repair and restoration activities will be presented to the USACE prior to implementation. All repair and restoration measures will be in accordance with USACE direction. A final topographical survey will be performed after restoration is completed to document as-left conditions.

4.6.2 BACKFILL MATERIALS

This subsection identifies materials to be used to backfill remediated areas and borrow source(s) where these materials will be obtained. Borrow source material is currently expected to be obtained from the North Granite Gravel Pit approximately 5 miles from the Area 2 Site. An excavator will be staged at this location to load this material into offroad dump trucks. If the on-site source does not meet the requirements for use on-site, then an off-site source will be identified and utilized.

4.6.2.1 Laboratory Analysis of Backfill Materials

In accordance with the UFP-QAPP (Appendix A) a minimum of 8 samples will be collected to evaluate the borrow material used to backfill remediated areas. Additional samples may be collected and analyzed when a change in material occurs, such as when an alternate source of borrow material must be used. Geotechnical laboratory analysis for borrow source materials is not required. Testing of the borrow source(s) will include chemical and radiological analyses, including:

- Gamma Spectroscopy –Method Ga-01-R
- Isotopic Thorium and Uranium by method A-01-R
- Target Analyte List Metals – EPA Methods 6020A/7471B
- Volatile Organic Compounds - EPA Method 8260C
- Semi-Volatile Organic Compounds – EPA Method 8270D
- Polychlorinated biphenyls – EPA Method 8082
- Pesticides/Herbicides – EPA Methods 8081A/8151

Results of laboratory analyses for borrow materials will be compared with published guidance values as described in the UFP-QAPP (Appendix A) to ensure that imported material is not contaminated.

A detailed discussion of sampling and analysis for the above is presented in the specific details of the methods, collection, and analysis of samples are provided in the UFP-QAPP (Appendix A).

4.7 DECONTAMINATION AND RELEASE OF EQUIPMENT AND TOOLS

Equipment and personnel exiting a work area will follow decontamination procedures presented in the RPP (Cabrera, 2024a). Decontamination areas will be located near work boundary exits. The level of decontamination of equipment will be determined by the SSHO/SRSO. The need for and degree of decontamination will be based on the characteristics of the material within the work area and the potential for transporting contaminants outside of the work area.

4.8 DEMOBILIZATION

Cabrera will demobilize from the Site at the conclusion of both site remediation and restoration activities. Following the completion of excavation, transportation of waste for off-site disposal and free release of remediation equipment, personnel and equipment required for remediation will be demobilized awaiting analytical results from FSS and USACE approval to restore the Site. All equipment coming into contact with contaminated waste will be decontaminated and radiological surveys performed for unconditional free release of potentially contaminated equipment prior to demobilization. Decontamination and free release of equipment are described in the UFP-QAPP and RPP. Radiological surveys will also be performed for haul roads and support areas prior to demobilization from the Site.

The second phase of demobilization will occur immediately follow backfilling and machine compaction of excavations and other areas as required.

Demobilization will consist of surveying, decontaminating, and removing all equipment and materials, cleaning the project site, inspecting the site, and the demobilization of personnel. Demobilization activities will also involve collection and disposal of any contaminated materials, including disposable equipment for which decontamination is inappropriate. Upon conclusion of the restoration and prior to closeout, a Final Inspection will be conducted to verify that project requirements are satisfied. Outstanding and nonconforming items will be identified and documented. As each item is resolved, it will be noted. The COR acceptance and closeout of each outstanding item is a prerequisite to project closeout and final demobilization.

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5.0 CONSTRUCTION QUALITY CONTROL

The remediation QC program outlined in the CQCP (Cabrera, 2024c) will be implemented for all activities described in this plan and its addenda. The QC program includes project-specific features of work, a three-phase QC inspection process, independent QC review of documents and a corrective action plan. The inspection and testing processes described therein will monitor the overall quality of work, and project controls will be instituted to assure correction of deficiencies identified during the inspections and testing. Project scheduling will be instituted to assure proper planning and performing work in proper sequence. A CPM schedule and detailed list of planned submittals for review and/or approval (submittal register) are included in the PMP (Cabrera, 2024b). The CPM schedule and submittal register will be updated throughout the project, with these updated documents as well as all submittals kept in the CQCSM's field records as well as project files.

The COR or designee will be notified in writing prior to proposed changes to the QC program and COR approval obtained for any such changes prior to implementation.

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6.0 REGULATORY COMPLIANCE

This section addresses the Federal, State, and local regulations and guidance that will govern the Site activities, providing an outline of the laws, rules, regulations, and standards. These statutory and regulatory requirements will be followed at all times to ensure that the objectives of protecting human health and the environment and maintaining the philosophy of as low as reasonably achievable (ALARA) are met.

USACE is overseeing the investigation and remediation of radiological contaminated material at the Site in accordance with CERCLA, 42 US Code (USC) § 9601 et seq., as amended, and the NCP, Title 40 CFR § 300.430(f) (2). These documents supported the excavation and off-site removal of contaminated soil as the preferred alternative remedial action. The purpose of the remedial action is to reduce the potential for future exposure to the contaminated soil and to accomplish the action in a way that minimizes risks to personnel performing the removal action, to the public, and to the environment, by implementing procedures that conform to the philosophy of ALARA.

Section 121 of CERCLA specifies that such remedial actions comply with requirements or standards under Federal or more stringent state laws that are ARARs for the site. Specifically, ARARs are to be attained to the extent practicable during the removal action. Requirements are determined to be applicable if such Federal or state standards or requirements are legally applicable to the hazardous substance or pollutants at the site. The requirements are determined to be relevant and appropriate if they are those that, while not applicable to a hazardous substance or pollutant, are found to be relevant and appropriate under the circumstances of the release or threatened release of the hazardous substance or pollutant at the site (USACE, 2006).

Based on the foregoing discussion, the following subsections provides the ARARs determined to be appropriate for this Site, and also provides a compilation of the specific laws, rules, regulations, and standards governing safety and operational requirements to be followed during the actual execution of the removal action.

6.1 ARARS CONSIDERED IN DETERMINING REMEDIAL ALTERNATIVE

USACE determined that ARARs to be addressed as the basis for the remedial action include those governing the decommissioning of sites and the radiological criteria for license termination (USACE, 2006). Title 10 Part 20 of the CFR promulgates the standards for protection against radiation. Specifically, 10 CFR 20, Subpart E, provides the criteria and requirements for the termination of licensure of an NRC site and the radiological release requirements for the unrestricted use of a site. Under Federal requirements, a facility is considered to be acceptable for unrestricted use if residual radioactivity exceeding background results in a total effective dose equivalent that does not exceed 25 mrem/yr to the average member of a critical group (e.g. on-site construction worker), and must further reduce residual radioactivity to ALARA levels. To meet these requirements, remedial activities completed by Cabrera and its subcontractors will be conducted in accordance with the statutory and regulatory requirements discussed in Section 6.2 below, as well as USACE guidelines and Cabrera Operation Procedures referenced in this and other project work plans.

6.2 BACKGROUND REQUIREMENTS FOR THE EXECUTION OF REMOVAL ACTION

6.2.1 PERMITTING

Pursuant to Section 121(e) of CERCLA (42 USC 9621[e]), permits typically required under Federal and State laws or statutes (such as the Clean Water Act or Clean Air Act), are not required for the portion of remedial actions conducted on-site. However, on-site operations completed by the USACE and its contractors (Cabrera) must comply with all substantive requirements of Federal, State, and local laws and regulations. As discussed in Section 3.3, all activities on this project are being performed under the DoD's authority under CERCLA, and while Cabrera will not invoke its Mobile NRC license #39-35044-01 to perform this work, Cabrera will conduct its work in accordance with the procedures approved under this license.

6.2.2 STATUTORY AUTHORITIES

This section introduces the major environmental laws that are the framework for conducting remedial actions at radiological and chemical contaminated sites. These laws form the basis for the majority of the regulations and standards affecting radiation protection and cleanup of radioactive waste.

- *Atomic Energy Act of 1954*, Public Law 83-703, as amended. Through the formation of the Atomic Energy Commission, this Act promulgated the basic criteria for the development, management, processing, and utilization of radioactive materials in a manner that protects public health and the environment. In 1974, under the Energy Reorganization Act, the Atomic Energy Commission was reorganized to separate the functions of national defense and development and energy-related work, which was established under what is now the DOE, and non-defense related radioactive material regulation under the newly created NRC.
- CERCLA, 42 USC §§ 9601-9675, 40 CFR 300 and 302, as amended. This Act serves as the basis for the cleanup of abandoned or closed waste sites, as well as providing the requirements for the response to uncontrolled releases of hazardous substances to the environment. Under CERCLA, the process of evaluating a site and its existing or potential hazards was established. This includes the process of completing a site RI/FS and, based on alternatives present therein, completion of remedial action to address the release or threat of release. The Act authorizes the EPA to complete remedial action in response to releases or substantial threats of releases of hazardous substances into the environment.
- SARA, 42 USC §§ 9601-9675, 40 CFR 300. Passage of SARA did not change the basic structure of CERCLA, but modified existing requirements related to topics including remedial alternative evaluation and providing for the long-term review of the effectiveness of an implemented remediation. This Act also promulgated new standards for the health and safety of workers associated with hazardous waste sites.
- RCRA, Public Law 94-580, 40 CFR 260 to 280. RCRA provides for the regulation of solid and hazardous waste, requiring detailed management of waste from generation to final disposal, under the "cradle to grave" management system. This process was established to prevent new uncontrolled hazardous releases from occurring and provided better protection for human health and the environment. Under RCRA, solid and hazardous wastes are defined and classified, and the processes for conducting and permitting the treatment, storage, and disposal of these wastes are set forth. Further, the duties of hazardous waste generators and transporters are established. Under the definitions of solid waste,

radioactive materials arising out of the AEA are expressly excluded from the definition, and thus from regulation under RCRA. Naturally occurring radioactive materials, however, are not.

- *Clean Water Act* (CWA), 33 USC §§ 1251-1387, 40 CFR 122 to 131. The CWA established interim water quality goals aimed at restoring and maintaining the chemical, physical, and biological integrity of the nations waters. The objective of the CWA is to prevent, reduce, and eliminate discharges of pollutants by developing a national monitoring program and procedures for interfacing with state programs of a similar nature. Major requirements of the CWA include setting discharge effluent limits, establishing the National Pollutant Discharge Elimination System (NPDES) permitting system as well as pretreatment requirements for industrial discharges, and setting toxicity-based water quality standards.
- *Clean Air Act*, 42 USC §§ 7601-7671Q, 40 CFR 50 to 96. This Act protects and enhances the nation's air quality through the establishment of the national ambient air quality standards, new source performance standards, and monitoring and reporting provisions. Under this Act, radionuclides are defined as a hazardous air pollutant.
- *Presidential Documents - Reorganization Plans:* Reorganization Plan No. 3 of 1970 established the US Environmental Protection Agency and gave it a role in establishing "generally applicable environmental standards for the protection of the general environment from radioactive material."

  Reorganization Plan No. 1 of 1980 strengthened the executive and administrative roles of the NRC Chairman, particularly in emergencies, transferring to the Chairman "all the functions vested in the Commission pertaining to an emergency concerning a particular facility or materials ... regulated by the Commission." This Reorganization Plan also provided that all policy formulation, policy-related rulemaking, and orders and adjudications would remain vested with the full Commission.

6.2.3 FEDERAL REGULATORY AGENCIES

The following federal and state agencies have requirements promulgated that will be followed during the completion of the remedial action, and may themselves have regulatory oversight for one or more of the activities to be performed at the Site:

- **NRC** - Responsibilities include regulatory and oversight duties associated with radiological materials and operations other than national defense or energy research and development. Specifically, the NRC provides the standards for licensing, radiation safety, and protection for source, byproduct and special nuclear materials licenses. The NRC also oversees the requirements for packaging, transporting, and disposal of radioactive waste.
- **OSHA** - Regulations apply to the health and safety of workers on hazardous, toxic, and radioactive sites. OSHA standards are promulgated for both general industry, as well as specifically for the construction industry, and includes the requirements for training of personnel that will be involved with hazardous waste clean-up projects.
- **Environmental Protection Agency (USEPA)** - Promulgates the standards under CERCLA and RCRA, which define solid and hazardous waste and provides for the remedial investigations and actions to be completed to address hazardous waste releases. Objectives are the protection of the public and environment by establishing limits on pollutant concentrations in air, water, and soil environments.
- **US DOT** - The US DOT oversees transportation of goods and commerce over federal highway, air, railroad, and maritime routes. Specific regulations apply to the packaging,

labeling, and all intrastate and interstate shipment of hazardous wastes, as well as DOD-defined low-level radioactive waste (<2,000 pCi/g]) and mixed (radioactive and hazardous) waste.

6.2.4 STATE REGULATORY AGENCIES

State of Utah agencies with regulatory authority over the Site removal actions include the UDEQ. Applicable regulations and standards related to the remedial action are found in the Table 3-1.

6.3 SUMMARY OF APPLICABLE REQUIREMENTS AND STANDARDS

Table 6-1 provides a listing of the applicable laws, rules, regulations and standards that will be followed during project execution, and includes the title, regulatory agency and reference, and the major guideline, rule, or standard that is promulgated. Specifically, the table includes laws and regulations from the NRC, USEPA, OSHA, US DOT, and the UDEQ that are related to various aspects of excavation, transportation, disposal, and documentation activities to be performed. The table also includes reference to additional work plans prepared for this project, which provide greater detail of the regulations, and Cabrera's means and methods in complying with such regulations. Table 6-1 also includes the regulations and standards of the DOT regarding the transport and documentation of the waste generated by the removal action. Specific regulations addressing radiation protection, handling, transportation, and disposal are applicable because of the nature of contamination identified in previous investigations and targeted for the remedial action. Regulations addressing hazardous material not defined as radioactive are relevant and appropriate because of the potential presence of these materials (e.g. organic compounds, such as arsenic) as a result of trench disposal activities at the Site, and due to the potential for small-scale accidental spills associated with machinery used for excavation and transportation.

Table 6-2 provides a listing of the relevant USACE EMs, Engineer Pamphlets, and Engineer Regulations applicable to hazardous, toxic, and radioactive waste sites and potentially applicable to the remedial action to be completed at the DPG Site.

Table 6-1. Potential Regulatory Requirements for the DPG SWMU-11 Site

Agency	Regulation, Standard, Requirement, Criteria	Citation or Reference *(see notes at end of table)*	Description	Application to Site
FEDERAL				
OSHA	Occupational Safety and Health Standards, General Industry	29 CFR 1910	Specifies the health and safety requirements applicable to the conditions, practices, means, methods and operations for general industry working conditions. Includes § 1910.120, *Hazardous Waste Operations and Emergency Response* (HAZWOPER), which sets forth training and safety requirements specific to CERCLA clean-up sites, uncontrolled hazardous waste sites, operations at TSD facilities, and emergency response to releases or threats thereof for hazardous waste.	Provides the general guidelines that will be followed for safe conduct of site work and worker protection (i.e. fall protection, personal protective equipment [PPE], heavy equipment operation, material handling and storage, tools, and electrical/fire safety). All Site Workers will have attended and successfully passed the 40-Hour HAZWOPER training course (required under § 1910.120(e), including annual 8-Hour refresher course within one calendar year of site mobilization. Certificates documenting course attendance and medical fit-for-duty forms will be maintained on-site [see the SSHP (Cabrera, 2024a)].
OSHA	Safety and Health Requirements for Construction	29 CFR 1926	Provides health and safety criteria similar to § 1910 but that is specific to the Construction industry pursuant to the *Contract Work Hours and Safety Standards Act* (40 USC 333).	Health and safety requirements under § 1926 will be followed at all times, including: sanitation, housekeeping, first-aid, electrical/fire safety, emergency action plans, material handling, PPE, and tool use. [see the SSHP (Cabrera, 2024a)].

Agency	Regulation, Standard, Requirement, Criteria	Citation or Reference *(see notes at end of table)*	Description	Application to Site
OSHA	Recording and Reporting Occupational Injuries and Illnesses	29 CFR 1904	Provides the criteria and methodologies for determining, recording, and reporting work-related illnesses, injuries, and fatalities.	Cabrera will make determinations and maintain records pursuant to § 1904 related to the DPG site. Records will be kept on-site at all times. Corporate data will also be made available for inspection by conspicuous placement of OSHA 300 Logs.
NRC	Standards for Protection Against Radiation	10 CFR 20	The regulations in this part establish standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the NRC. The regulations control the receipt, possession, use, transfer, and disposal of licensed material by any licensee in such a manner that the total dose to an individual does not exceed the standards for protection against radiation prescribed in the regulations in this part.	Occupational dose limits for various exposure pathways, dose limits for members of the public, waste disposal operations, records and reporting, and surveying/monitoring requirements and procedures, etc. of this part were reviewed in development of the SSHP, which includes the site-specific RPP (Cabrera, 2024a).
NRC	Licensing Requirements for Land Disposal of Radioactive Waste	10 CFR 61	The regulations in this part establish, for land disposal of radioactive waste, the procedures, criteria, and terms and conditions upon which the NRC issues licenses for the disposal of radioactive wastes containing byproduct, source and special nuclear material received from other persons.	ES has a current and valid license to operate a land disposal facility pursuant to § 61 (see Section 4.3.4).

Agency	Regulation, Standard, Requirement, Criteria	Citation or Reference *(see notes at end of table)*	Description	Application to Site
NRC	Packaging and Transportation of Radioactive Material	10 CFR 71	Establishes requirements for packaging, preparation for shipment, and transportation of licensed material.	Low-level radioactive materials with activity concentrations less than those values established in § 71, Appendix A are exempt from this regulation. Activities of the waste materials will be determined prior to shipment.
USEPA	National Primary and Secondary Ambient Air Quality Standards	40 CFR 50	Establishes numerical values for air pollutants that must be met at air emission sources for the respective pollutant. Specifically, § 50.6 establishes values for dust emissions (Particulate Matter [$PM_{2.5}$]).	Dust suppression activities (e.g. spray down of excavation areas and haul roads with water) will be used to minimize dust at the Site. Monitoring will be completed as described in the SSHP (Cabrera, 2024a).
USEPA	Discharge of Oil	40 CFR 110	Establishes the definition of and reporting requirements for discharges of oil to navigable waters of the US. Oil discharges are defined as those which result in either a violation of applicable water quality standards, or cause a film or sheen upon surface water or adjoining shorelines.	Good housekeeping and materials management practices will be followed to prevent oil spills. If such spills occur, the emergency procedures established in the SSHP (Cabrera, 2024a), will be followed, and the National Response Center (800-424-8802) will be notified as required in § 110.6.

Agency	Regulation, Standard, Requirement, Criteria	Citation or Reference *(see notes at end of table)*	Description	Application to Site
USEPA	Oil Pollution Prevention	40 CFR 112	This part establishes procedures, methods, equipment, and other requirements to prevent the discharge of oil from non-transportation-related onshore and offshore facilities into or upon the navigable waters of the US or adjoining shorelines.	Storage/use of oil in quantities as defined in § 112, requiring compliance with this part are not anticipated. Fuel oil for equipment will be obtained by using a product delivery vendor, or by routine purchases using DOT approved truck-mounted containers.
USEPA	Designation of Hazardous Substances	40 CFR 116	This regulation designates hazardous substances pursuant to the Clean Water Act, and applies to discharges of the substances listed in Table 116.4 of this part.	It is not anticipated that any of the listed chemicals (§ 116, Table 116.4) will be used in conjunction with this remedial action.
USEPA	Determination of Reportable Quantities for Hazardous Substances	40 CFR 117	This regulation sets forth a determination of the reportable quantity (RQ) for each substance designated as hazardous in 40 CFR 116. The regulation applies to quantities of designated substances equal to or greater than the RQs, when discharged into or upon the navigable waters of the US or adjoining shorelines.	If any materials determined to be hazardous pursuant to 40 CFR 116 are identified for use on-site, the reporting requirements under § 117 will be followed.

Agency	Regulation, Standard, Requirement, Criteria	Citation or Reference *(see notes at end of table)*	Description	Application to Site
USEPA	USEPA Administered Permit Program: The National Pollutant Discharge Elimination System	40 CFR 122	Promulgates the NPDES program for approved and permitted discharges to waterways and delegates authority of the NPDES program to approved State programs for state-level management.	Water is not being discharged and therefore, this guidance does not apply. All collected wastewater will be disposed in accordance with other regulations.
USEPA	Hazardous Waste Management System: General	40 CFR 260	Sets forth general provisions, terms, and standards for generators, transporters, and owners/operators of treatment, storage, or disposal facilities with respect to hazardous waste.	Activities completed under this remedial action that require management of hazardous waste will be done so in accordance with this part.
USEPA	Identification and Listing of Hazardous Waste	40 CFR 261	Identifies those "solid wastes" which are subject to regulation as "hazardous waste" that categorically defined or exhibit characteristics of hazardous waste.	Under § 261.4(a)(4), excluded from the definition of solid waste are source, special nuclear, or by-product material as defined by the AEA. Material sampling will confirm that the excavated soil does not also meet the criteria for classification as hazardous by exhibiting hazardous characteristics.
USEPA	Standards Applicable to Generators of Hazardous Waste	40 CFR 262	Establishes standards for the management, storage, treatment, pre-transportation, and recordkeeping of hazardous waste by persons that generate hazardous waste as defined in § 261.	It is anticipated that the waste materials generated on-site (excavated soil/debris and excavation/decontamination process wastewater) will not exhibit the characteristics of hazardous waste and therefore these regulations will not apply.

Agency	Regulation, Standard, Requirement, Criteria	Citation or Reference *(see notes at end of table)*	Description	Application to Site
USEPA	Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Establishes standards for the management and recordkeeping of hazardous waste by persons that transport hazardous waste as defined in § 261. Specifically establishes the Manifest System for tracking waste transportation.	It is anticipated that the waste materials generated on-site (excavated soil/debris) will not exhibit the characteristics of hazardous waste and therefore these regulations will not apply. Waste Manifest/Bills of Lading will be used to track the waste materials in accordance with the Section 4.3.4 of this plan.
USEPA	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR 264	Establishes national standards for the acceptable management of hazardous waste at treatment, storage, and disposal facilities.	Contracted waste disposal facilities that accept waste generated from this project and hazardous waste from other sources must comply with the requirements of this part. ES and the transportation subcontractors will have current and valid operating licenses.
USEPA	Land Disposal Restrictions	40 CFR 268	Identifies hazardous wastes that are restricted from land disposal and provides the limited circumstances under which an otherwise prohibited waste may continue to be land disposed.	As indicated above, it is not anticipated that any wastes generated on-site will be defined or classified due to characteristics as hazardous. ES will be in compliance with this part if required.

Agency	Regulation, Standard, Requirement, Criteria	Citation or Reference *(see notes at end of table)*	Description	Application to Site
USEPA	USEPA Administered Permit Programs: The Hazardous Waste Permit Program	40 CFR 270	Establishes the permit regulations and provisions for the issuance of a Hazardous Waste Permit under Subtitle C of the *Solid Waste Disposal Act* and covers basic USEPA permitting requirements, such as application requirements, standard permit conditions, and monitoring and reporting requirements.	ES has the necessary operating permits to comply with this regulation.
USEPA	National Oil and Hazardous Substances Contingency Plan	40 CFR 300	Establishes the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), whose purpose is to provide the organizational structure and procedures for preparing for and responding to discharges of oil and releases of hazardous substances, pollutants, and contaminants.	In part, provides the regulatory authority for completing the remedial action at the DPG Site to protect human health and the environment.

Agency	Regulation, Standard, Requirement, Criteria	Citation or Reference *(see notes at end of table)*	Description	Application to Site
DOT	Hazardous Materials Program	49 CFR 107	Establishes the authority for the program which provides the requirements for the intrastate and interstate transportation of hazardous materials	§ 107, Subpart G, requires registration of persons who offer or transport hazardous materials. This applies to a highway route-controlled quantity of Class 7 (radioactive) material as defined by §§ 173.403. If it is determined that the waste prepared for shipment meet the criteria of §§ 173.403, then the requirements of § 107, Subpart G will be followed.
DOT	General Information, Regulations, and Definitions	49 CFR 171	This part prescribes the DOT requirements governing the intrastate and interstate transportation of hazardous materials by rail car, aircraft, motor vehicle, and vessel.	Includes §§ 171.15, *Immediate Notice of Certain Hazardous Waste Materials Incidents*, and §§ 171.16, *Detailed Hazardous Materials Incident Reports*, providing the requirements for accident reporting.

Agency	Regulation, Standard, Requirement, Criteria	Citation or Reference *(see notes at end of table)*	Description	Application to Site
DOT	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements	49 CFR 172	This part lists and classifies those materials which the Department has designated as hazardous materials for purposes of transportation and prescribes the requirements for shipping papers, package marking, labeling, and transport vehicle placarding applicable to the shipment and transportation of those hazardous materials.	Includes the following provisions that will be complied with during the project: • Marking and Labeling - §§ 172, Subpart D; §§ 172.400 through 407; §§ 172.436 through 441. • Placarding - §§ 172, Subpart F, §§ 172.500 through 519 and §§ 172.556; §§ 172, Appendices B and C • Shipping Papers and Emergency Information - §§ 172, Subparts C and G • Hazardous Material Employee Training - §§ 172, Subpart H A dedicated Waste Manager will oversee all activities associated with the preparation, pre-transportation, and off-site transportation of waste materials [See Section 4.3.4].

Agency	Regulation, Standard, Requirement, Criteria	Citation or Reference *(see notes at end of table)*	Description	Application to Site
DOT	Shippers General Requirements for Shipments and Packagings	49 CFR 173	Establishes general requirements to be observed in preparing hazardous materials for shipment by air, highway, rail, or water vessel.	As stated above, the requirements of this part, specifically, §§ 173, Subparts A, B, and I, Packaging, will be overseen by the Waste Manager [See Section 4.3.4). IMCs will conform to the requirements for industrial packaging (IP) Type 1 pursuant to §§ 173.411 and the testing requirements of §§ 173.465.
DOT	Carriage by Public Highway	49 CFR 177	Provides specific requirements for transportation of hazardous materials by private, common, or contract carriers by motor vehicle.	For any portion of the transportation route that requires transportation of waste over public highways, the regulations of this part will apply. It is currently anticipated that the waste material will require public highway transportation.
DOT	Specifications for Packagings	49 CFR 178	This part prescribes the manufacturing and testing specifications for packaging and containers used for the transportation of hazardous materials in commerce.	Material and waste storage containers brought/used on-site will conform to the manufacturing and testing specifications of this part.
STATE				

Agency	Regulation, Standard, Requirement, Criteria	Citation or Reference *(see notes at end of table)*	Description	Application to Site
UDEQ	Utah Pollution Discharge Elimination System (UPDES) General Permit for Discharges from Construction Activities	UAC R317-8	Promulgates the UPDES program for approved and permitted discharges to waterways.	Water is not being discharged and therefore, this guidance does not apply. All collected wastewater will be disposed in accordance with other regulations.

Table 6-2. Applicable USACE Guidance Documents for DPG SWMU-11 Site

Document Number	Title
ENGINEER MANUALS	
EM 200-1-2	Technical Project Planning Process
EM 200-1-3	Requirements for the Preparation of Sampling and Analysis Plans
EM 385-1-1	Safety and Health Requirements Manual
EM 385-1-80	Radiation Protection Manual
EM 1110-1-4002	Guidance For Low-Level Radioactive Waste and Mixed Waste Treatment and Handling
EM 1110-1-4007	Safety and Health Aspects of HTRW Remediation Technologies
ER-1110-1-8156	Policies, Guidance and Requirements for Geospatial Data and Systems
EM 1110-35-1	Management Guidelines for Low-Level Radioactive Waste and Mixed Waste Site Remediation
ENGINEER PAMPHLETS	
EP 200-1-2	Process and Procedures for RCRA Manifesting
ENGINEER REGULATIONS	
ER 385-1-80	Ionizing Radiation Protection
ER 385-1-92	Safety and Occupational Health Requirements for Hazardous, Toxic and Radioactive Waste Activities

7.0 REPORTING REQUIREMENTS

Cabrera will prepare a RACR following site restoration and demobilization. The report will include a narrative description of key project activities, summary of field survey results, laboratory analytical reports, a summary of remediation and site restoration quantities, waste documentation, and relevant project records (including records from lower-tier subcontractors), including:

- Off-site laboratory analytical reports for excavated soil (waste characterization sampling);
- Records of radiological incoming and release surveys, instrument quality control checks, and calibration certificates;
- GWS results (initial and final);
- Civil surveys;
- Magnetometer survey;
- FSS Report, including FSS data packages (GWS and off-site analytical results)
- Off-site laboratory analytical reports for wastewater samples (if applicable);
- On-site field results for air samples;
- Off-site laboratory analytical reports for off-site borrow source samples;
- Copies of DQCRs (narrative discussion, manpower, and Health and Safety Report); and
- Copies of all waste transport and disposal documentation (shipping documents, weight tickets, disposal certificates, etc.).

Draft, draft final, and final versions of the document will be prepared, with comments on the draft addressed in the final iteration.

Cabrera will also prepare draft. Draft final, and final versions of a Lessons Learned Report for submittal to the USACE as well as participate in a USACE lessons learned conference/meeting, as identified in the PWS. Comments on the draft document will be incorporated into subsequent versions.

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8.0 REFERENCES

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Cabrera 2024c. Contractor Quality Control Plan, Area 2 of SWMU-11, Dugway Proving Ground, Dugway, Utah. Cabrera Services Inc. Draft, January.

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Parsons, 2009, Final Phase II RCRA Facility Investigation: SWMU 11 Addendum, Dugway Proving 886 Ground, Dugway, Utah, Parsons Engineering Science, Salt Lake City, UT, August.

USACE, 2013. EM 385-1-80, Radiation Protection Manual. September.

USACE 2014. EM 385-1-1, Safety and Health Requirements Manual. November.

Title 29, Part 1910 of the Code of Federal Regulations (29 CFR 1910), *Occupational Safety and Health Standards* (with special attention to Section 120, *Hazardous Waste Operations and Emergency Response*).

Title 29, Part 1926 of the Code of Federal Regulations (29 CFR 1926), *Safety and Health Regulations for Construction*.

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FIGURES

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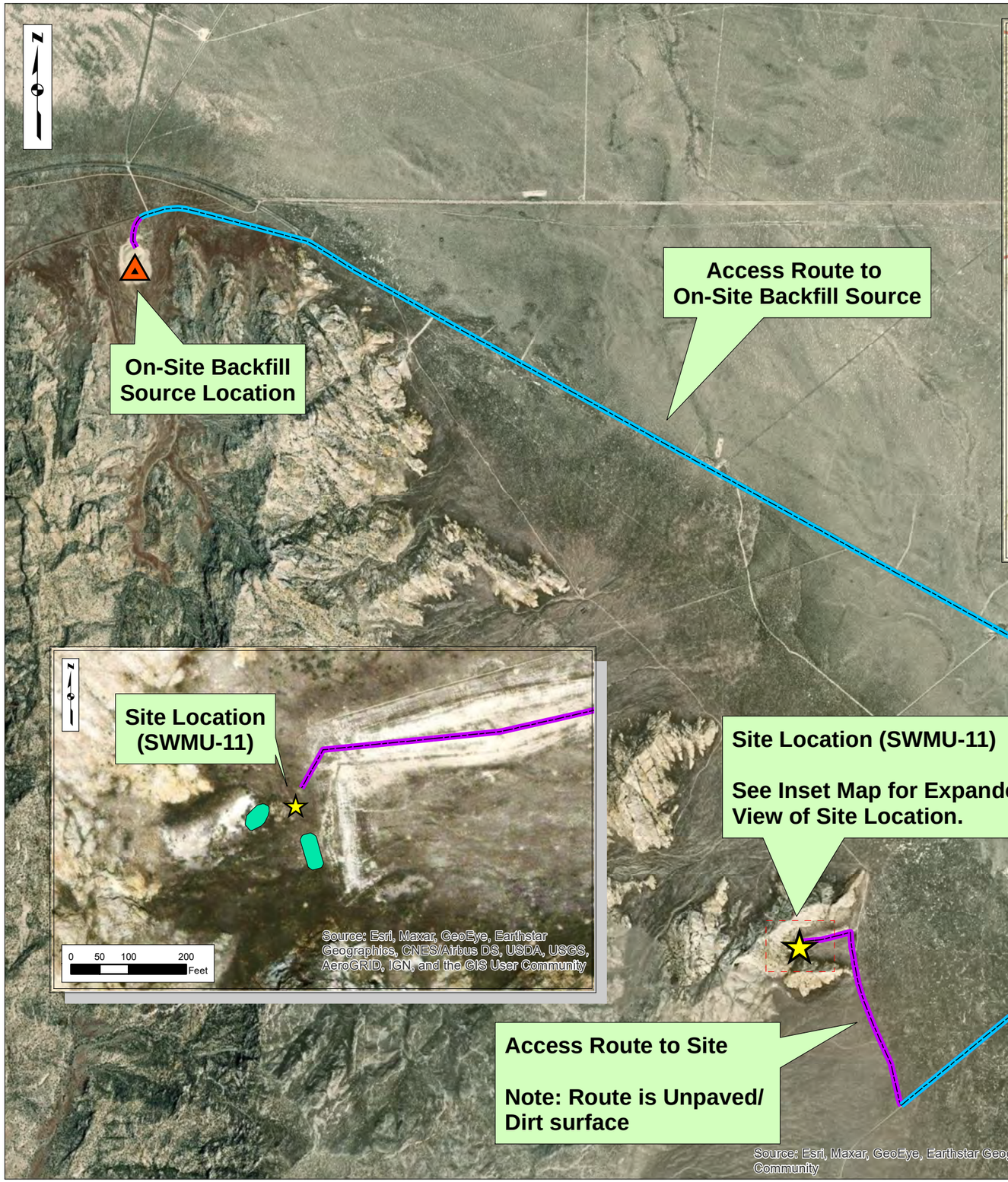
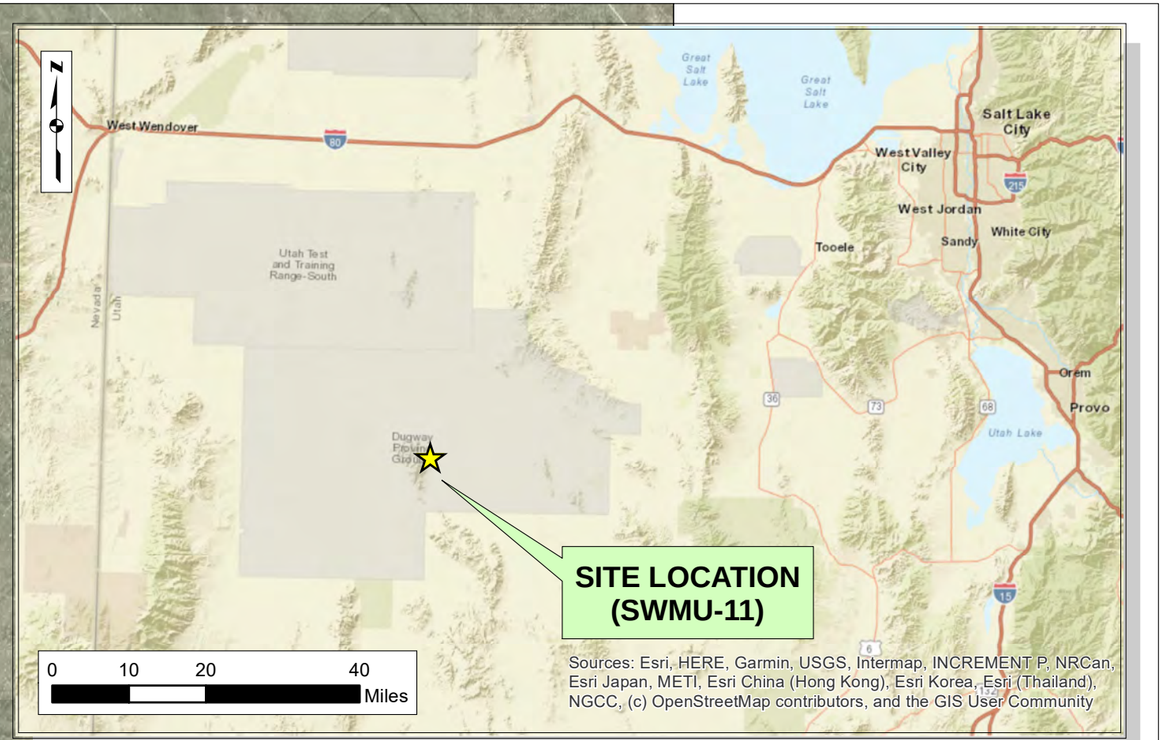




SWMU-11 Site Location

On-Site Backfill Source

Site Access Roads

On-Site Dirt Road

On-Site Paved Road

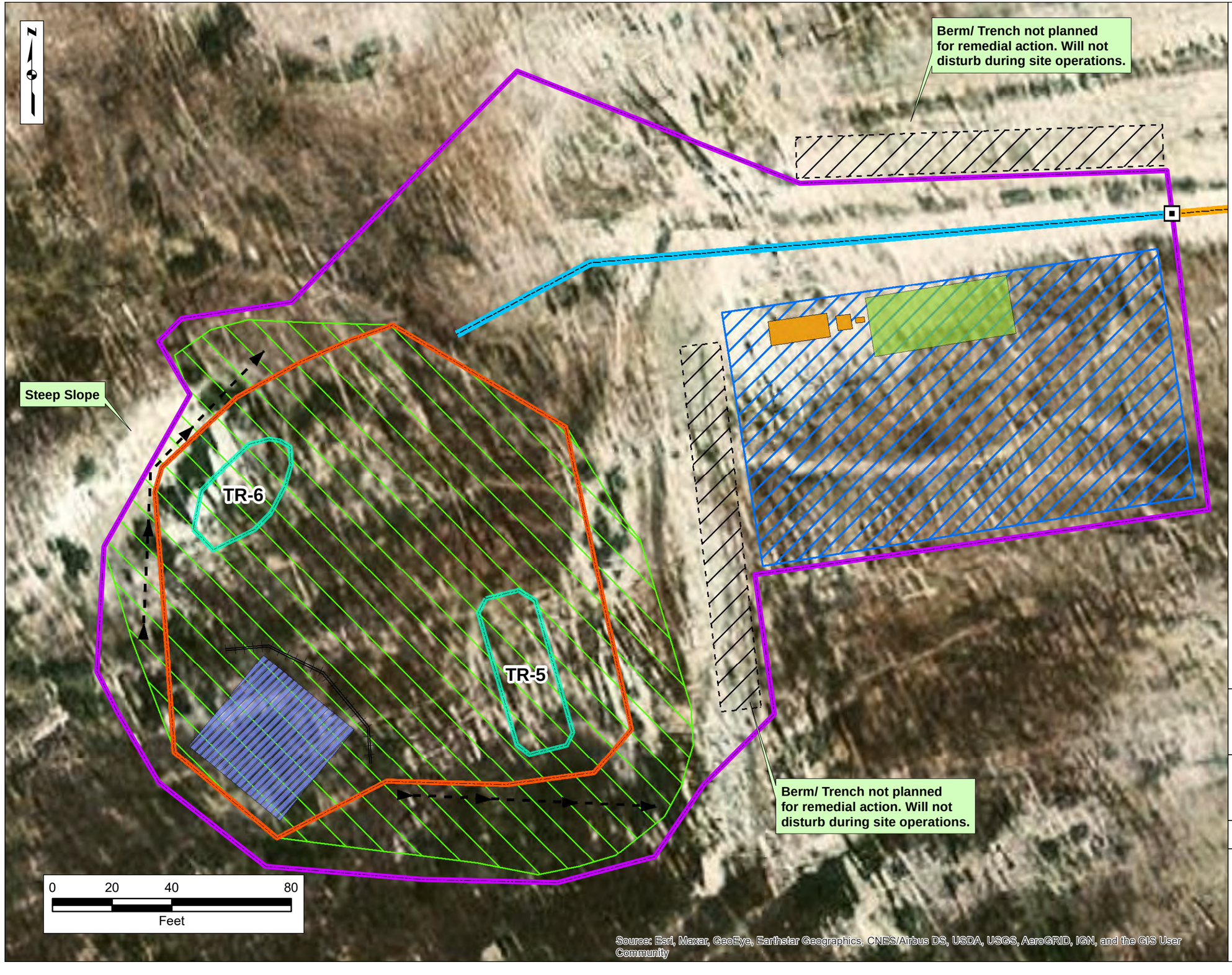
TR-5 & TR-6 Trench Locations

SITE LOCATION

DUGWAY PROVING GROUND
DUGWAY, UTAH

1/2024	GIS ANALYST: S. Owe	FIGURE 1-1

CABRERA SERVICES
CHALLENGE ACCEPTED



Legend

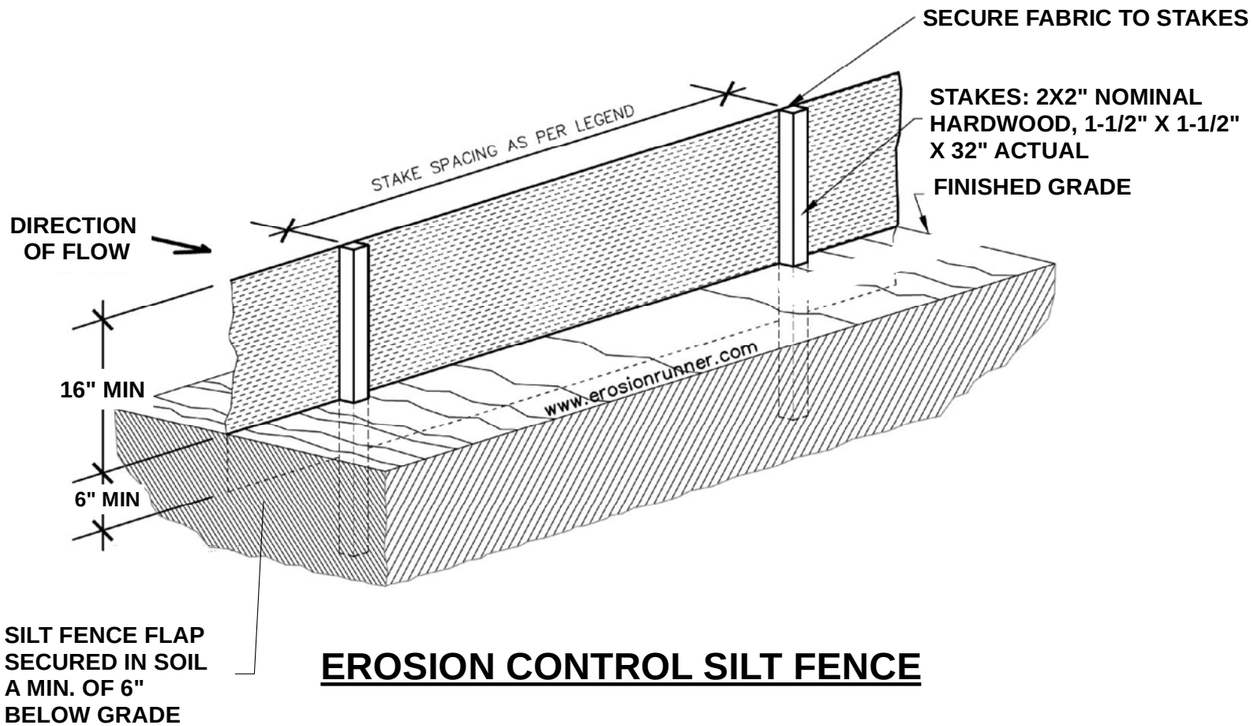
- Area to be Utilized During Remedial Phase of Work
- Trench Limits
- Site Entrance/ Exit
- Site Access Road
- Off-Site Access Road
- Diversion Trench
- Erosion Control/ Silt Fence
- Exclusion Zone (EZ) Temporary Fence
- Layback Soil Stockpile/ Geotextile Liner
- Backfill/ Restoration Area
- Support Zone
- Site Trailer/ Conex Box
- Parking Area

SITE LAYOUT

AREA 2 OF SWMU-11
DUGWAY PROVING GROUND
DUGWAY, UTAH

11/2024	GIS ANALYST: S. Owe	FIGURE 1-2

CABRERA SERVICES
CHALLENGE ACCEPTED



EROSION CONTROL SILT FENCE

1. SILT FENCE WILL BE CONSTRUCTED BEFORE UPSLOPE GROUND COVER IS REMOVED. CLEARING, GRUBBING, AND STUMPING CAN OCCUR BEFORE SILT FENCE INSTALLATION IF GROUND COVER IS NOT REMOVED.

2. ALL SILT FENCE WILL BE PLACED AS CLOSE TO THE CONTOUR AS POSSIBLE SO THAT WATER WILL NOT CONCENTRATE AT LOW POINTS IN THE FENCE AND SO THAT SMALL SWALES OR DEPRESSIONS THAT MAY CARRY SMALL CONCENTRATED FLOWS TO THE SILT FENCE ARE DISSIPATED ALONG ITS LENGTH.

3. ENDS OF THE SILT FENCES WILL BE BROUGHT UPSLOPE SLIGHTLY SO THAT WATER PONDED BY THE SILT FENCE WILL BE PREVENTED FROM FLOWING AROUND THE ENDS.

4. SILT FENCE SHOULD PREFERABLY BE A MINIMUM OF 10 FEET FROM THE TOE OF SLOPE.

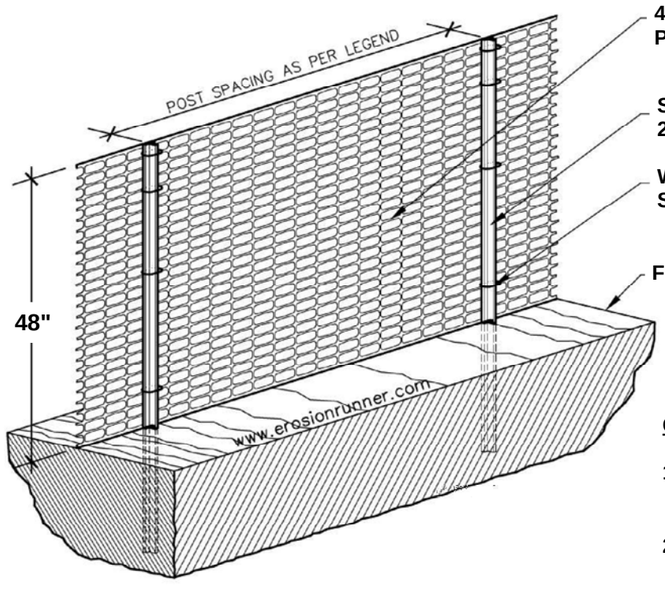
5. THE TRENCH WILL BE MADE WITH A TRENCHER, EXCAVATOR OR OTHER SUITABLE DEVICE THAT WILL ENSURE AN ADEQUATELY UNIFORM TRENCH DEPTH. BOTTOM OF SILT FENCE (FLAP) WILL BE SECURED IN SOIL A MINIMUM OF 6 INCHES BELOW GRADE. TRENCH WILL BE BACKFILLED.

6. WHERE TWO SECTIONS OF PREFABRICATED SILT FENCE ARE COMBINED INTO ONE RUN, THE END POSTS WILL BE CONNECTED TOGETHER, NOT SIMPLY OVERLAPPED.

7. SILT FENCE WILL ALLOW RUNOFF TO PASS ONLY AS DIFFUSE FLOW THROUGH THE GEOTEXTILE. IF RUNOFF OVERTOPS THE SILT FENCE, FLOWS AROUND THE ENDS, OR IN ANY OTHER WAY BECOMES A CONCENTRATED FLOW, ONE OF THE FOLLOWING SHALL BE PERFORMED, AS APPROPRIATE: A) AN ADDITIONAL RUN OF SILT FENCE SHALL BE PLACED UPSTREAM, B) THE LAYOUT OF THE SILT FENCE SHALL BE CHANGED, C) ACCUMULATED SEDIMENT SHALL BE REMOVED, OR D) OTHER PRACTICES WILL BE IMPLEMENTED.

8. SEDIMENT DEPOSITS WILL BE REMOVED WHEN THE DEPOSIT REACHES APPROXIMATELY ONE-HALF OF THE HEIGHT OF THE SILT FENCE.

9. SILT FENCE FABRIC WILL MEET THE FOLLOWING SPECIFICATIONS: MINIMUM TENSILE STRENGTH 12D LBS, ASTM D 4632; MAXIMUM ELONGATION AT 6D LBS., 15%, ASTM D 4632; MINIMUM PUNCTURE STRENGTH 5D LBS., ASTM D 4833; MINIMUM TEAR STRENGTH 40 LBS., ASTM D 4533, APPARENT OPENING SIZE <= D.84MM, ASTM D 4751; MINIMUM PERMITTIVITY 1X10-2SEC.-1, ASTM D 4491; WATER FLOW RATE 15GAL./MIN/SQ. FT.; UV EXPOSURE STRENGTH RETENTION, 70%, ASTM G 4355.

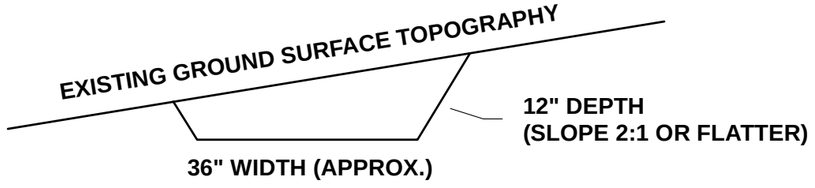


CONSTRUCTION SAFETY FENCE

CONSTRUCTION SAFETY FENCE

1. SAFETY FENCE SHOULD BE FASTENED SECURELY TO THE T-POSTS.

2. THE FENCING MUST REMAIN IN PLACE DURING ALL PHASES OF CONSTRUCTION.



RUNOFF DIVERSION TRENCH

1. RUNOFF DIVERSION TRENCH WILL BE INSTALLED USING EXCAVATOR BUCKET APPROX. 36" WIDE

2. WILL DIVERT FLOWS FROM ENTERING EXCAVATION/ DISTURBED AREAS

3. TRENCH WILL REMAIN IN PLACE UNTIL DISTURBED AREAS PERMANENTLY STABILIZED.

4. ALL TRENCHES WILL HAVE UNINTERRUPTED POSITIVE GRADE TO AN OUTLET.

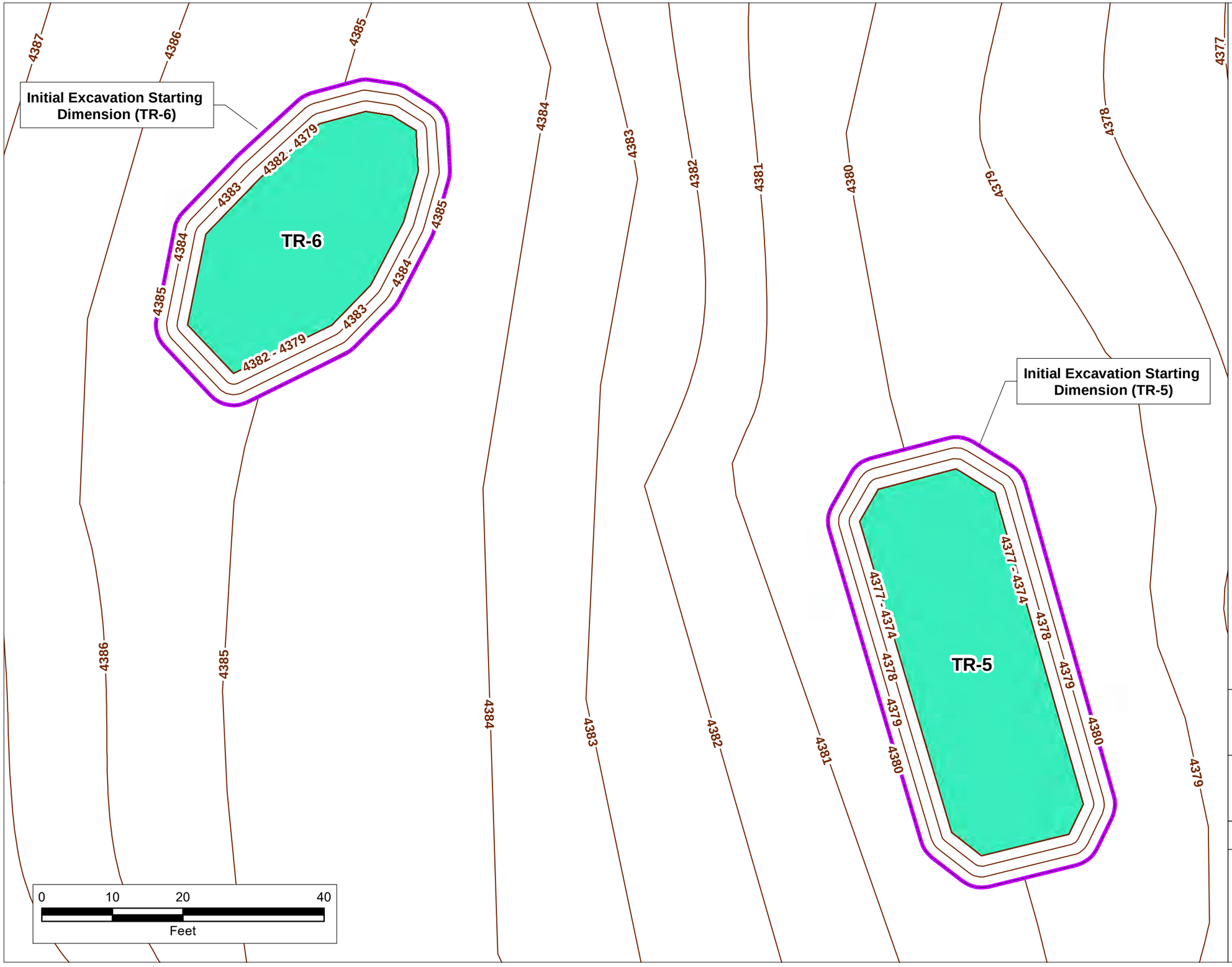
5. ON-SITE LOCATION MAY NEED TO BE ADJUSTED TO MEET FIELD CONDITIONS IN ORDER TO UTILIZE THE MOST SUITABLE OUTLET CONDITION.

EROSION AND SEDIMENT CONTROLS/ CONSTRUCTION DIAGRAMS

AREA 2 OF SWMU-11
DUGWAY PROVING GROUND
DUGWAY, UTAH

1/2024	PROJECT No. R1-0033.00	FIGURE 4-1

CABRERA SERVICES
CHALLENGE ACCEPTED



N

Legend

Trench Limits (TR-5 & TR-6)

Proposed Excavation Design

Topographic Contour Elevation

(Contour Interval = 1.0 Ft AMSL)

Initial Excavation Starting Dimension

Notes:
Ft = feet
AMSL = Above Mean Sea Level
bgs = below ground surface

GROSS EXCAVATION PLAN

AREA 2 OF SWMU-11
DUGWAY PROVING GROUND
DUGWAY, UTAH

1/2024	GIS ANALYST: S. Owe	FIGURE 4-2

CABRERA SERVICES
CHALLENGE ACCEPTED

Initial Excavation Starting Dimension (TR-6)

TR-6

4387 4386 4385 4384 4383 4382 4381 4380 4379 4378 4377

4382 - 4379 4383 4384 4385

TR-6 Excavation Details

Depth = 0 to 7 Ft bgs
Excavation Sloping = 1.5:1.0-Ft

Note vertical sidewall from 4382 to 4379 ft AMSL (3.0 to 7.0 Ft bgs)

Initial Excavation Starting Dimension (TR-5)

TR-5

4377 - 4374 4378 4379 4380

TR-5 Excavation Details

Depth = 0 to 7 Ft bgs
Excavation Sloping = 1.5:1.0-Ft

Note vertical sidewall from 4377 to 4374 ft AMSL (3.0 to 7.0 Ft bgs)

LAYBACK SOIL STOCKPILE

Erosion Control Silt Fence

0 10 20 40
Feet

N

Legend

- Trench Limits (TR-5 & TR-6)
- Exclusion Zone (EZ) Temporary Fence
- Layback Soil Stockpile/ Geotextile Liner
- Erosion Control/ Silt Fence

Proposed Excavation Design

- Topographic Contour Elevation
- (Contour Interval = 1.0 Ft AMSL)
- Initial Excavation Starting Dimension

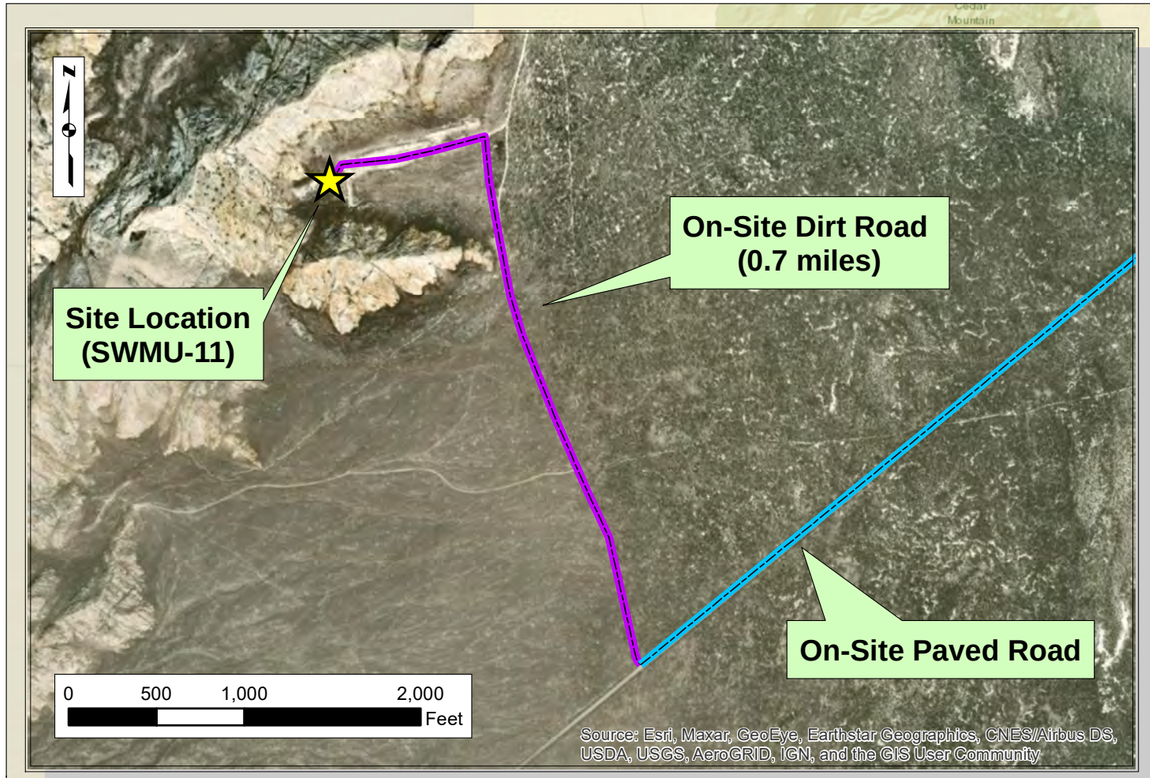
Notes:
Ft = feet
AMSL = Above Mean Sea Level
bgs = below ground surface

EXCAVATION DETAIL

AREA 2 OF SWMU-11
DUGWAY PROVING GROUND
DUGWAY, UTAH

1/2024	GIS ANALYST: S. Owe	FIGURE 4-3

CABRERA SERVICES
CHALLENGE ACCEPTED



Legend

- SWMU-11 Site Location
- DPG Visitor Center & Gate

Waste Transportation Route

- On-Site Dirt Road
- On-site Paved Road

WASTE TRANSPORTATION HAUL ROUTES

**DUGWAY PROVING GROUND
DUGWAY, UTAH**

1/2024	GIS ANALYST: S. Owe	FIGURE 4-4

CABRERA SERVICES
CHALLENGE ACCEPTED

Former TR-5/ TR-6 Excavation

Excavations will be backfilled using on-site fill source to original grade. Backfill source will be sampled per approved plans. Backfill will be mechanically compacted.

Final surface grade will be contoured to promote adequate surface water runoff towards the east.

Restoration Area

Restoration area includes all areas disturbed during construction/ remediation activities.

All erosion controls (diversion trenches and silt fence) will be removed prior to completion of restoration activities.

Final surface grade will be contoured to orginal grade and to promote adequate surface water runoff towards the east.

4395
4390
4385
4380
4375
4370

0 20 40 80
Feet

N

Legend

Former Backfilled Trench

Backfill/ Restoration Area

Site Restoration Final Grade

Topographic Contour Elevation

(Contour Interval = 1.0 Ft AMSL)

Notes:
Ft = feet
AMSL = Above Mean Sea Level
bgs = below ground surface

RESTORATION PLAN

AREA 2 OF SWMU-11
DUGWAY PROVING GROUND
DUGWAY, UTAH

1/2024	GIS ANALYST: S. Owe	FIGURE 4-5

CABRERA SERVICES
CHALLENGE ACCEPTED

APPENDIX A - UNIFORM FEDERAL POLICY FOR QUALITY ASSURANCE PROJECT PLANS (UFP-QAPP)

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FINAL

UNIFORM FEDERAL POLICY – QUALITY ASSURANCE PROJECT PLAN (UFP-QAPP)

Soils Remediation of Area 2 of SWMU 11
Dugway Proving Ground
Dugway, Utah

CONTRACT NUMBER: W9123824C0005

Prepared for

United States Army Corps of Engineers
Sacramento District
1325 J Street
Sacramento, California 95814-2922

Prepared by:

Cabrera Services Inc.
299 S Main Street, Suite 1700
Salt Lake City, Utah 84111

Revision 0

October 2024

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APPROVALS

UNIFORM FEDERAL POLICY - QUALITY ASSURANCE PROJECT PLAN

for the

SOILS REMEDIATION OF AREA 2 OF SWMU 11
DUGWAY PROVING GROUND
DUGWAY, UTAH

Authored By: _____ **Date:** October 11, 2024

Scott Hay

Principal Health Physicist

Cabrera Services Inc.

702-236-8401

Digitally signed by Gregory T. Bright
Date: 2024.10.11 15:16:34 -04'00'

Reviewed By: _____ **Date:** October 11, 2024

Greg Bright, PMP

Project Manager

Cabrera Services Inc.

508-315-6246

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TABLE OF CONTENTS

Section **Page**

Acronyms and Abbreviations iii
1.0 Introduction 1-1

1.1 Plan Organization 1-1
1.2 Background 1-1
1.3 Objectives and Approach 1-2
1.4 Activities 1-2
1.5 Communications Plan 1-3

2.0 Quality Assurance Project Plan Worksheets 2-1

QAPP Worksheets #1 and #2 Title and Approval Page ..... WS#1-1
QAPP Worksheets #3 and #5 Project Organization and Quality Assurance Project Plan Distribution ..... WS#3-1
QAPP Worksheets #4, #7, and #8 Personnel Qualifications and Sign-Off Sheet ..... WS#4-1
QAPP Worksheet #6 Communication Pathways ..... WS#6-1
QAPP Worksheet #9 Project Planning Session Summary ..... WS#9-1
QAPP Worksheet #10 Conceptual Site Model ..... WS#10-1
QAPP Worksheet #11 Project/Data Quality Objectives ..... WS#11-1
QAPP Worksheet #12 Measurement Performance Criteria ..... WS#12-1
QAPP Worksheet #13 Secondary Data Uses and Limitations ..... WS#13-1
QAPP Worksheets #14 and #16 Project Tasks and Schedule ..... WS#14-1
QAPP Worksheet #15 Project Action Limits and Laboratory-Specific Detections/ Quantitation Limits ..... WS#15-1
QAPP Worksheet #17 Sample Design and Rationale ..... WS#17-1
QAPP Worksheet #18 Sampling Locations and Methods ..... WS#18-1
QAPP Worksheets #19 and #30 Sample Containers, Preservation, and Hold Times ..... WS#19-1
QAPP Worksheet #20 Field Quality Control Summary ..... WS#20-1
QAPP Worksheet #21 Field Standard Operating Procedures ..... WS#21-1
QAPP Worksheet #22 Field Equipment Calibration, Maintenance, Testing, and Inspection Table ..... WS#22-1
QAPP Worksheet #23 Analytical Standard Operating Procedures ..... WS#23-1
QAPP Worksheet #24 Analytical Instrument Calibration ..... WS#24-1
QAPP Worksheet #25 Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table ..... WS#25-1
QAPP Worksheets #26 and #27 Sample Handling, Custody, and Disposal ..... WS#26-1
QAPP Worksheet #28 Analytical Quality and Corrective Action ..... WS#28-1
QAPP Worksheet #29 Project Documents and Records ..... WS#29-1
QAPP Worksheet #31, #32, and #33 Assessments and Corrective Action ..... WS#31-1
QAPP Worksheet #34 Data Verification and Validation Inputs ..... WS#34-1

TABLE OF CONTENTS (CONTINUED)

Section **Page**

QAPP Worksheet #35 Data Verification Procedures ..... WS#35-1
QAPP Worksheet #36 Data Validation Procedures ..... WS#36-1
QAPP Worksheet #37 Data Usability Assessment ..... WS#37-1

3.0 References 3-1

Figures F-1
Attachment A A-1
Attachment B B-1

ACRONYMS AND ABBREVIATIONS

3x3 NaI	two-inch by two-inch sodium iodide
AEC	Army Environmental Command
AHA	Activity Hazard Analysis
APP	Accident Prevention Plan
bgs	below ground surface
^{214}Bi	bismuth-214
BZ	breathing zone
°C	degrees Centigrade
Cabrera	Cabrera Services Inc.
CCB	Continuing Calibration Blank
CCV	Continuing Calibration Verification
cpm	counts per minute
CQCP	Contractor Quality Control Plan
CRDL	Contract required detection limit
CY	cubic yards
DAC	derived air concentration
$DCGL_W$	Derived Concentration Guideline Level over a wide area
DL	Detection Limit
DOD QSM	Department of Defense Quality Systems Manual
DPG	Dugway Proving Ground
DQO	Data Quality Objective
DWMRC	Division of Waste Management and Radiation Control
Enveco	Enveco Environmental Solutions, LLC
FIDLER	Field Instrument for the Detection of Low Energy Radiation
FSM	Field Site Manager
FSS	final status survey
ft	Foot (feet)
GIS	geographic information system
GWS	gamma walkover survey
HAZWOPER	Hazardous Waste Operations and Emergency Response
IAW	in accordance with
IDW	investigation-derived waste
IMC	Intermodal container
LBGR	Lower bound of the gray region
LCS	Laboratory control sample
LCS	Laboratory control sample duplicate
LOD	Limit of detection
LOQ	limit of quantitation

ACRONYMS AND ABBREVIATIONS (CONTINUED)

m/s	meters per second
MARSAME	Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum detectable concentration
µg /kg	micrograms per kilogram
µg /L	micrograms per liter
mL	milliliter
MS	Matrix spike
MSD	Matrix spike duplicate
^{94}Nb	niobium-94
NELAP	National Environmental Laboratory Accreditation Program
NRC	Nuclear Regulatory Commission
OP	Operating procedure
OSM	Occupational Safety Manager
^{214}Pb	lead-214
PCBs	polychlorinated biphenyls
pCi/g	picocuries per gram
pdf	portable document format
PgM	Program Manager
PM	Project Manager
PMP	Project Management Plan
PTFE	Polytetrafluoroethylene
QA	Quality Assurance
QC	Quality control
QCM	Quality Control Manager
QL	Quantitation Limit
^{226}Ra	radium-226
RAO	remedial action objective
RBA	reference background area
RCA	radiation control area
RCRA	Resource Conservation and Recovery Act
RCT	Radiation Control Technician
RDL	Reporting Detection Limit
RER	Relative Error Ratio
RFI	RCRA Facility Investigation
RL	Reporting Limit
ROD	Record of Decision
RPD	Relative percent difference
RPP	Radiation Protection Plan
RSO	Radiation Safety Officer
SOP	Site Operations Plan
^{90}Sr	strontium-90

ACRONYMS AND ABBREVIATIONS (CONTINUED)

SRSO	Site Radiation Safety Officer
SSHO	Site Safety and Health Officer
SU	survey unit
SWMU	Solid Waste Management Unit
TEDE	Total Effective Dose Equivalent
UDEQ	Utah Department of Environmental Quality
UFP-QAPP	Uniform Federal Policy - Quality Assurance Project Plan
USACE	U.S. Army Corps of Engineers
Validata	Validata Chemical Services, Inc.

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1.0 INTRODUCTION

Cabrera Services Inc. (Cabrera) has prepared this Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP) to support the remediation of soils at Area 2 of Solid Waste Management Unit 11 (SWMU-11) at Dugway Proving Ground (DPG) in Dugway, Utah. This UFP-QAPP provides the sampling and analysis procedures and rationale for the remediation and radiological investigation activities at Area 2 of SWMU-11.

The scope of work for this project includes the excavation of contaminated soils and debris, waste packaging, transportation and disposal of wastes, final status survey (FSS) to demonstrate compliance with clean up goals, and site restoration. The field work at Area 2 of SWMU-11 is governed by this UFP-QAPP and the other planning documents, which include the following:

- Site Operations Plan (SOP), of which this UFP-QAPP is an appendix;
- Project Management Plan (PMP; Cabrera, 2024a)
- Contractor Quality Control Plan (CQCP; Cabrera, 2024b)
- Accident Prevention Plan (APP), which includes a Site Safety and Health Plan and a Radiation Protection Plan (RPP; Cabrera, 2024c);

1.1 Plan Organization

This UFP-QAPP outlines the policies, organization, and specific quality assurance (QA)/quality control (QC) measures associated with the collection, analysis, and reporting of data collected in support of the characterization field activities performed to achieve the data quality goals. This document meets the requirements and elements set forth in the Intergovernmental Data Quality Task Force UFP for QAPPs (U.S. Environmental Protection Agency [EPA] 2005). This UFP-QAPP provides site-specific information unique to this project. Table 1 details information related to logistics and communications for the work planned for this site. Section 2.0 contains the 28 worksheets describing, among other information, procedures for field sampling and sample submittal for analysis, field parameter measurement, data documentation, data assessment and data reporting requirements. References used in the preparation of this UFP-QAPP are provided in Section 3.0. Cabrera Operating Procedures (OPs) describing the means and methods for collection and analysis of samples, as well as pertinent analytical laboratory information, are provided in Attachment A.

1.2 Background

DPG is located in southern Tooele County, Utah, on approximately 800,000 acres of Federal land managed by the Army (Figure 1-1). The Army is the lead agency for the investigation and cleanup of Area 2 of SWMU-11, and support agencies include the Utah Department of Environmental Quality (UDEQ) Division of Waste Management and Radiation Control (DWMRC) and the Nuclear Regulatory Agency (NRC). The U.S. Army Environmental Command (AEC) managed execution of the Feasibility Study and the Proposed Plan, and preparation of the Record of Decision (ROD) under the Army's Active Installation Defense Environmental Restoration Program on behalf of DPG. The DPG facility is bordered to the northeast by the Cedar Mountains and to the north-northwest by Wendover Air Force Range. DPG currently serves as the Army's designated Major Range Test Facility for chemical and biological defense. SWMU-11, also known as DPG-011 and the East Granite Holding Area, is located in the remote southwest portion of DPG and covers approximately 3.4 acres within a small canyon on the east side of Granite Mountain. SWMU-11 is divided into two distinct areas: Area 1 and Area 2. Area 1 of SWMU-11 was previously evaluated and closed under the Resource Conservation and Recovery Act (RCRA) and corrective action requirements of the DWMRC. Area 2 (0.86 acres) of SWMU-11 is a radiological

disposal area of concern and consists of two trenches (TR-5 and TR-6) and the area adjacent to the trenches (Figure 1).

In the DPG RCRA Facility Application, Area 2 of SWMU-11 was one of seven reported radioactive landfills. Historic records regarding radiological materials handling were summarized in the 2009 Phase II RCRA Facility Investigation (RFI) (Parsons, 2009). Specific records regarding radiological materials disposed at SWMU-11 are limited. The East Granite Holding Area (i.e., SWMU-11) is not identified in available literature as being associated with the testing of radiological munitions conducted at DPG in the 1950s and 1960s. Historical inspection records indicate that buried wastes in the SWMU-11 area consisted primarily of "contaminated rags and papers." Inspection records from the U.S. Atomic Energy Commission indicate that low-level radioactive waste materials were repackaged for sea disposal in the Able Area. Waste from this activity may have also been disposed at the DPG burial area corresponding to SWMU-11 after the sea disposal program was discontinued. Available documentation states that operation of the DPG radioactive waste disposal facility was discontinued in the early 1960s and that materials previously possessed under the Material License were transferred offsite during 1962 (NRC, 2001). Historical records indicate that the latest potential use of the SWMU-11 area for radiation-related operations was 1977. By extension, the last potential opportunity for radiological material to be added to trenches TR-5 and TR-6 would also be 1977.

Radioactive waste materials from laboratory activities in other areas of DPG were stored in a CONEX container at SWMU-11 to protect individual storage containers from the elements. Materials stored in the CONEX container included Tritium and Carbon-14. In March 1980, contaminated glassware was removed from the CONEX by the DPG radiation safety officer and disposed at an off-site location.

During the 2005 Phase II RFI, no waste remained in the CONEX container (Parsons, 2009). The CONEX container was determined to be radiologically clear and was removed in 2017 (Marsh, 2017).

1.3 Objectives and Approach

The major components of the selected remedy and technical project approach for Area 2 in SWMU-11 are presented in the Site Operations Plan (Cabrera 2024a) and include:

- Excavating approximately of 572 cubic yards (CY) from both TR-5 and TR-6 to a depth of approximately 7 ft below ground surface so as to meet the Remedial Action Objective (RAO).
- Establishing perimeter dust control measures, air monitoring and contamination control measures to monitor and control the discharge of surface water runoff and airborne dust from the excavation areas to local conveyances. This will be conducted for health and safety purposes during excavation.
- Ensuring the excavation was completed to meet unrestricted (i.e., residential) standards by performing confirmation surveys and soil sampling for radionuclides and a magnetometer survey to ensure all radiologically impacted materials have been removed.
- Backfilling with clean soil and contouring to promote surface water runoff in accordance with the approved site restoration plan.

Cabrera will be required to meet the RAO, as stated in the ROD (US Army Environmental Command, 2021):

- Prevent direct contact to or external exposure from surface and subsurface soil and debris (i.e., metal tubes) contaminated with Radium-226 (^{226}Ra), Strontium-90 (^{90}Sr), Bismuth-214 (^{214}Bi), Niobium-94 (^{94}Nb), Lead-214 (^{214}Pb), and Cesium-137 (^{137}Cs) by human receptors, with consideration to current and reasonably anticipated future land uses. The radiological criterion for unrestricted release is a dose limit of 25 millirem per year.

- Reduce the potential for migration of soil contaminated with ^{226}Ra, ^{90}Sr, ^{214}Bi, ^{94}Nb, ^{214}Pb, and ^{137}Cs to areas beyond the trenches (i.e., buffer zones surrounding the trenches, air, and groundwater).

1.4 Activities

The Project Base Tasks were provided in the Performance Work Statement and are presented in detail in the Site Operations Plan (Cabrera 2024a). Individual tasks associated with distinct work components were grouped into Definable Features of Work to create quality control requirements for implementation of work activities as described in the CQCP (Cabrera 2024b). The following sections briefly describe the separate Definable Features of Work.

1.4.1 Mobilization/Demobilization

Mobilization consists of moving project specific personnel and equipment to the site; the coordination/ completion of utility locations, if necessary; and conducting project-specific training for onsite workers. It has been previously determined that no on-site utilities exist, and utility clearance surveys are not anticipated.

Demobilization includes reversing some of the steps listed above with the goal of leaving the site as close to the same condition as it was prior to mobilization. All sampling equipment and other site remediation equipment will be decontaminated, as necessary, and released for unrestricted use prior to leaving the site. Materials and equipment that do not meet the requirements for unrestricted use will be disposed of appropriately.

1.4.2 Site Preparation

Site preparation will consist of the loading/unloading of materials/supplies on site, temporary office set-up, fence installation and repair, erosion and sedimentation controls installation, delineation of parking areas, and initial topographic and gamma walkover surveys (GWS). Initial instrument setup and establishment of quality control baselines will also take place during site preparation.

1.4.3 Monitoring, Sampling, Testing, and Analysis

During the first mobilization to the site, Cabrera will perform GWS of site areas and mobilize a Utah-licensed land surveyor to perform a baseline topographical survey in proposed work areas, laydown areas, and in planned haul road areas. Cabrera will conduct baseline radiation monitoring (total and removable surface levels) on incoming equipment used to support pre-characterization to ensure legacy contamination from another radiological site is not brought to DPG. Cabrera will conduct baseline perimeter air monitoring, consisting of one day of air monitoring and on-site counting. Samples of the onsite backfill materials will be collected and sent to the offsite laboratory for analysis to ensure these materials are suitable for their intended use.

1.4.4 Soil Excavation/Waste Packaging and Loadout

Soils from trenches TR-5 and TR-6 will be excavated and directly loaded into intermodal containers (IMCs) delivered to the Site via truck. Non-impacted layback soils adjacent to the trenches that are excavated to maintain adequate sloping will be stockpiled and sampled for evaluation as future re-use as backfill. This work also involves load-out and transportation of IMCs to the EnergySolutions disposal facility in Clive,

Utah. Existing characterization data will be utilized to develop the waste profile and to confirm compliance with the EnergySolutions' waste acceptance criteria.

1.4.5 Radiological Surveys

Cabrera will provide radiological support services during soil excavation operations, as well as for GWS in the excavation area. Support includes air monitoring for fugitive particulate emission, and direct measurements and smear tests on various locations of equipment and supplies.

Ongoing radiological surveys, to include FSS and Close-out, will be fully integrated into the remedial process to ensure responsiveness (to support remediation milestones) and completeness of data collection to support thorough and accurate close-out and post remedial action reporting.

The RP and FSS staff will use the global positioning system and radiation survey equipment to perform this task. Refer to the RPP within the APP (Cabrera, 2024c) for more complete details of radiological detection equipment.

1.4.6 Site Restoration

Site restoration will occur at the end of the project, following excavation of waste soils, waste packaging and load-out and completion of FSS to demonstrate compliance with clean-up criteria. Restoration includes backfilling excavations and final grading of surface topography. Site restoration will also include the removal of the CONEX storage container, removal of temporary fencing and erosion control devices (i.e. silt fencing, where necessary), and the disposal of construction debris. Exposures to potential contaminants of concern are not anticipated.

Excavated areas, temporary roads, and equipment staging areas will be restored to pre-excavation conditions. Cabrera will identify excavated soils below clean-up criteria as eligible for re-use, following sampling. Cabrera will sample and analyze all borrow material to ensure it is suitable for use as backfill.

1.5 Communications Plan

A summary table showing logistics and communication considerations that were evaluated for work to be conducted at the SWMU-11 Site is provided in Table 1.

Table 1 – Logistics and Communications Considerations

Logistics Consideration	Applicable?	Type	General Comments
Permits	No	N/A	No permits are required to perform this work.
Base Access and Access Passes	Yes	Security passes – Base access passes	Required for all on-Base work.
	Yes	Antiterrorism training, Operational Security training	Required for all site personnel.
Government Employee Escort	No	Escort for high security areas	Base security escorts may be required to perform work in some security-restricted areas of the Base. The contractor must coordinate through Base Point-of-Contact for escort.
Off-Base Access Agreements	No	NA	All work will be on DPG, no off-base access required.
Communications Plan	Yes	USACE	Cabrera PM will channel all project communications through the USACE PM, the USACE PM will communicate with other stakeholders. USACE PM will channel communications from stakeholders, as deemed necessary, to the Cabrera PM.
Adjusted Work Schedule	No	Weekend/after regular business hours	No after-hours work is scheduled or expected.
Impedance/ Hindering of Traffic	No	On-Base	For any work where traffic, especially emergency vehicles, will be hindered or impeded. This includes closures of parking lots, in part or whole.
Utility Location and Clearance	No	NA	No intrusive work requiring utility clearance planned for this project.
Utility Connections and Outages	No	NA	No utilities will be impacted by the planned work.

2.0 UFP-QAPP WORKSHEETS

This section documents the project organization, specific procedures for execution of the work, QC protocols, and the assessment and oversight planning that will help ensure the quality of the investigation. The format follows the current UFP Guidance for QAPPs (EPA, 2005) and optimizes the original 37 worksheets into 28 worksheets (EPA, 2012).

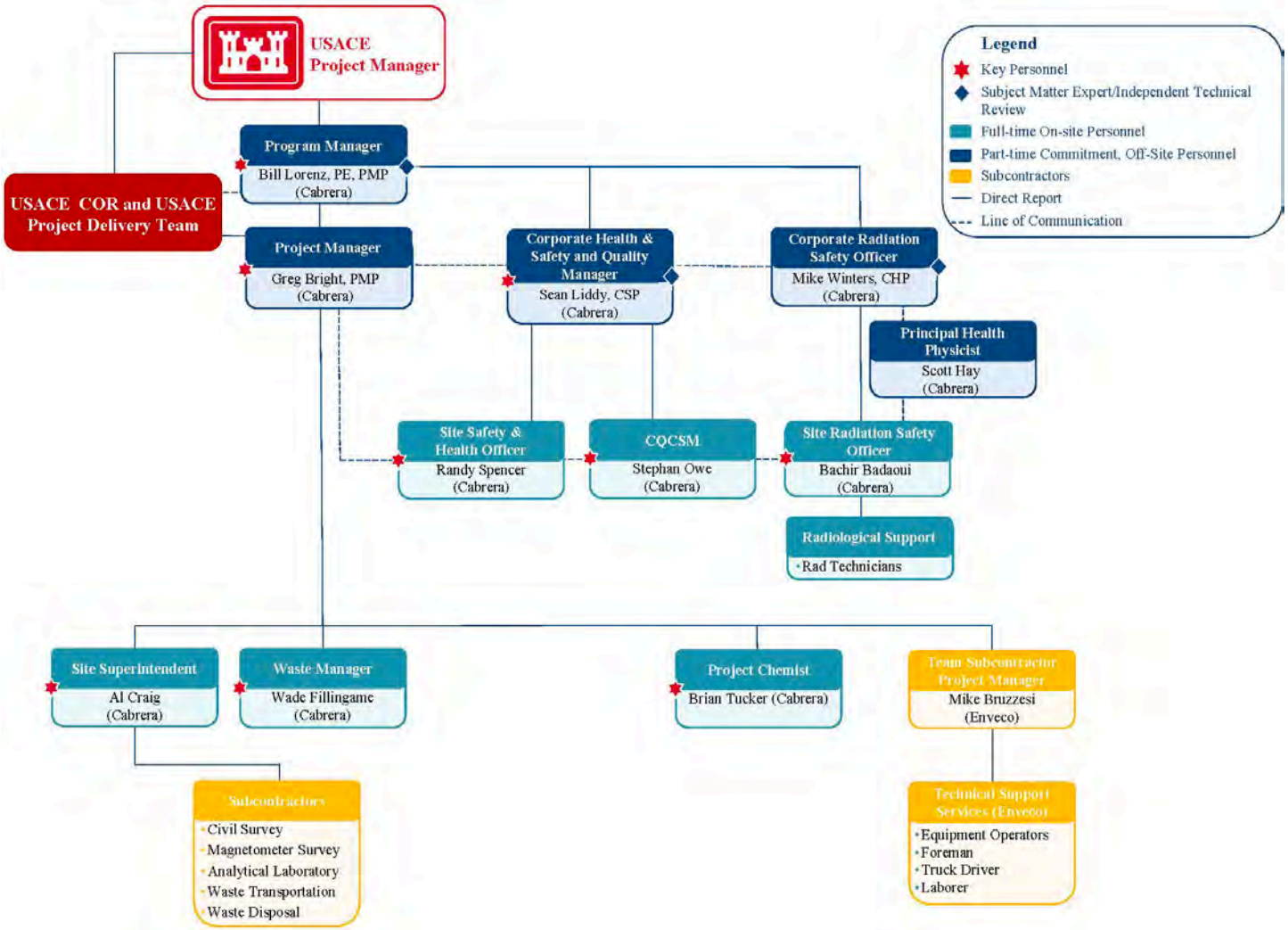
UFP-QAPP WORKSHEETS #1 AND #2
Title and Approval Page

Document Title:	Uniform Federal Policy-Quality Assurance Project Plan Soils Remediation of Area 2 of SWMU-11 DPG, Dugway, Utah
Site Name/Project Name:	Area 2 of SWMU-11
Site Location:	Dugway Proving Ground Dugway, Utah
Contract:	W9123824C0005
Preparer's Name and Organizational Affiliation:	Scott Hay/Cabrera
Preparer's Address, Telephone Number, and E-Mail Address:	Cabrera 50 Founders Plaza, Suite 207 East Hartford, CT 06108 (702) 236-8401 shay@cabreraservices.com
Preparation Date (Month/Year):	January 2024
Lead Organization:	USACE
USACE Project Manager:	Amy L. Estey
USACE Radiological Lead:	Julie Clements
DPG Lead:	Jeff Carter
Regulatory Program:	NRC
Regulatory Contact:	Not Applicable (N/A) (NRC communication through USACE Rad Lead)
State Regulatory Contact:	N/A (UDEQ communications through DPG Lead)
Document Control Numbering System:	Not required for this project
QA/QC Contact:	Sean Liddy/Cabrera

The Work Plan is (select one): __ Generic X Site-Specific

UFP-QAPP WORKSHEETS #3 AND #5

Project Organization and Quality Assurance Project Plan Distribution



UFP-QAPP WORKSHEETS #4, #7, AND #8
Personnel Qualifications and Sign-Off Sheet

The qualifications of USACE, Army Environmental Command (AEC), and DPG personnel are under the purview of the Department of Defense and will not be outlined in this UFP-QAPP. In addition, federal stakeholders' qualifications are under the purview of their respective agencies and will not be presented in this UFP-QAPP. The table below summarizes the responsibilities and provides a space for the signatures of personnel key to this UFP-QAPP. Signatures below indicate personnel have read and agree to implement this UFP-QAPP as written.

Organization: Cabrera

Name	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature/Date
Greg Bright	Cabrera Project Manager	>15 years of experience in project management	• Project Management Professional	
Scott Hay	Cabrera Principal Health Physicist	>40 years of experience in environmental health physics	• MARSSIM/MARSAME author	
Brian Tucker	Cabrera Principal Chemist	>40 years of experience in environmental chemistry	• PhD - Chemistry	
Bachir Badaoui	Cabrera Site Radiation Safety Officer (SRSO)	>20 years of experience in health physics field support	• NRRPT • 40-Hour Occupational Safety and Health Administration (OSHA) Training • 8-Hour OSHA Supervisor Training • First Aid	
Stephan Owe	Cabrera Contractor Quality Control Systems Manager (CQCSM)	> 15 years of experience in field management and safety	• Completed "Construction Quality Management for Contractors" • 40-Hour Occupational Safety and Health Administration (OSHA) Training • 8-Hour OSHA Supervisor Training • Safety Trained Supervisor (STS) Certification	

Organization: GEL Laboratories, Charleston SC

Name	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature/Date
Jake Crook	Offsite Laboratory Manager	On file with Laboratory Human Resources	On file with Laboratory Human Resources	

UFP-QAPP WORKSHEET #6
Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Modifications to Program	USACE Project Manager	Amy Estey	916-557-7431	Primary point-of-contact for USACE for programmatic information, coordination issues, and reports. Coordinate with Cabrera Project Manager and AEC.
Communication with NRC	USACE Radiological Lead	Julie Clements	402-212-5956	Primary point-of-contact for USACE for communications with NRC.
DPG Contact and Communication with UDEQ	DPG Lead	Jeff Carter	435-849-1200	Primary point-of-contact for DPG and for communications with UDEQ.
Quality and safety issues for Cabrera Project Phases	Cabrera Occupational Health and Safety, Quality Assurance (OHS/QA) Manager	Sean Liddy	410 982-0726	Notify Cabrera Project Manager of Cabrera Project Phase quality and safety issues.
Modification to Technical Direction of Cabrera Project Phases	Cabrera Project Manager	Greg Bright	508-315-6246	Notify Cabrera Program Manager of Cabrera Project Phase issues.
Modifications to Work Plan Procedures and Site Status Updates	Contractor Quality Systems Manager	Stephan Owe	410 982-0718	Notify Cabrera Project Manager of field-related issues and implement corrective actions for field and analytical issues.
Reporting Data Quality Issues	Contractor Quality Systems Manager	Stephan Owe	410 982-0718	All QA/QC issues with project field samples will be reported to Cabrera OHS/QA Manager within 2 business days
Modifications to Site Health and Safety Protocols and Reporting Site Safety Issues	Cabrera SSHO	Randy Spencer	217-710-3063	All safety issues with project field samples will be reported to Cabrera OHS/QA Manager as required

UFP-QAPP WORKSHEET #9
Project Planning Session Summary

Site Name/Project Name:	Area 2 of SWMU 11, Dugway Proving Ground
Site Location:	Dugway, Utah
Projected Date(s) of Work:	July 2024, October 2024, January 2025
Cabrera Project Manager:	Greg Bright
Date of Session:	December 14, 2023
Planning Session Purpose:	Kickoff Meeting for Remediation of Area 2 of SWMU-11

Participants

Name	Organization	Project Role	Phone	E-mail Address
Amy Estey	USACE	USACE Project Manager		Amy.L.Estey@usace.army.mil
Greg Bright	Cabrera	Cabrera Project Manager	508-315-6246	gbright@cabreraservices.com

USACE Technical Support	Julie Clements, Zenny Dinh, Kristyl Bentley, Matt Wetter, Monica Chahary, Melanie Prescott, Amber Scyoc, Davina Dardin, Arnel Margen
DPG Technical Support	Jeff Carter
U.S. Army Environmental Command	Stephen (Steve) Richard, Mike Bowlby
Cabrera Technical and Contract Support	Bill Lorenz, Mike Winters, Sean Liddy, Scott Hay, Stephan Owe, Michele Robert
Subcontractor (Enveco)	Mike Bruzzesi, Sean Carney

Comments

- Cabrera reviewed project purpose, site history, and contract information. USACE reminded Cabrera all contract revisions must be made in writing through the Contracting Officer.
- Cabrera provided a draft project schedule where the proposed schedule had been pushed ahead 3 months to coincide with award of the contract. A final schedule will be included in the PMP.
- Cabrera described the field work occurring over three mobilizations. Discussions on specifics of waste transport and disposal were scheduled for a later meeting.
- A discussion was held on lines of communication. General questions from Cabrera can be communicated by e-mail, but a more formal process should be used for larger issues. Radiological issues should be copied to Amy Estey, Matt Wetter, Kristyl Bentley, and Julie Clements at USACE. All communication with the NRC will go through USACE with Julie Clements as the point of contact. All communications with UDEQ will go through USACE with Jeff Carter from DPG as the point of contact.
- A discussion was held on training requirements. All field personnel will need to go through site training, including a background check, prior to accessing the range. Field personnel should complete training at the start of a mobilization. Truck drivers have an option of going through security the day they arrive onsite, but delays and issues with foreign nationals are possible.
- Cabrera asked if it was necessary to implement an NRC radioactive material license prior to initiating work. USACE explained that the project site is not licensed, but DOD is required to notify the NRC of all work with radioactive material. A final decision on lines of communication and will be discussed at a future meeting prior to initiating field work.
- USACE and DPG confirmed there are no special permits or notifications required from Cabrera to complete the tasks in the contract.

Action Items

- Cabrera will provide the contract scope for transport and disposal of waste to meeting participants in preparation for a more detailed discussion on this task.
- Julie Clements will contact the NRC and figure out what communication is required for this work in preparation for a more detailed discussion on communication of radiological issues with regulators.

UFP-QAPP WORKSHEET #10
Conceptual Site Model

The conceptual site model identifies the relationship between the sources of contamination, source areas, contaminants, transport mechanisms, exposure routes, and receptors. The conceptual side model provides a description of how contaminants enter into the environment, how they are transported within the environment, and the routes of exposures to humans.

1.0 Sources and Areas of Contamination

In the DPG RCRA Facility Application, Area 2 of SWMU-11 was one of seven reported radioactive landfills. Historic records regarding radiological materials handling were summarized in the 2009 Phase II RCRA Facility Investigation (RFI) (Parsons, 2009). Specific records regarding radiological materials disposed at SWMU-11 are limited. The East Granite Holding Area (i.e., SWMU-11) is not identified in available literature as being associated with the testing of radiological munitions conducted at DPG in the 1950s and 1960s. Historical inspection records indicate that buried wastes in the SWMU-11 area consisted primarily of "contaminated rags and papers." Inspection records from the U.S. Atomic Energy Commission indicate that low activity radioactive waste materials were repackaged for sea disposal in the Able Area. Waste from this activity may have also been disposed at the DPG burial area corresponding to SWMU-11 after the sea disposal program was discontinued. Historical records indicate that the latest potential use of the SWMU-11 area for radiation-related operations was 1977. By extension, the last potential opportunity for radiological material to be added to trenches TR-5 and TR-6 would also be 1977.

Figure 1-2 in the SOP (Cabrea, 2024a) shows the layout of the SWMU-11 Area 2 Site and the trench locations, which are the areas of contamination.

2.0 Known Contaminants

The radionuclides of concern are ^{226}Ra, ^{90}Sr, ^{214}Bi, ^{94}Nb, ^{214}Pb, and ^{137}Cs. An arsenic result from a solidified sand sample determined that Toxicity Characteristic Leaching Procedure (TCLP) analysis of the contents of drums within TR-6 may be warranted in future remedy implementation (North Wind, 2020).

3.0 Release Mechanism and Fate of Transport

Soils

ROCs in soil and debris pose the highest potential exposure for human and ecological receptors. The ROCs in soil (^{226}Ra, ^{90}Sr, ^{214}Bi, ^{94}Nb, ^{214}Pb) could be transported via wind or water erosion, could be redistributed via burrowing animals, and could be assimilated into the food chain via plant uptake or direct ingestion by animals. In addition, constituents in soil could leach and migrate towards the water table as precipitation percolates through the trenches. Small metal tubes in TR-6 contain signatures of ^{137}Cs; however, it has not been fully identified. Despite these "sealed" radioactive sources, the possibility of a leak due to aging, an accident, damage, or poor manufacture could cause releases or migration of radioactive contamination in TR-6.

The identified or potential exposure routes for the site include the following:
- Direct radiation,
- Inhalation of re-suspended dust, and
- Direct ingestion of soil

Groundwater

The groundwater pathway was evaluated during the Feasibility Study for Area 2 of SWMU-11 using a Resident Farmer scenario. Conservative parameter values were used for the groundwater pathway, basing the parameter values for the unsaturated and saturated zones on the typical properties of sand. Results of the RESRAD ONSITE computer code (Kamboj et al., 2018) show that the travel time of radionuclides to the aquifer for all radiological COCs of interest are greater than the 1,000-year model period. Therefore, radiological COCs will not migrate to the groundwater during the assessment period. Evidence from the attempt by Parsons (2009) to install a groundwater monitoring well near Area 2 of SWMU-11 indicates the development of a water well in this area of the site may not be possible. Therefore, the groundwater pathway is not a significant contributor to the receptor doses at Area 2 of SWMU-11 and does not pose a concern for potential exposure to human or ecological receptors.

4.0 Land Use Considerations and Potential Receptor Scenarios

DPG is a federal facility and an active military installation. Area 2 of SWMU-11 does not currently house any administrative buildings, family housing, industrial facilities, or barracks, and no future construction projects or residential housing are planned for this area. Future land use is anticipated to be consistent with the current land use. Groundwater was determined to be of overall low quality in the western DPG region, and no potable water resources have been developed in the area. Local groundwater is listed as Utah Class 2 drinking water quality groundwater (Parsons, 2009). Groundwater usage is not anticipated to change.

Current and future land users were identified as site Industrial Workers and ecological receptors. Because access to the site is restricted, trespassers are not expected at the site under current conditions. Anticipated future receptors are site Industrial Workers and ecological receptors; Resident Farmers or Residential Users are potential land users in the distant future.

UFP-QAPP WORKSHEET #11
PROJECT/DATA QUALITY OBJECTIVES

An integral part of a UFP-QAPP is the formulation of the Project Quality Objectives and Data Quality Objectives (DQOs). The Project Quality Objectives incorporate the elements of an EPA DQO process, which in turn consists of a series of seven planning steps that are designated to ensure that the type, quantity, and quality of the environmental data used in the decision making are appropriate for their intended application. The problem statement, goals of the study, data inputs, study boundaries, analytical approach, and plan for obtaining data are presented in the following sections of this worksheet and mirror the 7-step DQO process outlined in the EPA 2006 guidance document (EPA 2006).

The specific QA/QC requirements developed for the site are consistent with those presented in the Department of Defense Quality Systems Manual, Version 5.4 (DoD 2021).

Problem Definition

The Site, in the course of operations, disposed of materials in two trenches potentially containing alpha, beta, and gamma radiation. The trenches may also contain chemical and metals contaminants. The objective of this FSS is to obtain data of sufficient quality and quantity to determine if the post-remedial trench surfaces meet the release criteria for unrestricted use in 10 CFR 20.1402. The FSS will obtain data from the trench floor and sidewall surfaces.

The problem of this UFP-QAPP is to identify the types, quality, and quantity of data that will be used to support the remedial action within the planned project schedule. These data will be used to demonstrate that the residual radionuclide concentrations following remediation comply with concentration and exposure-based criteria per the decision documents. The ultimate decision regarding site disposition will rest with the USACE and AEC decision makers.

Identification Of Decisions

The following key decisions must be made to support project objectives.

1. ***Remedial Support Surveys***—Following the completion of remedial action, remedial support surveys, consisting of GWS, will be used to identify elevated areas of gamma activity at the limits of excavation. If elevated activity is recorded during the GWS, then these locations will be investigated. If elevated activity is confirmed following additional investigation (i.e., follow-up gamma activity scans), then this area will be excavated in 1-ft lifts until remedial support survey scan results are consistent with background reference area GWS results.

   There will be two investigation levels (ILs) calculated per instrument: one for surface soils, and one for trench soils. For this project, elevated activity for GWS data (i.e., ILs) will be set at the mean count rate plus three sigma (σ), where σ is the standard deviation of the newly obtained gamma measurements. Surface soil scans will be evaluated against the surface soil IL, and trench floor and sidewall soil scans will be evaluated against the trench soils IL. Cabrera's Principal HP will evaluate gamma survey count rates and provide GWS maps to the Site RSO for use in selecting FSS sample locations. The key question for remediation is:

   - Do post-remedial site soil concentrations meet their appropriate ILs?

2. ***FSS***—Following the completion of remedial action, FSS will be conducted for various classes

(Class 1, Class 2, and Class 3) of survey units (SUs) by utilizing the guidelines presented in MARSSIM (NRC 2000). GWS will be performed to identify areas of elevated gamma activity and biased soil sample locations. Confirmatory soil samples will be collected from each SU. The key questions include:

- Are the sum of the ratios for each confirmatory sample less than 1?
- If small areas of elevated radioactivity exist in a SU, are these concentrations at levels below the DCGL used for elevated measurement comparison?
- Do soil sample results satisfy the Wilcoxon Rank Sum statistical test as described in the MARSSIM?
- Project action levels for all ROCs are presented in Worksheet #15.

3. ***Layback Soils Sampling***—To ensure safe entry into excavations, sidewalls will be sloped and any non-contaminated layback soils outside of the trench footprint will be staged in the Layback Soils Staging Area (see Figure 4-3 of the SOP). Soils will be sampled to ensure that they meet the criteria for reuse presented in Worksheet #15. The key question for layback soils is:

    - Do layback soil concentrations meet their appropriate project action levels?

4. ***Offsite Borrow Source Backfill Sampling***—Once excavation and FSS activities have been completed, backfill activities will be performed. Backfill will consist of non-impacted layback soils below reuse criteria and clean borrow material from an approved on-site source (the expected on-site backfill source is the North Granite Gravel Pit shown in Figure 1-1 of the SOP. Clean borrow materials will be sampled prior to being used as backfill to ensure that they meet the reuse criteria presented in Worksheet #15. The key question for offsite borrow source material sampling is:

    - Do offsite borrow backfill materials meet their appropriate project action levels?

5. ***Waste Characterization Sampling***—Sample analysis results from previous investigations are adequate to establish a profile for the excavated soil/debris waste with the EnergySolutions disposal facility. However, there is a possibility that solidified sand material in/around drum carcasses in Trench TR-6 may contain leachable arsenic contamination. The key question for waste characterization sampling is:
    - Do arsenic concentrations from sand material in Trench TR-6 exceed the limits in 40 CFR 268.40?

In addition, air monitoring samples, periodic routine and release surveys, and contamination control surveys will be conducted at the site in order to protect the workers and general public from exposure to airborne radioactive contaminated materials and to prevent the contaminated radioactive materials from leaving the site.

Data Needed to Meet Objectives and Development of Analytical Approach

1. ***Remedial Support Surveys***—One major input decision is assurance that the site work area has been remediated. This will be demonstrated through the use of GWS during remedial support surveys (and later FSS). Gross gamma activity data will be compared to the ILs for GWS to determine if further excavation is required.

2. ***FSS***—An FSS will be performed for various classes of SUs and is made up of the following:

- GWS using hand-held radiation survey instruments to small areas of elevated activity exceeding the action level of three standard deviations above the reference area mean count rate.
- Systematic soil samples collected for each SU. Samples will be analyzed for radionuclides of concern (UFP-QAPP Worksheet #23).
- Biased soil samples collected from the relative maxima of each GWS. Samples will be analyzed for ROCs (UFP-QAPP Worksheet #23).

These soil sample concentrations will be used in a dose assessment to demonstrate successful remediation for all ROCs at SWMU-11 and acceptable dose remaining at the Site.

3. ***Layback Sampling***—Non-impacted layback soils will be used for backfill. Samples will be analyzed for gamma spectroscopy, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, hexavalent chromium, and total cyanide. Worksheet #12 provides measurement performance criteria for these analytes. Prior to backfilling, sample data will be used to ensure suitability as backfill.

4. ***On-Site Borrow Source Backfill Sampling***— Clean borrow material from an approved on-site source will be used for backfill. Samples will be analyzed for gamma spectroscopy, VOCs, SVOCs, PCBs, pesticides, hexavalent chromium, and total cyanide. Worksheet #12 provides measurement performance criteria for these analytes. Prior to backfilling, sample data will be used to ensure suitability as backfill.

5. ***Waste Characterization Sampling***—Samples will be collected from solidified sand material in/around drums in Trench TR-6. Samples will be analyzed for TAL metals using TCLP. Worksheet #12 provides measurement performance criteria for these analytes. Prior to off-site transportation and disposal, sample data will be used to ensure compliance with the waste acceptance criteria of the EnergySolutions disposal facility in Clive, Utah.

Data needed for air monitoring samples, periodic routine and release surveys, and contamination control surveys are included in Worksheet #17.

Definition of Study Boundaries

Data Population

The data population of interest for the TR-5 and TR-6 trenches is the concentrations of the ROCs, the associated comparison to their project action limits in soils, and the comparison of the dose assessment based on these concentrations to the requirements of 10CFR20.1402.

Spatial and Temporal Boundaries

The spatial boundaries for this survey are the known trench boundaries previously established during previous investigations and a buffer area around each trench impacted by site remediation activities (see Figure 4-2 of the SOP).

Temporal boundaries include performing field work outside of times with the potential for bad weather and difficult site conditions.

Performance and Acceptance Criteria

Definitive data are required for supporting project decisions. To limit decision errors, analytical method performance criteria for accuracy and precision for QC sample results have been established and are presented in Worksheet #12. All sampling results will be qualified with respect to the performance criteria specified in Worksheet #12. All qualified data will be reported and utilized to evaluate the performance of the remedial action.

Acceptability decisions are often made based on acceptance criteria. If the mean and median concentrations of a contaminant are less than the associated acceptance criteria; for example, the results can usually be accepted. In cases where data results are not so clear, statistically based decisions are necessary. Statistical acceptability decisions, however, are always subject to error. Two possible error types are associated with such decisions.

The Type I decision error provides a 95 percent confidence level that the statistical tests will not incorrectly indicate that an SU satisfies acceptance criteria when, in fact, it does not. The Type II decision error provides a 95 percent confidence level that the statistical tests will not incorrectly indicate that an SU does not satisfy acceptance criteria when, in fact, it does. Type II errors are more a function of labor and survey costs and do not adversely impact public safety or health, and thus are subject to adjustment as needed. For the purposes of the FSS, the acceptable error rate for both Type I and Type II errors is 5 percent (i.e., $\alpha = \beta = 0.05$).

Optimize the Design

The variability of data will have an effect on the sampling design. If necessary, the sample frequency and the analytical procedures will undergo changes to optimize the design. Changes will occur concurrently for several steps with the DQO process. The design options, such as sample collection design, sample size, and analytical procedures, will be evaluated based on cost and the ability to meet the DQOs. A more detailed discussion on the sampling design with analytical design requirements is presented in Worksheets #19, #20, #24, #25, #26, #28, and #30.

UFP-QAPP WORKSHEET #12
MEASUREMENT PERFORMANCE CRITERIA

To measure and control the quality of analyses, certain QA parameters are defined and utilized in data analysis activities. These parameters are defined below.

Precision. Precision measures the reproducibility of data or measurements under specific conditions. Precision is a quantitative measure of the variability of a group of data compared to their average value. Measurement of precision is dependent upon sampling technique and analytical method and may be affected by the natural variation of the sample matrix or contamination within the matrix, as well as by errors made in the field and/or laboratory handling procedures. Matrix Spike (MS) and matrix spike duplicate (MSD) pairs and laboratory replicate samples are used to assess analytical precision. Field precision is assessed by analysis of field duplicate sample pairs for grab samples.

Laboratory and field duplicate precision is stated in terms of the relative percent difference (RPD) between two measurements using the absolute difference between the two results. For a pair of measurements, the RPD is calculated as follows:

$$RPD = \left(\frac{|X_1 - X_2|}{\frac{(X_1 + X_2)}{2}} \right) x100$$

Where: X_1 and X_2 = the two replicate values

Accuracy. Accuracy measures the bias in a measurement system. Sources of error include the sampling process, field contamination, preservation, handling, shipping, sample matrix, sample preparation, and analysis technique. Analytical accuracy will be assessed through calibration checks, surrogate spikes, tracers, MS, Laboratory Control Sample (LCS), and other method-specific checks. Accuracy is measured in terms of percent recovery (%R) of an added known spike concentration.

%R is calculated as follows:

$$\%R = \left(\frac{|SSR - SR|}{SA} \right) x100$$

Where: SSR = measured value of the spiked sample
SR = measured value of the unspiked sample
SA = known amount of the spike in the sample

The accuracy of analytical results reported in environmental samples is also measured against any contamination present in laboratory backgrounds, method blanks and daily blanks, as well as field blanks such as trip and equipment rinsate blank samples. For all COCs, the Warning and Control Limits for daily blanks, method blanks and backgrounds are +/-2sigma and +/-3sigma, respectively.

Representativeness. Representativeness expresses the degree to which data accurately and precisely reflects a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is a qualitative parameter that is dependent upon the proper design and implementation of the sampling program and proper laboratory protocol. The sampling design created for this project was designed to provide data representative of site conditions. During development of the sampling designs, consideration was given to the history of contamination at the site, existing analytical data, physical setting, and process. Representativeness will be satisfied by determining that the UFP-QAPP is followed; proper sampling techniques, preservation, and handling are used; proper analytical procedures are followed; and holding times for the samples are not exceeded in the laboratory. If during

data evaluation, results indicate that a sample is not representative Cabrera will notify USACE and provide recommendations for an alternate sample location or sample collection method.

Completeness. Completeness is a measure of the amount of usable data obtained from a measurement system compared to the amount that was expected under normal conditions. To be considered complete and valid, the reported data set must meet all acceptance criteria, including precision and accuracy in accordance with the performance criteria presented for various matrix and analytical methods within Worksheet #12.

Completeness for sample collection. Completeness for sample collection is defined as the percentage of samples listed in the UFP-QAPP that were collected. The completeness acceptance criterion for samples collected in the field will be 90% of the quantity of samples planned for collection in the UFP-QAPP. Corrective action may be implemented to recollect samples where necessary (e.g., modifying a planned sample location, sample jars broken during shipment). Laboratory notification of sample receipt conditions will be used to determine as soon as possible whether any problems during sample shipment would necessitate recollection of samples. The percent completeness for sample collection will be calculated using the following equation:

$$\%C = \left(\frac{V}{N}\right) x100$$

Where: V = number of samples collected
N = total number of samples planned

Completeness for acceptable data. Completeness for acceptable data is defined as the percentage of acceptable data out of the total number of data generated. This completeness will be 95% for each analytical method. Acceptable data is defined as data that passes all applicable quality control systems defined in the UFP-QAPP. The percent completeness will be calculated using the following equation:

$$\%C = \left(\frac{V}{N}\right) x100$$

Where: V = number of measurements judged acceptable
N = total number of sample results

The data review process will be used to determine the quality and quantity of usable analytical data generated. For calculating completeness, results that are assigned “J” qualifiers during data review will be acceptable, while results that are assigned “R” qualifiers during data review will be considered unacceptable.

UFP-QAPP Worksheet #12-1: Measurement Performance Criteria Table

Matrix: Soil

Analytical Group or Method: VOC/ 8260D total

Concentration Level: Low/Medium

Data Quality Indicator (DQI)	QC sample or measurement performance activity	Frequency	Measurement Performance Criteria
Overall Precision; Representativeness	Field Duplicates	5% of total number of project samples	RPD ≤ 50%
Overall Precision	Duplicates	One per preparation batch	RPD: RPD </+ 20
Analytical Precision (laboratory)	Laboratory Control Sample Duplicates	One per preparation batch	RPD: 20%
Analytical Accuracy/Bias (laboratory)	Laboratory Control Samples	Per sample	Recovery within 70% - 130%
Analytical Accuracy/Bias (matrix interference)	Post Spike	One per preparation batch	Recovery within 70% - 130%
Analytical Accuracy/Bias (matrix interference)	Post Spike Duplicates	Per sample	RPD 20%
Completeness	Data Evaluation	Once when all analyses have been completed	95%

Notes:
RPD – relative percent difference

UFP-QAPP Worksheet #12-2: Measurement Performance Criteria Table

Matrix: Soil

Analytical Group or Method: Metals / 6010B total

Concentration Level: Low/Medium

Data Quality Indicator (DQI)	QC sample or measurement performance activity	Frequency	Measurement Performance Criteria
Overall Precision	Duplicates	5% of total number of project samples	RPD: RPD </+ 20
Analytical Precision (laboratory)	Laboratory Control Sample Duplicates	Analytical Precision (laboratory)	RPD: 20%
Analytical Accuracy/Bias (laboratory)	Laboratory Control Samples	Analytical Accuracy/Bias (laboratory)	Recovery within 80% - 120%
Analytical Accuracy/Bias (matrix interference)	Post Spike	Analytical Accuracy/Bias (matrix interference)	Recovery within 75% - 125%
Analytical Accuracy/Bias (matrix interference)	Post Spike Duplicates	Analytical Accuracy/Bias (matrix interference)	RPD 20%
Completeness	Data Evaluation	Once when all analyses have been completed	95%

Notes:
RPD – relative percent difference
LOQ – limit of quantitation

UFP-QAPP Worksheet #12-3: Measurement Performance Criteria Table

Matrix: Aqueous (TCLP leachate)

Analytical Group or Method: Metals / 6010B total

Concentration Level: Low/Medium

Data Quality Indicator (DQI)	QC sample or measurement performance activity	Frequency	Measurement Performance Criteria
Overall Precision	Duplicates	5% of total number of project samples	RPD: RPD </+ 20
Analytical Precision (laboratory)	Laboratory Control Sample Duplicates	Analytical Precision (laboratory)	RPD: 20%
Analytical Accuracy/Bias (laboratory)	Laboratory Control Samples	Analytical Accuracy/Bias (laboratory)	Recovery within 80% - 120%
Analytical Accuracy/Bias (matrix interference)	Post Spike	Analytical Accuracy/Bias (matrix interference)	Recovery within 75% - 125%
Analytical Accuracy/Bias (matrix interference)	Post Spike Duplicates	Analytical Accuracy/Bias (matrix interference)	RPD 20%
Completeness	Data Evaluation	Once when all analyses have been completed	95%

Notes:
RPD – relative percent difference

UFP-QAPP Worksheet #12-4: Measurement Performance Criteria Table

Matrix: Soil

Analytical Group or Method: Mercury (7471B)

Concentration Level: Low/Medium

Data Quality Indicator (DQI)	QC sample or measurement performance activity	Frequency	Measurement Performance Criteria
Overall Precision; Representativeness	Field Duplicates	5% of total number of project samples	RPD ≤ 20%
Analytical Precision (laboratory)	Laboratory Control Sample Duplicates	One per preparation batch	RPD: 20%
Analytical Accuracy/Bias (laboratory)	Laboratory Control Samples	One per preparation batch	Recovery within 80% - 120%
Analytical Accuracy/Bias (matrix interference)	Post Spike	One per preparation batch	Recovery within 80% - 120%
Analytical Accuracy/Bias (matrix interference)	Post Spike Duplicates	One per preparation batch	RPD 20%
Completeness	Data Evaluation	Once when all analyses have been completed	95%

Notes:
RPD – relative percent difference
LOQ – limit of quantitation

UFP-QAPP Worksheet #12-5: Measurement Performance Criteria Table

Matrix: Soil

Analytical Group or Method: SVOC/ 8270C

Concentration Level: Low/Medium

Data Quality Indicator (DQI)	QC sample or measurement performance activity	Frequency	Measurement Performance Criteria
Overall Precision; Representativeness	Field Duplicates	5% of total number of project samples	RPD ≤ 50%
Analytical Precision (laboratory)	Laboratory Control Sample Duplicates	One per preparation batch	See limits in table below
Analytical Accuracy/Bias (laboratory)	Laboratory Control Samples	One per preparation batch	See limits in table below
Analytical Accuracy/Bias (matrix interference)	Post Spike	One per preparation batch	See limits in table below
Analytical Accuracy/Bias (matrix interference)	Post Spike Duplicates	One per preparation batch	See limits in table below
Completeness	Data Evaluation	Once when all analyses have been completed	95%

Parameter	Duplicate	MS	MSD	LCS	LCSD	Yield
1-Methylnaphthalene	0-20	38-106	0-20	44-104	0-20	NA
2-Chloronaphthalene	0-20	39-124	0-20	38-124	0-20	NA
2-Methylnaphthalene	0-20	37-104	0-20	43-102	0-20	NA
5-alpha-Androstane	0-20	NA	NA	NA	NA	26-121
Acenaphthene	0-20	39-112	0-20	46-108	0-20	NA
Acenaphthylene	0-20	49-111	0-20	46-108	0-20	NA
Anthracene	0-20	39-115	0-20	51-113	0-20	NA

UFP-QAPP Worksheet #12-5: Measurement Performance Criteria Table (Continued)

Matrix: Soil

Analytical Group or Method: SVOC/ 8270C

Concentration Level: Low/Medium

Parameter	Duplicate	MS	MSD	LCS	LCSD	Yield
Benzo(a)anthracene	0-20	38-116	0-20	48-117	0-20	NA
Benzo(a)pyrene	0-20	40-123	0-26	45-129	0-20	NA
Benzo(b)fluoranthene	0-20	39-120	0-20	45-119	0-20	NA
Benzo(ghi)perylene	0-20	37-121	0-20	38-115	0-20	NA
Benzo(k)fluoranthene	0-20	34-118	0-20	44-119	0-20	NA
Chrysene	0-20	37-119	0-20	54-118	0-20	NA
Dibenzo(a,h)anthracene	0-20	35-126	0-20	41-119	0-20	NA
Fluoranthene	0-20	43-118	0-20	49-119	0-20	NA
Fluorene	0-20	38-113	0-20	48-111	0-20	NA
Indeno(1,2,3-cd)pyrene	0-20	34-125	0-20	41-121	0-20	NA
Naphthalene	0-20	29-104	0-20	48-101	0-20	NA
Phenanthrene	0-20	49-112	0-20	52-115	0-20	NA
Pyrene	0-20	43-114	0-20	45-119	0-20	NA

Notes:
MS – Matrix Spike
MSD – Matrix Spike Duplicate
LCS – Laboratory Control Sample
LCSD – Laboratory Control Sample Duplicate
NA – Not applicable

UFP-QAPP Worksheet #12-6: Measurement Performance Criteria Table

Matrix: Soil

Analytical Group or Method: Pesticides/ 8081A

Concentration Level: Low/Medium

Data Quality Indicator (DQI)	QC sample or measurement performance activity	Frequency	Measurement Performance Criteria
Overall Precision; Representativeness	Field Duplicates	5% of total number of project samples	RPD ≤ 50%
Analytical Precision (laboratory)	Laboratory Control Sample Duplicates	One per preparation batch	RPD: 20%
Analytical Accuracy/Bias (laboratory)	Laboratory Control Samples	One per preparation batch	Recovery within limits specified in the DOD QSM
Analytical Accuracy/Bias (matrix interference)	Matrix Spike	One per preparation batch	Recovery within limits specified in the DOD QSM
Analytical Accuracy/Bias (matrix interference)	MatrixSpike Duplicates	One per preparation batch	RPD 30%
Sensitivity	LOQ verification sample (spiked at LOQ)	One per preparation batch	Recovery within established limits.
Completeness	Data Evaluation	Once when all analyses have been completed	95%

Notes:
RPD – relative percent difference
LOQ – limit of quantitation

DOD QSM – Department of Defense Quality Systems Manual (Department of Defense, 2021)

UFP-QAPP Worksheet #12-7: Measurement Performance Criteria Table

Matrix: Soil

Analytical Group or Method: PCBs/ 8082A

Concentration Level: Low/Medium

Data Quality Indicator (DQI)	QC sample or measurement performance activity	Frequency	Measurement Performance Criteria
Overall Precision; Representativeness	Field Duplicates	5% of total number of project samples	RPDs 30% when PCBs are detected in both samples
Analytical Precision (laboratory)	Laboratory Control Sample Duplicates	One per preparation batch	RPDs 30%
Analytical Accuracy/Bias (laboratory)	Laboratory Control Samples	One per preparation batch	1016: 48-109% 1260: 51-115%
Analytical Accuracy/Bias (matrix interference)	Matrix Spike Duplicates	One per preparation batch	1016: 25-130% 1260: 28-131%
Overall accuracy/bias (contamination)	Equipment Blanks	One per preparation batch	No target analyte concentrations 2: 1/2 LOQ
Sensitivity	LOQ verification sample (spiked at LOQ)	One per preparation batch	Recovery within ±25% of LOQ
Completeness	Data Evaluation	Once when all analyses have been completed	95%

Notes:
RPD – relative percent difference
LOQ – limit of quantitation

UFP-QAPP Worksheet #12-8: Measurement Performance Criteria Table

Matrix: Soil

Analytical Group or Method: Cyanide / 9012B (Total)

Concentration Level: Low/Medium

Data Quality Indicator (DQI)	QC sample or measurement performance activity	Frequency	Measurement Performance Criteria
Overall Precision; Representativeness	Field Duplicates	5% of total number of project samples	RPD ≤ 30%
Analytical Precision (laboratory)	Laboratory Control Sample Duplicates	One per preparation batch	RPD: 30%
Analytical Accuracy/Bias (laboratory)	Laboratory Control Samples	One per preparation batch	Recovery within 79%-102%
Analytical Accuracy/Bias (matrix interference)	Matrix Spike	One per preparation batch	Recovery within 57%-104%
Analytical Accuracy/Bias (matrix interference)	Matrix Spike Duplicates	One per preparation batch	RPD 30%
Completeness	Data Evaluation	Once when all analyses have been completed	95%

Notes:
RPD – relative percent difference
LOQ – limit of quantitation

UFP-QAPP Worksheet #12-9: Measurement Performance Criteria Table

Matrix: Soil

Analytical Group or Method: Hexavalent Chromium / 7196A (Total)

Concentration Level: Low/Medium

Data Quality Indicator (DQI)	QC sample or measurement performance activity	Frequency	Measurement Performance Criteria
Overall Precision	Duplicates	RPD: RPD </+ 50% for samples >5 times CRDL. +/- CRDL for samples </= 5 times CRDL.	Overall Precision
Analytical Precision (laboratory)	Laboratory Control Sample Duplicates	RPD: 15%	Analytical Precision (laboratory)
Analytical Accuracy/Bias (laboratory)	Laboratory Control Samples	Recovery within 80% - 120%	Analytical Accuracy/Bias (laboratory)
Analytical Accuracy/Bias (matrix interference)	Post Spike	Recovery within 75% - 125%	Analytical Accuracy/Bias (matrix interference)
Analytical Accuracy/Bias (matrix interference)	Post Spike Duplicates	RPD: 30%	Analytical Accuracy/Bias (matrix interference)
Completeness	Data Evaluation	Once when all analyses have been completed	95%

Notes:
RPD – relative percent difference
QC – quality control
CRDL – contract required detection limit

UFP-QAPP Worksheet #12-10: Measurement Performance Criteria Table

Matrix: Soil

Analytical Group or Method: ^{226}Ra, ^{214}Bi, ^{214}Pb, ^{94}Nb, ^{137}Cs - EPA 901.1 MOD

Concentration Level: Low/Medium

Data Quality Indicator (DQI)	QC sample or measurement performance activity	Frequency	Measurement Performance Criteria
Overall Precision; Representativeness	Field Duplicates	5% of total number of project samples	RPD ≤ 50%
Analytical Accuracy/Bias (laboratory)	Laboratory Control Samples	One per preparation batch	75 - 125% of pre-prepared sources.
Analytical Accuracy/Bias (matrix interference)	Sample Duplicate	One per preparation batch	20% RPD
Analytical accuracy/bias (laboratory contamination)	Method Blanks	One per preparation batch	Result < RL/MDA
Completeness	Data Evaluation	Once when all analyses have been completed	95%

Notes:
RPD – Relative Percent Difference
RL – Reporting Limit
MDA – minimum detectable activity

UFP-QAPP Worksheet #12-11: Measurement Performance Criteria Table

Matrix: Soil

Analytical Group or Method: ^{90}Sr - EPA 904.0M

Concentration Level: Low/Medium

Data Quality Indicator (DQI)	QC sample or measurement performance activity	Frequency	Measurement Performance Criteria
Overall Precision Representativeness	Field Duplicates	5% of total number of project samples	Results must be within a factor of 4
Analytical Precision (laboratory)	Laboratory Sample Duplicates	One per preparation batch	act<5*MDC, then RPD is 100% or less. If act>5*MDC, then RPD is 20% or less or RER</=3
Analytical Accuracy/Bias (laboratory)	Laboratory Control Samples	One per preparation batch	75-125%

Notes:
RPD – Relative Percent Difference
MDC – minimum detectable concentration
RER – relative error ratio

UFP-QAPP WORKSHEET #13

Secondary Data Uses and Limitations

Data Type	Source	Data Uses Relative to Current Project	Factors Affecting the Reliability of Data and Limitations on Data Use
Characterization Survey Data	North Wind, 2020. Final Characterization Report Area 2 of SWMU-11 Dugway Proving Ground, Dugway, Utah. February 2020.	The results were used to determine the nature and extent of residual radiological contamination for the trenches and to provide waste characterization information to establish a waste profile.	None

UFP-QAPP WORKSHEETS #14 AND #16
PROJECT TASKS AND SCHEDULE

This worksheet lists a summarized project schedule (a detailed critical path method schedule is provided as an attachment to the PMP (Cabrera, 2024a) and summarizes tasks and describes the procedures to be followed for activities to be performed in support of the soil removal activities at the site. The sampling design, strategy, and sequencing are further addressed in Worksheet #17.

Activity	Organization	Dates (MM/DD/YY)[1]		Deliverable	Deliverable Due Date
		Anticipated Dates of Initiation	Anticipated Dates of Completion		
Task 5.1.1 – Pre-Mobilization Survey	Cabrera	9/3/24	9/6/24	Baseline Air Monitoring Results, Baseline GWS, Baseline Topographical Survey	9/10/24
Task 5.1.2: Submittals/ Implementation Plans	Cabrera	11/30/23	8/23/24	PMP and Project Schedule, CQCP, UFP-QAPP/FSSP, APP/SSHP, RPP, SOP, FSS Data Packages	7/12/24 (for project plans) 5/29/25 (for FSS data packages)
5.2 Monitoring, Sampling, Testing, and Analysis	Cabrera (Sampling), GEL Laboratories (Analysis)	9/3/24	4/10/25	Backfill Sample Results, Waste Characterization Analysis	11/7/24 (Backfill Sample Analysis), 4/10/25 (Waste Characterization Analysis
5.3 Site Work	Cabrera	3/20/25	3/25/25	N/A	N/A
5.4 Contaminated Soil Removal	Cabrera	3/26/25	4/8/25	Waste Manifests, Civil Survey at Limits of Excavation	3/6/25 – 4/10/25
5.5 Transport and Disposal	Cabrera / Energy Solutions	3/26/25	4/3/25	Certificates of Disposal	5/3/25
5.6 Site Restoration	Cabrera	8/29/25	9/2/25	Post-Removal As-Built Survey	9/10/25
5.7 Demobilization	Cabrera	9/6/24	9/4/25	N/A	N/A
5.7.3 Submittals / Final Reports	Cabrera	9/3/25	3/27/26	Lessons Learned Report, Remedial Action Completion Report	3/27/26

UFP-QAPP	Uniform Federal Policy-Quality Assurance Project Plan
APP/SSHP/RPP	Accident Prevention Plan, Site Safety and Health Plan, Radiation Protection Plan (Cabrera 2023)
SOP	Site Operations Plan
CQCP	Contractor Quality Control Plan
PMP	Project Management Plan

Sequence of Work

Daily site operations will be under the day-to-day management of Cabrera's Project Manager and the Site Superintendent. Major scope activities, which are in addition to the mobilization, site preparation, and utility clearance activities, are identified as follows:

- Pre-Mobilization Survey
  - Perform baseline GWS
  - Perform baseline air monitoring
  - Collect borrow source material samples from on-site source
  - Perform baseline topographical survey

- Remedial Action

  — Coordinate site access through the USACE, AEC, and Dugway personnel.

  — Delineate the trench areas utilizing a global positioning unit. Once the areas of investigation has been delineated, and post all applicable radiological and safety signs.

  — Perform a GWS of the Layback Soil Stockpile Area and install geotextile, install diversion trenches and silt fence.

  — Excavate the layback soils and soil wastes and layback soils from the proposed excavation footprint. Excavated soils will be directly loaded into IMCs.

  — Perform an FSS of trench excavations and buffer area to support release for unrestricted use. FSS will include GWS and systematic soil sample collection.

  — Process GWS data and coordinates will be relayed to the field team to locate biased sample locations.

  — Prepare shipping papers for IMCs and transport the removed wastes to the EnergySolutions disposal facility.

  — Demobilize from the site, awaiting FSS sample results and approval from project stakeholders, including USACE, AEC, and NRC, to backfill excavation and restore site

  — Upon receiving approval, mobilize to the site, backfill with layback soils and borrow material that are approved for use to the excavation areas, and restore the site to its original grade/contours.

  — Perform "as left" surveys of soil stockpile area, outgoing material and equipment surveys, and demobilize from the site for the final time.

Sampling Tasks

Cabrera will collect soil samples from the survey areas within SWMU-11 Area 2 and will send them to GEL Laboratories to be analyzed in accordance with laboratory OPs. Sampling will be conducted in accordance with the applicable OPs. Cabrera OPs are provided in Attachment A.

Analysis Tasks

Samples for laboratory analysis will be sent to the offsite laboratory that will process, prepare, and analyze the samples. Worksheet #15 presents the target analytes, project action limits, and project quantitation limits.

Quality Control Tasks

Field QC samples will be collected in accordance with Worksheet #20.

Secondary Data

See Worksheet #13 for a synopsis of secondary data.

Data Management Tasks

The Site RSO is responsible for collecting, managing, performing quality checks on and processing data generated in the field, or delegating and overseeing these tasks. All field data will be stored and archived including, but not limited to: GWS data, sample analysis results, health physics surveys, and chain-of-custody records. All field data will be backed up daily on a secure independent storage device to ensure data integrity and availability. Some important data management tasks are summarized below.

GWS Results:

GWS results will be processed and evaluated as described in Cabrera OP-3606 (OP-388) *Gamma Walkover Survey – GIS Process*.

Laboratory Analytical Results

1. The offsite analytical sampling results will be reviewed by the Project Chemist and the Principal HP. The individual analyst constantly reviews the quality of data through calibration checks, QC sample results, and performance evaluation samples. The laboratory manager will review data for reasonableness and consistency with other generated data to determine whether program requirements have been satisfied before submitting the data report to Cabrera. The independent third-party data validation subcontractor performs validation of all the analytical data before it is used by Cabrera.

2. The laboratory shall generate a defensible data package equivalent to those components listed in the Department of Defense Quality Systems Manual Version 5.4 (2021). The data package will be in .pdf (Adobe) format (no hard copies). The electronic data deliverable will be formatted for Environmental Resources Program Information Management System and be in Microsoft Excel.

Documentation and Records

Field, laboratory, and cartographic data generated during this project will be archived on durable electronic media. Backup media containing databases and programs or software utilities will be maintained in a secure location. Cabrera will retain the relevant and appropriate project information in a master project file.

The field and laboratory data generated during the project will be summarized in the FSS Report. The report will present the findings of the radiation survey, and will summarize the results. The report will include a QA section that summarizes the QC sample results and the results of instrument QC checks.

Assessment/Audit Tasks

Worksheet #32 provides information regarding project specific assessment/audit task.

Data Review Tasks

See Data Management Tasks section above.

UFP-QAPP WORKSHEET #15
PROJECT ACTION LIMITS AND LABORATORY-SPECIFIC DETECTIONS/QUANTITATION LIMITS

The potential analyte groups, potentially applicable screening levels, reporting limits, and achievable laboratory detection limits for FSS samples to be collected from SWMU-11 Area 2 are presented in Table 15-1 – Reference Limits for Soil. This table details the potential analytical groups and concentration levels for each compound for which soil samples may be analyzed on the project.

Table 15.1 – Reference Limits for FSS Samples

Analyte	CAS Number	Project Action[(1)] Limit (applicable units)	Project Quantitation Limit (applicable units)	Laboratory-Specific		
				LOQs (ug/L)*	LODs (ug/L)	MDCs (pCi/g)
^{226}Ra [(2)]	13982-63-3	7.4 pCi/g	1.0 pCi/g	N/A	N/A	0.5 pCi/g
^{137}Cs	10045-97-3	33 pCi/g	1.0 pCi/g	N/A	N/A	0.5 pCi/g
^{90}Sr	10098-97-2	47 pCi/g	5.0 pCi/g	N/A	N/A	2.0 pCi/g
^{94}Nb	14681-63-1	12 pCi/g	1.0 pCi/g	N/A	N/A	0.5 pCi/g
^{214}Bi[(2)]	14733-03-0	7.4 pCi/g	1.0 pCi/g	N/A	N/A	0.5 pCi/g
^{214}Pb[(2)]	15067-28-4	7.4 pCi/g	1.0 pCi/g	N/A	N/A	0.5 pCi/g

NOTES:

(1) The project action limits (Derived Concentration Guideline Level [$DCGL_W$]) for soil collected during FSS were obtained from Table 5 of the Characterization Survey Report (North Wind 2020). These are the lowest (most conservative) DCGLw values for the TR-5 Trench using the Resident Farmer scenario. These values include background concentrations.

(2) These radionuclides will be determined via gamma spec with ingrowth and the ^{214}Bi result will be reported as ^{226}Ra assuming on secular equilibrium.

pCi/g = picoCuries per gram.

SAP Worksheet #15.2: Reference Limits & Evaluation Table—Site Contaminants (Solids – VOC Analytes)

Chemical	CAS Number	Trigger Level	TCLP Limit	Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
		mg/kg	mg/L	LOQ (ug/kg)	LOD (ug/kg)	MDL (ug/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)
1,1,1,2-Tetrachloroethane	630-20-6	NA	NA	1	0.666	0.333	10	6.66	3.33
1,1,1-Trichloroethane	71-55-6	NA	NA	1	0.666	0.333	10	6.66	3.33
1,1,2,2-Tetrachloroethane	79-34-5	NA	NA	1	0.666	0.333	10	6.66	3.33
1,1,2-Trichloroethane	79-00-5	NA	NA	1	0.666	0.333	10	6.66	3.33
1,1-Dichloroethane	75-34-3	NA	NA	1	0.666	0.333	10	6.66	3.33
1,1-Dichloroethylene	75-35-4	14.0	0.7	1	0.666	0.333	10	6.66	3.33
1,1-Dichloropropene	563-58-6	NA	NA	1	0.666	0.333	10	6.66	3.33
1,2,3-Trichlorobenzene	87-61-6	NA	NA	1	0.666	0.333	10	6.66	3.33
1,2,3-Trichloropropane	96-18-4	NA	NA	1	0.666	0.333	10	6.66	3.33
1,2,4-Trichlorobenzene	120-82-1	NA	NA	1	0.666	0.333	10	6.66	3.33
1,2,4-Trimethylbenzene	95-63-6	NA	NA	1	0.666	0.333	10	6.66	3.33
1,2-Dibromo-3-chloropropane	96-12-8	NA	NA	2	1	0.5	10	6.66	3.33
1,2-Dibromoethane	106-93-4	NA	NA	1	0.666	0.333	10	6.66	3.33
1,2-Dichlorobenzene	95-50-1	NA	NA	1	0.666	0.333	10	6.66	3.33
1,2-Dichloroethane	107-06-2	10.0	0.5	1	0.666	0.333	10	6.66	3.33
1,2-Dichloroethylene (total)	540-59-0	NA	NA	2	0.666	0.333	20	13.34	6.67
1,2-Dichloropropane	78-87-5	NA	NA	1	0.666	0.333	10	6.66	3.33
1,3,5-Trimethylbenzene	108-67-8	NA	NA	1	0.666	0.333	20	13.34	6.67
1,3-Dichlorobenzene	541-73-1	NA	NA	1	0.666	0.333	10	6.66	3.33

SAP Worksheet #15.2: Reference Limits & Evaluation Table—Site Contaminants (Solids – VOC Analytes)

Chemical	CAS Number	Trigger Level	TCLP Limit	Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
		mg/kg	mg/L	LOQ (ug/kg)	LOD (ug/kg)	MDL (ug/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)
1,3-Dichloropropane	142-28-9	NA	NA	1	0.666	0.333	10	6.66	3.33
1,3-Dichloropropylene	542-75-6	NA	NA	2	0.666	0.333	20	13.34	6.67
1,4-Dichlorobenzene	106-46-7	150	7.5	1	0.666	0.333	10	6.66	3.33
1,4-Dioxane	123-91-1	NA	NA	50	33.334	16.667	500	333.34	166.67
1-Chlorohexane	544-10-5	NA	NA	1	0.666	0.333	10	6.66	3.33
2,2-Dichloropropane	594-20-7	NA	NA	1	0.666	0.333	10	6.66	3.33
2-Butanone	78-93-3	NA	NA	5	3.334	1.667	50	33.34	16.67
2-Chloro-1,1,1-trifluoroethane	75-88-7	NA	NA	10	6.666	3.333	NA	NA	NA
2-Chloro-1,3-butadiene	126-99-8	NA	NA	1	0.666	0.333	10	6.66	3.33
2-Chloroethylvinyl ether	110-75-8	NA	NA	5	3.334	1.667	50	33.34	16.67
2-Chlorotoluene	95-49-8	NA	NA	1	0.666	0.333	10	6.66	3.33
2-Hexanone	591-78-6	NA	NA	5	3.334	1.667	50	33.34	16.67
2-Nitropropane	79-46-9	NA	NA	5	3.334	1.667	50	33.34	16.67
2-Pentanone	107-87-9	NA	NA	10	6.666	3.333	100	66.66	33.33
4-Chlorotoluene	106-43-4	NA	NA	1	0.666	0.333	10	6.66	3.33
4-Isopropyltoluene	99-87-6	NA	NA	1	0.666	0.333	10	6.66	3.33
4-Methyl-2-pentanone	108-10-1	NA	NA	5	3.334	1.667	50	33.34	16.67
Acetone	67-64-1	NA	NA	5	3.334	1.667	50	34.88	17.44
Acetonitrile	75-05-8	NA	NA	25	16.666	8.333	250	166.66	83.33

SAP Worksheet #15.2: Reference Limits & Evaluation Table—Site Contaminants (Solids – VOC Analytes)

Chemical	CAS Number	Trigger Level	TCLP Limit	Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
		mg/kg	mg/L	LOQ (ug/kg)	LOD (ug/kg)	MDL (ug/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)
Acrolein	107-02-8	NA	NA	5	3.334	1.667	50	33.34	16.67
Acrylonitrile	107-13-1	NA	NA	5	3.334	1.667	50	33.34	16.67
Allyl chloride	107-05-1	NA	NA	5	3.334	1.667	50	33.34	16.67
Benzene	71-43-2	10	0.5	1	0.666	0.333	10	6.66	3.33
Benzyl chloride	100-44-7	NA	NA	5	3.334	1.667	50	33.34	16.67
Bromobenzene	108-86-1	NA	NA	1	0.666	0.333	10	6.66	3.33
Bromochloromethane	74-97-5	NA	NA	1	0.666	0.333	10	6.66	3.33
Bromodichloromethane	75-27-4	NA	NA	1	0.666	0.333	10	6.66	3.33
Bromoform	75-25-2	NA	NA	1	0.666	0.333	10	6.66	3.33
Bromomethane	74-83-9	NA	NA	1	0.666	0.333	10	6.74	3.37
Carbon disulfide	75-15-0	NA	NA	5	3.334	1.667	50	33.34	16.67
Carbon tetrachloride	56-23-5	10	0.5	1	0.666	0.333	10	6.66	3.33
Chlorobenzene	108-90-7	2,000	100.0	1	0.666	0.333	10	6.66	3.33
Chloroethane	75-00-3	NA	NA	1	0.666	0.333	10	6.66	3.33
Chloroform	67-66-3	120	6.0	1	0.666	0.333	10	6.66	3.33
Chloromethane	74-87-3	NA	NA	1	0.666	0.333	10	6.66	3.33
Chlorotrifluoroethylene	79-38-9	NA	NA	10	6.666	3.333	NA	NA	NA
Cyclohexane	110-82-7	NA	NA	1	0.666	0.333	10	6.66	3.33
Cyclohexanone	108-94-1	NA	NA	50	33.334	16.667	500	333.34	166.67

SAP Worksheet #15.2: Reference Limits & Evaluation Table—Site Contaminants (Solids – VOC Analytes)

Chemical	CAS Number	Trigger Level	TCLP Limit	Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
		mg/kg	mg/L	LOQ (ug/kg)	LOD (ug/kg)	MDL (ug/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)
Cyclohexene	110-83-8	NA	NA	1	0.666	0.333	10	6.66	3.33
Dibromochloromethane	124-48-1	NA	NA	1	0.666	0.333	10	6.66	3.33
Dibromomethane	74-95-3	NA	NA	1	0.666	0.333	10	6.66	3.33
Dichlorodifluoromethane	75-71-8	NA	NA	1	0.666	0.333	10	7.1	3.55
Ethyl acetate	141-78-6	NA	NA	5	3.334	1.667	50	33.34	16.67
Ethyl ether	60-29-7	NA	NA	1	0.666	0.333	10	6.66	3.33
Ethyl methacrylate	97-63-2	NA	NA	5	3.334	1.667	50	33.34	16.67
Ethyl tert-butyl ether	637-92-3	NA	NA	2	1.334	0.667	10	6.66	3.33
Ethylbenzene	100-41-4	NA	NA	1	0.666	0.333	10	6.66	3.33
Hexachlorobutadiene	87-68-3	10	0.5	1	0.666	0.333	10	6.66	3.33
Hexane	110-54-3	NA	NA	5	3.334	1.667	50	35.38	17.69
Iodomethane	74-88-4	NA	NA	5	3.334	1.667	50	33.34	16.67
Isobutyl alcohol	78-83-1	NA	NA	50	33.334	16.667	500	333.34	166.67
Isopropyl Alcohol	67-63-0	NA	NA	50	33.334	16.667	500	333.34	166.67
Isopropyl ether	108-20-3	NA	NA	2	1.334	0.667	10	6.66	3.33
Isopropylbenzene	98-82-8	NA	NA	1	0.666	0.333	10	6.66	3.33
Methacrylonitrile	126-98-7	NA	NA	5	3.334	1.667	50	33.34	16.67
Methyl acetate	79-20-9	NA	NA	5	3.334	1.667	50	33.34	16.67
Methyl methacrylate	80-62-6	NA	NA	5	3.334	1.667	50	33.34	16.67

SAP Worksheet #15.2: Reference Limits & Evaluation Table—Site Contaminants (Solids – VOC Analytes)

Chemical	CAS Number	Trigger Level	TCLP Limit	Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
		mg/kg	mg/L	LOQ (ug/kg)	LOD (ug/kg)	MDL (ug/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)
Methyl tert-amyl ether	994-05-8	NA	NA	2	1.334	0.667	10	6.66	3.33
Methylcyclohexane	108-87-2	NA	NA	1	0.666	0.333	10	6.66	3.33
Methylene chloride	75-09-2	NA	NA	5	3.334	1.667	50	33.34	16.67
Naphthalene	91-20-3	NA	NA	1	0.666	0.333	10	6.66	3.33
Pentachloroethane	76-01-7	NA	NA	5	3.334	1.667	50	33.34	16.67
Propionitrile	107-12-0	NA	NA	5	3.334	1.667	50	33.34	16.67
Styrene	100-42-5	NA	NA	1	0.666	0.333	10	6.66	3.33
Tetrachloroethylene	127-18-4	14	0.7	1	0.666	0.333	10	6.66	3.33
Tetrahydrofuran	109-99-9	NA	NA	5	3.334	1.667	50	33.34	16.67
Toluene	108-88-3	NA	NA	1	0.666	0.333	10	6.66	3.33
Trichloroethylene	79-01-6	10	0.5	1	0.666	0.333	10	6.66	3.33
Trichlorofluoromethane	75-69-4	NA	NA	1	0.666	0.333	10	6.66	3.33
Trichlorotrifluoroethane	76-13-1	NA	NA	5	3.334	1.667	100	59.56	29.78
Vinyl acetate	108-05-4	NA	NA	5	3.334	1.667	50	33.34	16.67
Vinyl chloride	75-01-4	4	0.2	1	0.666	0.333	10	6.66	3.33
Xylenes (total)	1330-20-7	NA	NA	3	2	1	30	20	10
bis(2-Chloro-1-	108-60-1	NA	NA	5	3.334	1.667	50	33.34	16.67
cis-1,2-Dichloroethylene	156-59-2	NA	NA	1	0.666	0.333	10	6.66	3.33
cis-1,3-Dichloropropylene	10061-01-5	NA	NA	1	0.666	0.333	10	6.66	3.33

SAP Worksheet #15.2: Reference Limits & Evaluation Table—Site Contaminants (Solids – VOC Analytes)

Chemical	CAS Number	Trigger Level	TCLP Limit	Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
		mg/kg	mg/L	LOQ (ug/kg)	LOD (ug/kg)	MDL (ug/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)
cis-1,4-Dichloro-2-butene	1476-11-5	NA	NA	5	3.334	1.667	50	33.34	16.67
m,p-Xylenes	179601-23-1	NA	NA	2	1.334	0.667	20	13.34	6.67
n-Butyl alcohol	71-36-3	NA	NA	50	33.334	16.667	500	422.62	211.31
n-Butylbenzene	104-51-8	NA	NA	1	0.666	0.333	10	6.66	3.33
n-Propylbenzene	103-65-1	NA	NA	1	0.666	0.333	10	6.66	3.33
o-Xylene	95-47-6	NA	NA	1	0.666	0.333	10	6.66	3.33
sec-Butylbenzene	135-98-8	NA	NA	1	0.666	0.333	10	6.66	3.33
tert-Butyl Alcohol	75-65-0	NA	NA	50	33.334	16.667	500	333.34	166.67
tert-Butyl methyl ether	1634-04-4	NA	NA	1	0.666	0.333	10	6.66	3.33
tert-Butylbenzene	98-06-6	NA	NA	1	0.666	0.333	10	6.66	3.33
trans-1,2-Dichloroethylene	156-60-5	NA	NA	1	0.666	0.333	10	6.66	3.33
trans-1,3-Dichloropropylene	10061-02-6	NA	NA	1	0.666	0.333	10	6.66	3.33
trans-1,4-Dichloro-2-butene	110-57-6	NA	NA	5	3.334	1.667	50	33.34	16.67

Notes: 1) If the trigger level for total VOCs analysis is exceeded (greater than a non-detect) then the TCLP analysis must also be conducted.
TCLP – Toxicity Characteristic Leaching Procedure
mg/L – milligrams per liter
mg/kg – milligrams per kilogram
LOQ – limit of quantitation
LOD – limit of detection
MDL – minimum detection limit
µg /kg – micrograms per kilogram
µg /L – micrograms per liter

SAP Worksheet #15.3: Reference Limits & Evaluation Table—Site Contaminants (Solids – SVOC Analytes)

Chemical	CAS Number	Trigger Level [1]	TCLP Limit	Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
		mg/kg	mg/L	LOQ (ug/kg)	LOD (ug/kg)	MDL (ug/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)
1-Methylnaphthalene	90-12-0	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
2-Chloronaphthalene	91-58-7	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
2-Methylnaphthalene	91-57-6	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Acenaphthene	83-32-9	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Acenaphthylene	208-96-8	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Anthracene	120-12-7	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Benzo(a)anthracene	56-55-3	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Benzo(a)pyrene	50-32-8	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Benzo(b)fluoranthene	205-99-2	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Benzo(ghi)perylene	191-24-2	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Benzo(k)fluoranthene	207-08-9	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Chrysene	218-01-9	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Dibenzo(a,h)anthracene	53-70-3	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Fluoranthene	206-44-0	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Fluorene	86-73-7	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Indeno(1,2,3-cd)pyrene	193-39-5	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Naphthalene	91-20-3	NA	NA	3.33	1.998	0.999	0.1	0.06	0.03
Phenanthrene	85-01-8	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03
Pyrene	129-00-0	NA	NA	6.66	3.33	1.665	0.1	0.06	0.03

Notes: 1) If the trigger level for total SVOCs analysis is exceeded (greater than a non-detect) then the TCLP analysis must also be conducted.

TCLP – Toxicity Characteristic Leaching Procedure
mg/L – milligrams per liter
mg/kg – milligrams per kilogram
LOQ – limit of quantitation
LOD – limit of detection
MDL – minimum detection limit
µg /kg – micrograms per kilogram
µg /L – micrograms per liter

SAP Worksheet #15.4: Reference Limits & Evaluation Table—Site Contaminants (Solids – Metals Analytes)

Analytical Group: ICP Metals

Analytical Method: SW846 6010C or 6010D

Chemical	CAS Number	Trigger Level for Total (mg/kg)	TCLP Limit mg/L	Laboratory Specific			Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
				LOQ (mg/kg)	LOD (mg/kg)	MDL (mg/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)	LOQ (mg/L)	LOD (mg/L)	MDL (mg/L)
Aluminum	7429-90-5	NA	NA	20	13.6	6.8	200	136	68	2	1.36	0.68
Antimony	7440-36-0	NA	NA	2	0.66	0.33	20	7	3.5	0.2	0.07	0.035
Arsenic	7440-38-2	100	5.0	3	1	0.5	30	10	5	0.3	0.1	0.05
Barium	7440-39-3	2,000	100	0.5	0.2	0.1	5	2	1	0.05	0.02	0.01
Beryllium	7440-41-7	15	NA	0.5	0.2	0.1	5	2	1	0.05	0.02	0.01
Boron	7440-42-8	NA	NA	5	2	1	50	30	15	0.5	0.3	0.15
Cadmium	7440-43-9	20	1.0	0.5	0.2	0.1	5	2	1	0.05	0.02	0.01
Calcium	7440-70-2	NA	NA	25	16	8	200	100	50	2	1	0.5
Chromium	7440-47-3	50	5.0	1	0.3	0.15	10	2	1	0.1	0.02	0.01
Cobalt	7440-48-4	1,600	NA	0.5	0.3	0.15	5	2	1	0.05	0.02	0.01
Copper	7440-50-8	500	NA	2	0.6	0.3	20	6	3	0.2	0.06	0.03
Iron	7439-89-6	NA	NA	25	16	8	100	60	30	1	0.6	0.3
Lead	7439-92-1	100	5.0	2	0.66	0.33	20	6.6	3.3	0.2	0.066	0.033
Magnesium	7439-95-4	NA	NA	30	17	8.5	300	220	110	3	2.2	1.1
Manganese	7439-96-5	NA	NA	1	0.4	0.2	10	4	2	0.1	0.04	0.02
Molybdenum	7439-98-7	7,000	NA	1	0.4	0.2	10	4	2	0.1	0.04	0.02
Nickel	7440-02-0	400	NA	0.5	0.3	0.15	5	3	1.5	0.05	0.03	0.015
Phosphorous	7723-14-0	NA	NA	15	10	5	150	120	60	1.5	1.2	0.6
Potassium	7440-09-7	NA	NA	25	12.8	6.4	150	100	50	1.5	1	0.5
Selenium	7782-49-2	20	1.0	3	1	0.5	30	12	6	0.3	0.12	0.06
Silica	7631-86-9	NA	NA	21.4	6.417	3.2085	213	106	53	2.13	1.06	0.53
Silicon	7440-21-3	NA	NA	10	3	1.5	100	50	25	1	0.5	0.25

SAP Worksheet #15.4: Reference Limits & Evaluation Table—Site Contaminants (Solids – Metals Analytes)

Analytical Group: ICP Metals

Analytical Method: SW846 6010C or 6010D

Chemical	CAS Number	Trigger Level for Total (mg/kg)	TCLP Limit mg/L	Laboratory Specific			Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
				LOQ (mg/kg)	LOD (mg/kg)	MDL (mg/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)	LOQ (mg/L)	LOD (mg/L)	MDL (mg/L)
Silver	7440-22-4	100	5.0	0.5	0.2	0.1	5	2	1	0.05	0.02	0.01
Sodium	7440-23-5	NA	NA	25	14	7	300	200	100	3	2	1
Strontium	7440-24-6	NA	NA	0.5	0.2	0.1	5	2	1	0.05	0.02	0.01
Sulfur	7704-34-9	NA	NA	10	5	2.5	50	24	12	0.5	0.24	0.12
Thallium	7440-28-0	140	NA	2	1	0.5	20	10	5	0.2	0.1	0.05
Tin	7440-31-5	NA	NA	1	0.6	0.3	10	5	2.5	0.1	0.05	0.025
Titanium	7440-32-6	NA	NA	0.5	0.2	0.1	5	2	1	0.05	0.02	0.01
Uranium	7440-61-1	NA	NA	5	2	1	50	20	10	0.5	0.2	0.1
Vanadium	7440-62-2	480	NA	0.5	0.2	0.1	5	2	1	0.05	0.02	0.01
Zinc	7440-66-6	5,000	NA	2	0.8	0.4	20	6.6	3.3	0.2	0.066	0.033

Notes: 1. If the trigger level for total metals analysis is exceeded and greater than a non-detection result then the TCLP analysis must also be conducted.

TCLP – Toxicity Characteristic Leaching Procedure
mg/L – milligrams per liter
mg/kg – milligrams per kilogram
LOQ – limit of quantitation
LOD – limit of detection
MDL – minimum detection limit
µg /kg – micrograms per kilogram
µg /L – micrograms per liter

SAP Worksheet #15.5: Reference Limits & Evaluation Table—Site Contaminants (Solids – Mercury)

Analytical Group: Mercury

Analytical Method: SW846 7471B, 7470A

Chemical	CAS Number	Trigger Level for Total (mg/kg)	TCLP Limit mg/L	Laboratory Specific			Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
				LOQ (mg/kg)	LOD (mg/kg)	MDL (mg/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)	LOQ (mg/L)	LOD (mg/L)	MDL (mg/L)
Mercury	7439-97-6	4.0	0.2	24	16.08	8.04	0.2	0.134	0.067	0.002	0.00134	0.00067

Notes: 1. If the trigger level for total mercury analysis is exceeded and greater than a non-detection result then the TCLP analysis must also be conducted.

TCLP – Toxicity Characteristic Leaching Procedure
mg/L – milligrams per liter
mg/kg – milligrams per kilogram
LOQ – limit of quantitation
LOD – limit of detection
MDL – minimum detection limit
µg /kg – micrograms per kilogram
µg /L – micrograms per liter

SAP Worksheet #15.6: Reference Limits & Evaluation Table—Site Contaminants (Solids – Mercury)

Analytical Group: Hexavalent Chromium

Analytical Method: 7196 GL-GC-E-132

Chemical	CAS Number	Trigger Level for Total (mg/kg)	TCLP Limit mg/L	Laboratory Specific			Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
				LOQ (mg/kg)	LOD (mg/kg)	MDL (mg/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)	LOQ (mg/L)	LOD (mg/L)	MDL (mg/L)
Hexavalent Chromium	NA	100	NA	0.4 mg/kg	NA	0.13 mg/kg	N/A	N/A	N/A	0.01 mg/L	NA	0.0033 mg/L

Notes: 1. If the trigger level for total hexavalent chromium analysis is exceeded and greater than a non-detection result then the TCLP analysis must also be conducted.

TCLP – Toxicity Characteristic Leaching Procedure
mg/L – milligrams per liter
mg/kg – milligrams per kilogram
LOQ – limit of quantitation
LOD – limit of detection
MDL – minimum detection limit
µg /kg – micrograms per kilogram
µg /L – micrograms per liter

SAP Worksheet #15.7: Reference Limits & Evaluation Table—Site Contaminants (Solids – PCBs)

Analytical Group: PCBs

Analytical Method: SW846 8082A

Chemical	CAS Number	Trigger Level for Total (mg/kg)	TCLP Limit mg/L	Laboratory Specific			Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
				LOQ (mg/kg)	LOD (mg/kg)	MDL (mg/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)	LOQ (mg/L)	LOD (mg/L)	MDL (mg/L)
Aroclor-1016	12674-11-2	50	NA	3.3	2.1978	1.0989	0.1	0.0666	0.0333	3.3	2.1978	1.0989
Aroclor-1221	11104-28-2	50	NA	3.3	2.1978	1.0989	0.1	0.0666	0.0333	3.3	2.1978	1.0989
Aroclor-1232	11141-16-5	50	NA	3.3	2.1978	1.0989	0.1	0.0666	0.0333	3.3	2.1978	1.0989
Aroclor-1242	53469-21-9	50	NA	3.3	2.1978	1.0989	0.1	0.0666	0.0333	3.3	2.1978	1.0989
Aroclor-1248	12672-29-6	50	NA	3.3	2.1978	1.0989	0.1	0.0666	0.0333	3.3	2.1978	1.0989
Aroclor-1254	11097-69-1	50	NA	3.3	2.1978	1.0989	0.1	0.0666	0.0333	3.3	2.1978	1.0989
Aroclor-1260	11096-82-5	50	NA	3.3	2.1978	1.0989	0.1	0.0666	0.0333	3.3	2.1978	1.0989
Aroclor-1262	37324-23-5	50	NA	3.3	2.1978	1.0989	0.1	0.0666	0.0333	3.3	2.1978	1.0989
Aroclor-1268	11100-14-4	50	NA	3.3	2.1978	1.0989	0.1	0.0666	0.0333	3.3	2.1978	1.0989
Aroclor-Total	PCBTOT	50	NA	3.33	2.21778	1.10889	0.1	0.0666	0.0333	3.33	2.21778	1.10889

Notes: 1. If the trigger level for total PCBs analysis is exceeded and greater than a non-detection result then the TCLP analysis must also be conducted.

TCLP – Toxicity Characteristic Leaching Procedure
mg/L – milligrams per liter
mg/kg – milligrams per kilogram
LOQ – limit of quantitation
LOD – limit of detection
MDL – minimum detection limit
µg /kg – micrograms per kilogram
µg /L – micrograms per liter

SAP Worksheet #15.8: Reference Limits & Evaluation Table—Site Contaminants (Solids – Pesticides Analytes)

Analytical Group: Pesticides

Analytical Method: SW846 8081A

Chemical	CAS Number	Trigger Level for Total (mg/kg)	TCLP Limit mg/L	Laboratory Specific			Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
				LOQ (mg/kg)	LOD (mg/kg)	MDL (mg/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)	LOQ (mg/L)	LOD (mg/L)	MDL (mg/L)
2,4-DDD	53-19-0	1.0	0.1	0.668	0.334	0.167	0.02	0.01	0.005	0.2	0.1	0.05
2,4-DDE	3424-82-6	1.0	0.1	0.668	0.334	0.167	0.02	0.012	0.006	0.2	0.12	0.06
2,4-DDT	789-02-6	1.0	0.1	0.668	0.334	0.167	0.02	0.01	0.005	0.2	0.1	0.05
4,4'-DDD	72-54-8	1.0	0.1	1.336	0.668	0.334	0.04	0.02	0.01	0.4	0.2	0.1
4,4'-DDE	72-55-9	1.0	0.1	1.336	0.668	0.334	0.04	0.02	0.01	0.4	0.2	0.1
4,4'-DDT	50-29-3	1.0	0.1	1.336	0.668	0.334	0.04	0.02	0.01	0.4	0.2	0.1
4cmx	877-09-8	NA	NA	0.264	0.132	0.066	0.04	0.02	0.01	0.4	0.2	0.1
Aldrin	309-00-2	1.4	NA	0.668	0.334	0.167	0.02	0.0133	0.00665	0.2	0.133	0.0665
Chlordane	57-74-9	2.5	0.03	8.35	3.34	1.67	0.25	0.153	0.0765	2.5	1.53	0.765
Decachlorobiphenyl	2051-24-3	NA	NA	0.264	0.132	0.066	0.04	0.02	0.01	0.4	0.2	0.1
Dieldrin	60-57-1	8.0	NA	1.336	0.668	0.334	0.04	0.02	0.01	0.4	0.2	0.1
Endosulfan I	959-98-8	NA	NA	0.668	0.334	0.167	0.02	0.0133	0.00665	0.2	0.133	0.0665
Endosulfan II	33213-65-9	NA	NA	1.336	0.668	0.334	0.04	0.02	0.01	0.4	0.2	0.1
Endosulfan sulfate	1031-07-8	NA	NA	1.336	0.668	0.334	0.04	0.02	0.01	0.4	0.2	0.1
Endrin	72-20-8	0.2	0.02	1.336	0.668	0.334	0.04	0.02	0.01	0.4	0.2	0.1
Endrin aldehyde	7421-93-4	NA	NA	1.336	0.668	0.334	0.04	0.0133	0.00665	0.4	0.133	0.0665
Endrin ketone	53494-70-5	NA	NA	1.336	0.668	0.334	0.04	0.02	0.01	0.4	0.2	0.1
Heptachlor	76-44-8	4.7	0.008	0.668	0.334	0.167	0.02	0.0133	0.00665	0.2	0.133	0.0665
Heptachlor epoxide	1024-57-3	4.7	0.008	0.668	0.334	0.167	0.02	0.0133	0.00665	0.2	0.133	0.0665
Hexachlorobenzene	118-74-1	2.6	0.13	0.668	0.668	0.334	0.02	0.0125	0.00625	0.2	0.125	0.0625
Methoxychlor	72-43-5	NA	NA	6.68	3.34	1.67	0.2	0.1	0.05	2	1	0.5

SAP Worksheet #15.8: Reference Limits & Evaluation Table—Site Contaminants (Solids – Pesticides Analytes)

Analytical Group: Pesticides

Analytical Method: SW846 8081A

Chemical	CAS Number	Trigger Level for Total (mg/kg)	TCLP Limit mg/L	Laboratory Specific			Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
				LOQ (mg/kg)	LOD (mg/kg)	MDL (mg/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)	LOQ (mg/L)	LOD (mg/L)	MDL (mg/L)
Mirex	2385-85-5	21	NA	0.668	0.334	0.167	0.02	0.0133	0.00665	0.2	0.133	0.0665
O-Chlordane	27304-13-8	NA	NA	0.668	0.334	0.167	0.02	0.01	0.005	0.2	0.1	0.05
Toxaphene	8001-35-2	5.0	0.5	16.7	11.1222	5.5611	0.5	0.3	0.15	5	3	1.5
alpha-BHC	319-84-6	NA	NA	0.668	0.334	0.167	0.02	0.0133	0.00665	0.2	0.133	0.0665
beta-BHC	319-85-7	NA	NA	0.668	0.334	0.167	0.02	0.0133	0.00665	0.2	0.133	0.0665
cis-Chlordane	5103-71-9	NA	NA	0.668	0.334	0.167	0.02	0.0133	0.00665	0.2	0.133	0.0665
cis-Nonachlor	5703-73-1	NA	NA	0.668	0.334	0.167	0.02	0.0102	0.0051	0.2	0.102	0.051
delta-BHC	319-86-8	NA	NA	0.668	0.334	0.167	0.02	0.0133	0.00665	0.2	0.133	0.0665
gamma-BHC (Lindane)	58-89-9	NA	NA	0.668	0.334	0.167	0.02	0.0133	0.00665	0.2	0.133	0.0665
trans-Chlordane	5103-74-2	NA	NA	0.668	0.334	0.167	0.02	0.0133	0.00665	0.2	0.133	0.0665
trans-Nonachlor	39765-80-5	NA	NA	0.668	0.334	0.167	0.02	0.01	0.005	0.2	0.1	0.05

Notes: 1. If the trigger level for total pesticides analysis is exceeded and greater than a non-detection result then the TCLP analysis must also be conducted.

TCLP – Toxicity Characteristic Leaching Procedure
mg/L – milligrams per liter
mg/kg – milligrams per kilogram
LOQ – limit of quantitation
LOD – limit of detection
MDL – minimum detection limit
µg /kg – micrograms per kilogram
µg /L – micrograms per liter

SAP Worksheet #15.9: Reference Limits & Evaluation Table—Site Contaminants (Solids – Cyanide)

Analytical Group: Hexavalent Chromium

Analytical Method: 7196 GL-GC-E-132

Chemical	CAS Number	Trigger Level for Total (mg/kg)	TCLP Limit mg/L	Laboratory Specific			Laboratory Specific			TCLP Laboratory Specific (Df = 10)		
				LOQ (mg/kg)	LOD (mg/kg)	MDL (mg/kg)	LOQ (ug/L)	LOD (ug/L)	MDL (ug/L)	LOQ (mg/L)	LOD (mg/L)	MDL (mg/L)
Cyanide	NA	250	NA	0.25 mg/kg	0.167 mg/kg	0.085 mg/kg	N/A	N/A	N/A	0.005 mg/L	0.0033 mg/L	0.0017 mg/L

Notes: 1. If the trigger level for total hexavalent chromium analysis is exceeded and greater than a non-detection result then the TCLP analysis must also be conducted.

TCLP – Toxicity Characteristic Leaching Procedure
mg/L – milligrams per liter
mg/kg – milligrams per kilogram
LOQ – limit of quantitation
LOD – limit of detection
MDL – minimum detection limit
µg /kg – micrograms per kilogram
µg /L – micrograms per liter

UFP-QAPP WORKSHEET #17
SAMPLE DESIGN AND RATIONALE

This Worksheet provides the FSS design as well as the design and rationale for other sampling (i.e., waste characterization, backfill).

Survey Instrumentation and Techniques

This section describes the GWS, and volumetric sample collection and analysis instruments and methodology that will be used during the FSS of Area 2 at SWMU-11. Specific survey and sampling requirements including percent coverage and types of surveys, numbers and types of samples, and analytical tests to be performed are discussed in the following sections. More detailed descriptions related to design of the SUs are presented in Section 5.0. Minimum detectable concentrations (MDCs) and minimum detectable count rates (MDCRs) required for the GWSs are calculated in accordance with MARSSIM and NUREG-1507.

Gamma Walkover Surveys

GWSs will be performed in accordance with Cabrera OP-001, Radiological Surveys. Surveys will be performed to measure surface radioactivity on the grounds. Equipment required for performing the GWS survey includes the following:

- Trimble Pathfinder Pro XRS/XH GPS (or equivalent)
- Three inch by three inch sodium iodide (3x3 NaI, Ludlum Model 44-20. or equivalent) coupled to a Ludlum Model 2221 ratemeter (or equivalent)
- Field Instrument for the Detection of Low Energy Radiation (FIDLER, or equivalent) as specified in the ROD (AEC, 2021) coupled to a Ludlum 2221 ratemeter (or equivalent)

The survey will be performed following MARSSIM protocol by moving the detector in straight parallel lines at a speed not to exceed 0.5 meters per second over an area with the detector kept a fixed distance from the surface being surveyed (≤ 4 inches). Survey passes will be approximately 0.5 meters apart. Data from the rate meter/scaler will be automatically logged into the GPS unit every second. This system will log the gross gamma reading and position (in State Plane Coordinates) every second. After completion of the survey, the raw data will be downloaded from the GPS and transmitted to a data processing specialist for export into a geospatial software program.

Evaluation of the GWS data includes geospatial imaging for visual trend analysis and comparison of count rates to investigation levels for identification of distribution outliers. Investigation levels will be equal to three sigma (standard deviations) above the mean GWS count rates for the surface and trench soils data sets.

The GWS results will be processed and organized and then reviewed by the Principal Health Physicist. The review will combine observation of individual data points that exceed the investigation levels with any identifiable spatial patterns or trends that might indicate areas of relatively elevated activity, particularly those that correspond to the areas where historical data indicated contamination within the particular excavation unit.

Section 5.5.3 in MARSSIM discusses the recommended scanning survey coverage for land areas. The objective of a scanning survey is to identify locations within the SU that exceed the cleanup level. These areas of elevated readings are marked for additional investigation. For Class 1 areas, scanning surveys are designed to detect small areas of elevated activity that are not detected by the soil samples collected using the systematic pattern. To achieve this goal, a 100 percent GWS will be performed over all Class 1

soils. Class 2 SUs have a lower probability for areas of elevated activity than Class 1 SUs, but some portions of the SU may have a higher potential than others based on remediation efforts. The coverage goal for Class 2 areas will be 100 percent as a conservative measure with 50-100 percent considered acceptable, depending on safety and accessibility. If the entire SU has an equal probability for areas of elevated activity, systematic scans along transects of the SU or scanning surveys of randomly selected grid blocks are performed. Table 17-1 contains information regarding the scanning survey coverage of the FSS.

Table 17-1. Gamma Scan Survey Coverage

Survey Unit	Survey Unit Description	Survey Unit MARSSIM Class	Survey Unit Size (m^2)	Measurement Spacing Results (L) (m)	Coverage
1	Trench TR-5	1	94	4.1	100% coverage 0.5-m paths 0.5 m/s
2	Trench TR-6	1	68	3.5	100% coverage 0.5-m paths 0.5 m/s
3	Buffer Area Around Trenches	2	1,576	10.1	100% coverage 0.5-m paths 0.5 m/s

Notes: m^2 – square meters
m - meters
m/s - meters per second

Before a detection system is utilized for surveys, it is necessary to perform an a priori calculation of the Scan Minimum Detectable Concentration (Scan MDC) for the system. NUREG-1507 Rev. 1 (NRC, 2020) provides a method for estimating a priori gamma scan MDC values using the following equation with selected parameter values:

$$Scan\ MDC = \frac{d' \times \sqrt{b_i} \times \left({}^{60}/_{i}\right)}{\sqrt{p} \times CPMR \times ERC}$$

Where:

d’	=	index of sensitivity (2.56, 10% false positive, 90% true positive)
i	=	observation interval
b_i	=	background counts during the observation interval
p	=	observer efficiency (0.5)
CPMR	=	count rate to exposure rate ratio
ERC	=	exposure rate to concentration ratio

The values for CPMR and ERC are energy and nuclide specific. Microshield Version 12.00 was used to model the exposure rate (with buildup) for the emission energies for each of the radionuclides of concern. The source of radiation was assumed to be a 0.25 m^2 cylinder of soil 15 cm thick. The exposure rate was calculated at a point 10 cm (4 inches) above the surface of the source. The methodology described in NUREG-1507 Rev. 1 was used to calculate the Scan MDC for each radionuclide of concern for the two detectors used to perform the GWS. The results of the Microshield modeling and the Scan MDC calculations for each detector are provided in Attachment 1 to Worksheet #17.
Scanning at 0.5 meters per second along parallel survey paths 0.5 meters apart provides an observation interval of just over 1 second for each 0.25 m^2 area. The detector will be suspended 10 cm from the surface being surveyed.

The a priori scan MDC for ^{137}Cs using the FIDLER is 34.8 pCi/g. This result is slightly above the project action level of 33 pCi/g for ^{137}Cs. The use of the FIDLER to collect data is specified in the ROD, but this detector may not achieve the remediation goals specified in the project objectives. The a priori scan MDC for ^{137}Cs using the 3x3 NaI detector is 7.8 pCi/g, significantly lower than the action level of 33 pCi/g. Performing the GWS using the 3x3 NaI will ensure the project objectives are achieved.

Similarly, the a priori scan MDC for ^{94}Nb using the FIDLER is 18.6 pCi/g, exceeding the action level of 12 pCi/g. The a priori scan MDC using the 3x3 NaI detector is 3.5, ensuring the project objectives will be achieved.

The a priori scan MDC for ^{226}Ra using the FIDLER is 5.8 pCi/g, below the action level of 7.4 pCi/g and capable of achieving the project objectives. The a priori scan MDC using the 3x3 NaI detector is 3.0 pCi/g and provides additional confidence the project objectives will be achieved.
The Scan MDCs for the ROCs using each detector are provided in terms of pCi/g in Table 17-2.

Table 17-2. Scan MDCs

Detector Model No.	ROC	Survey Speed (m/s)	Background Count Rate (cpm)	Observation Interval (observations per second)	Minimum Detectable Count Rate (cpm)	Minimum Detectable Concentration (pCi/g)
FIDLER	^{226}Ra	0.5	4,500	1.12	1,257	5.8
	^{137}Cs	0.5	4,500	1.12	1,257	34.8
	^{94}Nb	0.5	4,500	1.12	1,257	18.6
3x3 NaI	^{226}Ra	0.5	23,000	1.12	2,842	3.0
	^{137}Cs	0.5	23,000	1.12	2,842	7.8
	^{94}Nb	0.5	23,000	1.12	2,842	3.5

Soil Sampling

Volumetric samples of soil samples will be collected from each SU and will be sent to GEL Laboratories for analysis and analyzed in accordance with GEL Laboratories standard operating procedures. Samples will be collected in accordance with Cabrera OP-005: Volumetric and Material Sampling Within Radiological Control Areas (Rev. 2.0) and OP-3100: Surface Soil Sampling Rev. 1.0. Sample chain-of-custody will be maintained in accordance with Cabrera OP-3202: Chain-of-Custody, Rev. 1.0.

Soil samples will be collected using a hand auger or stainless steel trowel, and homogenized in a stainless steel bowl prior to containerization. During the homogenization of soil samples, twigs, stones, and other non-soil items will be removed from the sample material in the field and excluded from the laboratory samples to avoid biasing results low. Samples will not be preserved in the field, as there are no preservation requirements for radiological analyses. One set of QC samples (e.g., field duplicate, matrix spike [MS], and matrix spike duplicate [MSD]) will be collected as required by each test method for each medium sampled.

Samples will be handled, packaged, labeled, sealed, preserved, and shipped as described in the Cabrera OP-3202 (OP-062): Sample Management and Shipping, Rev. 2.0. Utensils and equipment that contact the sample material will be decontaminated between sampling locations, as necessary, to prevent cross-contamination of the samples. A Ludlum 43-93 detector and smear sample will be used to ascertain that no cross-contamination occurs between samples.

Hand augers/hand trowels/shovels, mixing utensils, and homogenizing bowls will be decontaminated between samples in order to avoid cross-contamination. Decontamination will be performed by wiping the tool or bowl with a MASSLIN wipe to remove any residual contamination.

Systematic, biased, and field QC soil samples will be numbered, logged, and transferred under applicable chain-of-custody procedures to an offsite laboratory for analyses. Field duplicate samples will be collected at the frequency of 5 percent. Soil samples will be submitted to a GEL Laboratories. All soil samples will be analyzed via gamma spectroscopy (EPA Method 901.1 modified) and sample purification followed by gas proportional counting (EPA Method 905.0/SR-02.

Additional Survey Activities

In addition to the FSS at Area 2 of SWMU-11, radiation measurements will be performed to support project activities. These project activities include evaluation of borrow material used to backfill remediated areas, air monitoring, periodic routine and release surveys, and contamination control surveys.

Grab samples of surface soil will be used to determine if borrow material meets the requirements for use as backfill for remediated areas. The minimum number of samples required to support decisions on accepting borrow material were based on guidance in the Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME). The calculation of the minimum number of measurements is based on assumptions about the borrow materials, including:

- The borrow material does not contain any chemicals or radionuclides of concern at concentrations above background, resulting in a large relative shift of at least 3.0,
- Background concentrations of all chemicals and radionuclides of concern are negligible and can be ignored for this evaluation, so no reference area data is required, and the Sign test is used to develop a survey design,
- The consequences of Type II decision errors are less severe, and decision error rates of 25% are acceptable.

MARSAME Table A.2.a lists a minimum of 8 samples are required to support decisions for data with a relative shift of 3.0, Type I decision error rates of 5%, and Type II decision error rates of 25%. A total volume of approximately 600 CY of backfill is expected, so the frequency of sampling is approximately 1 sample for every 75 yards of material.

Particulate breathing zone (BZ) and work area air monitoring will be performed during intrusive survey activities, including GWS and soil sampling. There is limited potential for personnel to intake radioactivity in excess of 10% of the Derived Air Concentration (DAC) values presented in Table 6-2 of the RPP (Cabrera, 2024c). BZ and work area air monitoring of selected workers will be based on exposure potential and conducted to confirm assumptions concerning exposure to radiation and site conditions. The Cabrera Corporate RSO will be notified if cohort sample results with positive detections exceed 10% DAC and will direct additional individual monitoring per 10 CFR 20.1502. If DAC levels exceed 100%, work will stop until area postings and additional monitoring and controls are established under the direction of the Corporate RSO.

Perimeter air monitoring will be performed during intrusive activities and compared to the effluent values presented in Table 6-2 of the RPP (Cabrera, 2024c). The Cabrera Corporate RSO will be notified if cohort sample results with positive detections exceed 10% of the effluent limit. If effluent levels exceed 100%, work will stop until area postings and additional monitoring and controls are established under the direction of the Corporate RSO.

Routine surveys of work areas and work surfaces outside the established RCAs will be performed periodically, typically once per work week. These surveys will include dose/exposure rate surveys combined with alpha/beta total and removable surface activity measurements. The results of the routine surveys will be compared with baseline survey results and background levels to identify increased levels of radioactivity resulting from project work outside the established RCAs. Routine surveys will be reviewed by the SRSO and evidence of increased radioactivity levels will be reported to the Cabrera RSO.

Release and contamination control surveys will be performed on all materials, equipment, and personnel prior to exiting the established RCAs. These surveys will include personnel frisking under OP-3403 (OP-243) and clearance surveys under OP-3802. The results of these surveys will be reviewed by the SRSO and the Project HP.

Final Status Survey Design

The FSS at the SWMU-11 Area 2 Site is designed in accordance with FSS guidance from MARSSIM (NRC 2000). FSS activities will consist of scanning surveys over 100 percent of the reasonably accessible surface soil. Discrete soil sampling will be performed at frequencies based on MARSSIM guidance. Biased soil samples will be collected at locations with the highest gross gamma activity.

Classify Areas by Contamination Potential

As discussed in MARSSIM (NRC 2000), areas of sites undergoing an FSS should be classified into SU according to their potential for residual radioactivity. Section 2.2 of MARSSIM provides the following definitions for classifying areas (herein identified as SUs):

Non-Impacted Areas	Areas that have no reasonable potential for residual contamination.
Impacted Areas	Any area not classified as non-impacted; areas with the possibility of containing residual radioactivity in excess of natural background or fallout levels.
Class 1 Areas	Impacted areas that have, or had prior to remediation, a potential for contamination (based on site operating history) or known contamination (based on previous radiological surveys) above the $DCGL_w$.
Class 2 Areas	Impacted areas that, prior to remediation, are not likely to have concentrations of residual radioactivity that exceed the DCGLw.
Class 3 Areas	Impacted areas that have a low probability of containing residual radioactivity.

Using MARSSIM as guidance, the site will be divided into two Class 1 SUs and one Class 2 SU as shown on Figure 2. The initial SU classifications are based on sample matrix, area, and contamination potential from previous investigations. MARSSIM suggests that outdoor Class 1 and Class 2 SUs be not more than 2,000 and 10,000 square meters, respectively, in size.

Select a Background Reference Area Data Set

A background reference area will be established outside the radiologically impacted area of the site. A GWS data set will be collected for each instrument used to perform GWS measurements as part of an FSS. The GWS reference area data sets will be used to develop instrument-specific GWS ILs for surface soils. Each GWS IL will be calculated as the average of the GWS reference area data set plus three standard deviations. The results of GWS performed inside the trenches will be evaluated to determine the applicability of the surface soil ILs to soils at the bottom of the excavated trenches.

A background reference area soil sample data set will not be established for this project. ROC concentrations will be compared directly to $DCGL_W$ values in Table 15.1. A radiological dose/risk

assessment will be performed using the actual FSS results to determine if the site meets the release criteria (i.e., less than 25 mrem/yr).

Establish Survey Location Reference System

An FSS reference coordinate system will be developed and installed early in the FSS process. Coordinates will be referenced to the State Plane Coordinate System (e.g., North American Datum 83 U.S State Plane meters). The reference coordinate system will be established such that the grid spacing satisfies the survey design requirements (and, therefore, the grid intersections correspond to the survey data point locations) for Class 1 and Class 2 SUs.

Measurement locations within Class 1 and Class 2 areas will be placed on a triangular grid overlaid on the ground surface. The spacing of the grid in each area will depend upon the calculated area since the number of locations will not change.

A Geographic Information System (GIS) program will be used to lay a triangular grid with proper length spacing over the SUs. A random start point for the grid will be established using a computer-generated random coordinate set. The number of sample locations corresponding to the random grid will be determined using GIS.

Each survey will be designed to optimize the data collection procedure, taking into account the SU's configuration, hazards, and other obstructions. Copies of the base map on which temporary structures, roads, or other major features have been located will be available onsite. Technicians will annotate copies of the base map with information relevant to the survey, as appropriate. Each survey will be assigned an SU number and date of collection.

At a minimum, the boundaries of the SU will be identified and clearly marked. Additionally, to facilitate the GWS, intermediate markings may be installed using pin flags to mark the start and end points of planned survey lines. The use of a GPS obviates the need for marking small grid intervals.

Number of Systematic Soil Samples

MARSSIM provides a method to determine the number of measurement locations required in a given SU. A minimum number of measurement locations are required in each SU to obtain sufficient statistical confidence that the conclusions drawn from the measurements are correct. The following subsections describe the bases for and derivation of the minimum required measurement locations per SU.

Estimation of Relative Shift

The minimum number of measurement locations required is dependent on the distribution of site residual radionuclide concentrations relative to the $DCGL_w$ and acceptable decision error limits (α and β). The relative shift describes the relationship of site residual radionuclide concentrations to the $DCGL_w$ and is calculated using the guidance found in Section 5.5.2.3 of MARSSIM. The relative shift is calculated as follows:

$$\Delta / \sigma = \frac{DCGL_w - LBGR}{\sigma}$$

where

$DCGL_w$ = Derived Concentration Guideline Level over a wide area.

LBGR = Concentration at the lower bound of the gray region. The Lower Bound of the Grey Region (LBGR) is the concentration at which the SU has an acceptable probability of passing the statistical tests.

σ = An estimate of the standard deviation of the concentration of residual radioactivity in the survey unit (which includes real spatial variability in the concentration as well as the precision of the measurement system).

MARSSIM recommends that it may be reasonable to assume a sigma on the order of 30 percent, which is equivalent to a sigma value of 0.3 (NRC 2000). Using a $DCGL_w$ equal to an SOR of 1, an LBGR of 0.5 (half the $DCGL_w$), and a sigma equal to 0.3, the relative shift is calculated to be 1.67. To account for the lack of site-specific data, the relative shift was rounded down to 1.5.

Determination of Systematic Samples (Number of Required Measurement Locations)

The Sign statistical test will be used to determine when SUs are suitable for release for unrestricted use, according to the DCGLs. The minimum number of systematic measurement locations required in each SU for the Sign statistical test can be determined using Table 5.5 in MARSSIM (NRC 2000). Section 4.6 establishes the acceptable decision errors for the SUs as $\alpha = \beta = 0.05$. Based on the relative shift established above and these decision errors, the estimated minimum number of required measurement locations is 17. Therefore, a minimum of 17 sample locations is required in Class 1 and Class 2 SUs.

Systematic Measurement Locations

Field personnel will mark the perimeter of each SU using GPS. Actual SU dimensions will be measured in the field and are contingent upon the extent of excavations performed in the course of remediation. These data will then be transferred into the GIS so that a triangular sampling grid can be established. A random start point will be generated and systematic sample locations will be calculated in an equilateral triangular grid pattern using the spacing given by the equation shown below (Equation 5-5 from MARSSIM).

$$L = \sqrt{\frac{A}{0.866 \times N}}$$

where

L = Triangular grid spacing for SU.
A = Area of SU.
N = Number of sample locations.

Measurement spacing results (L) using the equation above are presented in Table 17-1. Site SU delineations and Class 1 and Class 2 sampling locations are presented in Figure 2. Actual sample locations will be calculated in the field based on SU size after remediation and will follow the same process as above.

After the systematic sample locations have been established and prior to sample collection, soil sample locations will be marked in the field. Table 17-1 lists each SU by area, number of samples to be collected in that SU, and the spacing between each sample using a triangular grid pattern.

Determination of Biased Samples

Areas exceeding the investigation level will be investigated with hand-held instruments (3x3 NaI) to locate the highest gross gamma activity. Biased samples will be collected within each SU at the location(s) GWS data and the hand-held instrument investigation data indicate elevated radioactivity. Additional biased (or focused) samples may be collected within each area that has historically been shown to have contamination or suspected to be contaminated. The number of biased locations will be determined by the Site RSO and Principal Health Physicist based on the actual survey results.

Evaluation of FSS Results

Potential radiation exposure at the Sites will be estimated based on the FSS soil sample results. The purpose of this evaluation will be to determine whether workers at the Sites would potentially receive an unacceptable TEDE from exposure to radiation at the Sites, including any background contributions. The radiation exposure analysis will be performed using the ROCs identified during the radiological assessment: ^{226}Ra, ^{90}Sr, ^{214}Bi, ^{94}Nb, ^{214}Pb, and ^{137}Cs. Radiological doses will be estimated using the DOE RESRAD-ONSITE exposure pathway model Version 7.2 and the most conservative Resident Farmer Scenario described in the Characterization Survey Report (North Wind, 2020). The input parameters for calculating dose will match Table B-1 of that report.

UFP-QAPP WORKSHEET #18
Sampling Locations and Methods

Sampling Location/ Identification Number	Matrix[1]	Depth (Units)	Type	Analyte/Analytical Group(s)	Sampling SOP	Comments
FSS Samples - 18 systematic samples will be collected per SU. At least one biased sample will be collected per SU. The field duplicate samples (co-located grab samples) will be collected at a minimum frequency of 1 for every 20 samples collected.	Soil	Surface (0-6 inches)	Systematic and biased grab samples, 5% field duplicate samples	Radiological Contaminants using Gamma Spectroscopy and ^{90}Sr gas flow proportional analysis.	Cabrera OP-3110, Surface Soil Sampling	Proposed systematic sample locations are shown in Figure 2.
Layback Soils – approximately 90 CY will be excavated and staged on-site. One grab sample will be collected of this material from each excavation.	Soil	Surface (0-6 inches)	Grab	Gamma spectroscopy, VOCs, SVOCs, PCBs, TAL metals, pesticides, hexavalent chromium, and total cyanide	Cabrera OP-3110, Surface Soil Sampling	
On-Site Borrow Material - a minimum of 8 grab samples will be collected from the borrow material, additional samples will be collected at a frequency of 1 sample for every 75 CY if required	Soil	Surface (0-6 inches)	Grab	Gamma spectroscopy, VOCs, SVOCs, PCBs, TAL metals, pesticides, hexavalent chromium, and total cyanide	Cabrera OP-3110, Surface Soil Sampling	
Waste Characterization – One sample will be collected in/around drums in Trench TR-6	Solid	Surface (0-6 inches)	Grab	TAL metals (arsenic), TCLP	Cabrera OP-3110, Surface Soil Sampling	

UFP-QAPP WORKSHEETS #19 AND #30
Sample Containers, Preservation, and Hold Times

Sample containers, preservation, and hold time information for standard methods is provided below.

Laboratory: GEL Laboratories
2040 Savage Road
Charleston, SC 29407
Point-of-contact: Mr. Jacob Crook (843) 556-8171;
email team.crook@gel.com

List any required accreditations/certifications: Department of Defense Environmental Laboratory Analytical Program and State of New Mexico Environment Department Environmental Laboratory Certification Program

Sample Delivery Method: Overnight delivery

Analyte/ Analytical Group	Matrix	Method/SOP	Sample Size	Container Size/Type	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround
^{226}Ra, ^{137}Cs, ^{94}Nb, ^{214}Bi, ^{214}Pb	Surface soil	GL-RAD-A-013 DOE HASL 300 4.5.2.3/Ga-01-R	500 – 1,000 grams	1 8 oz jar or Ziploc bag	None	6 months	6 months	30 calendar days
^{90}Sr	Surface Soil	EPA 904.0M	20 grams	Plastic 500 milliliter or Ziploc bag	None	6 months	6 months	30 calendar days
VOCs	Soil	5035/8260D GL-OA-E-038	2 x 40-ml	VOA vials w/ PTFE-faced silicone septum	4 ± 2°C	14 days	14 days	28 days
TAL Metals	Soil	3050B/6010C or D GL-MA-E-013	4 oz.	4 oz. Polyethylene	None	180 days	NA	28 days
TCLP TAL Metals	Waste	1311/3010A/6010 C or D GL-MA-E-013	250 mL Polyethylene	250 mL Polyethylene	None	14 days to tumble, 180 days to digest	NA	28 days
Mercury	Soil	7471B GL-MA-E-010	1 x 4 oz.	1, 4 oz. Polyethylene	0 ≤ 6° C	28 days	28 days	28 days

Analyte/ Analytical Group	Matrix	Method/SOP	Sample Size	Container Size/Type	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround
PCBs	Soil	3541A/8082A GL-OA-E-040	2 x 4 oz	2, 4 oz. Amber glass w/ PTFE-faced silicone septum	4 ± 2°C	365 days	40 days	28 days
Hexavalent Chromium	Liquid/solid	7196 GL-GC-E-132	1 x 250 ml,	1, 250 ml, Polyethylene/ glass	0 ≤ 6° C	24 hours (L), 40 days (solid)	24 hours (L), 40 days (solid)	28 days
SVOCs	Soil	3541/8270 GL-OA-E-009	2 x 4 oz.	2, 4 oz. Amber glass w/ PTFE-faced silicone septum	4 ± 2°C	14 days	40 days	28 days
Pesticides	Soil	3541A/8081B GL-OA-E-041	2 x 4 oz.	2 x 4 oz. Amber glass w/ PTFE-faced silicone septum	4 ± 2°C	14 days	40 days	28 days
Cyanide	Liquid/solid	9012B/GL-GC-E-112	1 x 250 ml	1, 250 ml, Polyethylene or glass	pH >12 NaOH (L), 0 ≤ 6° C (S)	NA	14 days	28 days

Notes:
^{226}Ra – radium-226
^{137}Cs – cesium-137
^{94}Nb – niobium-94
^{214}Bi – bismuth-214
^{214}Pb – lead-214
^{90}Sr – strontium-90
Oz. – ounces
L – liquid
mL – milliliters
°C – degrees Centigrade
PTFE – Polytetrafluoroethylene
PCBs – polychlorinated biphenyls

UFP-QAPP WORKSHEET #20
Field Quality Control Summary

Matrix	Analyte/ Analytical Group	Field Samples	Field Duplicates	Matrix Spikes	Matrix Spike Duplicates	Field Blanks	Equipment Blanks	Trip Blanks	Total Analyses
Soil – Final Status Survey	Gamma Spec, ^{90}Sr	Approximately 70	5% frequency	Not applicable	Not applicable	Not Applicable	Not applicable	Not applicable	Approximately 140
Soil – Layback Soil/Borrow Source	Gamma Spec, ^{90}Sr, VOCs, SVOCs, TAL Metals, PCBs, Pesticides, Cyanide, Hexavalent Chromium	Approximately 10	5% frequency	Not applicable	Not applicable	Not Applicable	Not Applicable	Not Applicable	Approximately 90
Soil – Waste Characterization	TAL Metals (TCLP)	Approximately 1	Not applicable	Not applicable	Not applicable	Not Applicable	Not applicable	Not applicable	Approximately 1

(1) Anticipated number of sample locations: The total number of samples collected will depend upon the results of the GWS and decisions made by the stakeholders. The initial survey design includes a minimum of 54 soil samples at systematic locations, 6 field duplicates, and 10 samples at targeted locations based on professional judgement and GWS results. The SRSO will coordinate with the Project HP and Cabrera Project Manager during the field event to confirm that the total number of collected samples meet the project objectives.

UFP-QAPP WORKSHEET #21
Field Standard Operating Procedures

The table below presents the OPs that will be used during the remedial action at the Site.

OP Number	Title	Organizing Organization	SOP Option or Equipment Type (if SOP provides different options)	Modified for Project Work (Check if yes)	Comments
OP-1106 (OP-187)	Records Management	Cabrera	Not applicable		
OP-3001	Field Activity Documentation	Cabrera	Not applicable		
OP-3102	Wipe Sampling Procedure	Cabrera	Not applicable		
OP-3110	Surface Soil Sampling	Cabrera	Not applicable		
OP-3116 (OP-005)	Volumetric and Material Sampling Within Radiological Control Areas	Cabrera	Not applicable		
OP-3203 (OP-008)	Chain of Custody	Cabrera	Not applicable		
OP-3203 (OP-362)	Sample Management and Shipping	Cabrera	Not applicable		
OP-3401 (OP-358)	Health Physics Instrument General Quality Control Procedure	Cabrera	Not applicable		
OP-3402 (OP-380)	Calculating Alpha and Beta Total Efficiency for Field Instruments	Cabrera	Not applicable		
CS-RS-PR-002	Personnel Survey and Decontamination Procedure	EnergySolutions	Not applicable		
OP-3407 (OP-020)	Operation of Contamination Survey Meters	Cabrera	Not applicable		
OP-3408	Alpha-Beta Counting Instrumentation	Cabrera	Not applicable		
OP-3410 (OP-023)	Operation of Micro-R Meters	Cabrera	Not applicable		
OP-3502	Global Positioning Systems (GPS)	Cabrera	Not applicable		
OP-3601 (OP-001)	Radiological Surveys	Cabrera	Not applicable		
OP-3605 (OP-387)	Gamma Walkover Survey	Cabrera	Not applicable		
OP-3606 (OP-388)	Gamma Walkover Survey – GIS Process	Cabrera	Not applicable		
OP-3704	Investigation Derived Waste Management	Cabrera	Not applicable		
CS-RS-PR-006	Unconditional Release of Tools and Equipment from Projects	EnergySolutions	Not applicable		
OP-3805	Decontamination of Residual Surface Radioactivity	Cabrera	Not applicable		
OP-3806 (OP-019)	Radiological Posting	Cabrera	Not applicable		
CS-RS-PR-009	Radioactive Source Inventory, Leak Testing, and Control at Field Projects	EnergySolutions	Not applicable		
CS-RS-PR-010	Personnel Monitoring for Exposure	EnergySolutions	Not applicable		
CS-RS-PR-004	Radiation Work Permits	EnergySolutions	Not Applicable		

OP Number	Title	Organizing Organization	SOP Option or Equipment Type (if SOP provides different options)	Modified for Project Work (Check if yes)	Comments
OP-5000	Occupational Health and Safety Management System	Cabrera	Not applicable		
CS-RS-PG-001	Commercial Services Radiation Protection Program	EnergySolutions	Not applicable		
OP-5107	Hazardous Material Communication	Cabrera	Not applicable		
CS-RS-PR-015	Air Sampling and Analysis	EnergySolutions	Not applicable		
CS-RS-PR-001	Selection and Use of Radiological Protective Clothing	EnergySolutions	Not applicable		
CS-RS-PG-003	ALARA and Dose Tracking	EnergySolutions	Not applicable		
CS-RS-PR-003	Commercial Services Field Project Training Requirements	EnergySolutions	Not applicable		

NOTE:
All Cabrera OPs listed in the table above except OP-5000 and OP-5107 are included in Attachment A. OP-5000 and OP-5107 are included in the Accident Protection Plan (APP, Cabrera 2024d). The EnergySolutions OPs are provided in the Radiation Protection Plan (RPP), Attachment A. The RPP is attached to the APP (Cabrera 2024d).

UFP-QAPP WORKSHEET #22
Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Activity	SOP Reference	Title or Position of Responsible Person	Frequency	Acceptance Criteria	Corrective Action
3x3 NaI (Ludlum Model 44-20, or equivalent) couples with a Ludlum Model 2221 ratemeter (or equivalent)	Gamma walkover surveys with GPS for position-correlated measurements	Cabrera OP-3605 (OP-387) Cabrera OP-3606 (OP-388)	Field personnel	Prior to use and at the beginning and end of each workday	Cabrera OP-3401 (OP-358)	Instruments with response rates outside the acceptable criteria will be removed from service. The equipment will be sent to the macufacturer for repair and re-calibrated.
Ludlum 2224-1 Ludlum 43-93 Alpha/Beta Surveys	Personnel and equipment surveys Personnel monitoring (frisking)	Cabrera OP-3601 (OP-001) EnergySolutions CS-RS-PR-002 Cabrera OP-3407 (OP-020) Cabrera OP-3802	Radiation Technician			
Micro Rem, Model 12S Gamma	Dose/Exposure rate surveys Waste Package Surveys	Cabrera OP-3410 (OP-023)	Radiation Technicians			
Ludlum 2929 and 43-10-1 Alpha/Beta Sample Counter	Counting air filters and smears	Cabrera OP-3408	Radiation Technicians			
GilAir 5, or equivalent	Personnel air sampling pump	EnergySolutions CS-RS-PR-015	Radiation Technicians	Intrusive work	Not applicable	
LV-1 low volume air sampler	Work area and perimeter air monitoring	EnergySolutions CS-RS-PR-015	Radiation Technicians	Pre-Mobilization Survey and Intrusive work	Not applicable	
Photo Ionization Detector (PID) (RAE Systems Mini-RAE or Multi-RAE (min. 10.6 eV bulb))	Work area air monitoring	Cabrera OP-3301	SSHO	Intrusive work	Not applicable	
Thermo Scientific Model PDR 1500	Respirable Dust Monitoring	Cabrera OP-3303	SSHO	Intrusive work	Not applicable	

UFP-QAPP WORKSHEET #23
ANALYTICAL STANDARD OPERATING PROCEDURES

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work
GL-RAD-A-013	The Determination of Gamma Isotopes, Rev 28, May 2023	Definitive	Solid	Gamma Spectrometer	GEL Laboratories, LLC, South Carolina	No
GL-RAD-A-004	The Determination of Strontium 89/90 in Water, Soil, Milk, Filters, Vegetation and Tissues	Definitive	Solid	Gas flow proportional counter	GEL Laboratories, LLC, South Carolina	No
GL-OA-E-038	*Volatile Organic Compounds (VOC) by Gas Chromatograph/Mass Spectrometer, June 2023, Rev. 29, 8260B, 8260C, 8260D*	Definitive	VOCs	Low-level, closed-system purge and trap	GEL Laboratories, LLC, South Carolina	N
GL-OA-E-039	*Closed-System Purge-and-Trap Collection and Extraction: Volatile Organics in Soil and Waste Samples, Sep. 2018, Rev. 13, 5035A (reviewed 10/22/23)*	Definitive	VOCs	Low-level, closed-system purge and trap	GEL Laboratories, LLC, South Carolina	N
GL-LB-E-006	*Toxicity Characteristic Leaching Procedure Preparation, Jan. 2018, Rev 22, 1311 (reviewed 1/25/23)*	Definitive	VOCs	ZHE	GEL Laboratories, LLC, South Carolina	N
GL-MA-E-013	*Determination of Metals by ICP, July 2023, Rev. 33, 6010C, 6010D*	Definitive	ICP Metals	ICP-AES	GEL Laboratories, LLC, South Carolina	N
GL-MA-E-006	*Acid Digestion of Total Recoverable or Dissolved Metals in Surface and Groundwater Samples for Analysis by ICP or ICP-MS, Oct. 2017, Rev. 14, 3005A (reviewed 10/13/22)*	Definitive	ICP Metals	Hot Block	GEL Laboratories, LLC, South Carolina	N
GL-MA-E-008	*Acid Digestion of Total Recoverable or Dissolved Metals in Surface and Groundwater Samples for Analysis by ICP or ICP-MS, Oct. 2017, Rev. 19, 3010A (reviewed 10/13/22)*	Definitive	ICP Metals	Hot Block	GEL Laboratories, LLC, South Carolina	N
GL-MA-E-009	*Acid Digestion of Sediments, Sludges, and Soils, Dec. 2019, Rev. 29, 3050B (reviewed 12/6/22)*	Definitive	ICP Metals	Hot Block	GEL Laboratories, LLC, South Carolina	N
GL-LB-E-006	*Toxicity Characteristic Leaching Procedure Preparation, Jan. 2018, Rev 22, 1311 (reviewed 1/25/23)*	Definitive	ICP Metals	Rotating Agitation Apparatus	GEL Laboratories, LLC, South Carolina	N
GL-LB-E-024	*Synthetic Precipitation Leaching Preparation, Sep. 2017, Rev 12, 1312 (reviewed 1/25/23)*	Definitive	ICP Metals	Rotating Agitation Apparatus	GEL Laboratories, LLC, South Carolina	N

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work
GL-MA-E-014	*Determination of Metals by ICP-MS, Aug. 2023, Rev. 36, 6020A, 6020B*	Definitive	ICP-MS Metals	ICP-AES	GEL Laboratories, LLC, South Carolina	N
GL-MA-E-010	*Mercury Analysis Using the Perkin Elmer Automated Mercury Analyzer, Aug. 2023, Rev. 40, 7470A, 7471B*	Definitive	Mercury	CVAA	GEL Laboratories, LLC, South Carolina	N
GL-OA-E-040	*Polychlorinated Biphenyls, 8082A, Dec. 2023, Rev. 27*	Definitive	PCBs	GC/ECD	GEL Laboratories, LLC, South Carolina	GL-OA-E-040
GL-OA-E-045	*Sulfur Clean-up, Jan. 2013, Rev. 3, 3660B (reviewed 2/7/23)*	Definitive	PCBs	Activated copper	GEL Laboratories, LLC, South Carolina	GL-OA-E-045
GL-OA-E-066	*Automated Soxhlet Extraction, Aug. 2018, Rev. 9, 3541 (reviewed 10/24/23)*	Definitive	PCBs	Automated Soxhlet	GEL Laboratories, LLC, South Carolina	GL-OA-E-066
GL-OA-E-070	*Solid-Phase Extraction, Nov. 2023, Rev. 12, 3535A*	Definitive	PCBs	Solid Phase Extraction	GEL Laboratories, LLC, South Carolina	GL-OA-E-070
GL-GC-E-132	*Hexavalent Chromium Cr (VI) Analysis Using The Lachat QuikChem FIA+ 8000 Series Instrument, May 2019, Rev. 3, 7196A, 3060A, SM 3500 Cr B-2011 (Reviewed June 2023)*	Definitive	Hexavalent Chromium	Spectrophotometer	GEL Laboratories, LLC, South Carolina	GL-GC-E-132
GL-OA-E-009	*Analysis of Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry, June 2023, Rev. 47, 8270D, 8270E*	Definitive	SVOCs	GC/MS	GEL Laboratories, LLC, South Carolina	GL-OA-E-009
GL-OA-E-013	*Extraction of Semivolatile and Nonvolatile Organic Compounds from Groundwater, Wastewater, and Other Aqueous Samples, Apr. 2021, Rev. 35, 3510C (Reviewed 5/16/23)*	Definitive	SVOCs	Separatory Liquid-Liquid	GEL Laboratories, LLC, South Carolina	GL-OA-E-013
GL-OA-E-047	*Gel Permeation Cleanup of Solvent Extracts, Aug. 2012, Rev. 4, 3640A (Reviewed 5/15/23)*	Definitive	SVOCs	GPC	GEL Laboratories, LLC, South Carolina	GL-OA-E-047
GL-OA-E-041	*Organochlorine Pesticides and Chlorinated Hydrocarbons, Dec. 2023, Rev. 22, 8081A, 8081B*	Definitive	Pesticides	GC/ECD	GEL Laboratories, LLC, South Carolina	GL-OA-E-041
GL-OA-E-045	*Sulfur Clean-up, Jan. 2013, Rev. 3, 3660B (reviewed 2/7/23)*	Definitive	Pesticides	Activated copper	GEL Laboratories, LLC, South Carolina	GL-OA-E-045
GL-OA-E-047	*Gel Permeation Cleanup of Solvent Extracts, Aug. 2012, Rev. 4, 3640A (reviewed 5/15/23)*	Definitive	Pesticides	GPC	GEL Laboratories, LLC, South Carolina	GL-OA-E-047

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work
GL-OA-E-049	*Silica Gel Cleanup Using Solid Phase Silica Gel Extraction Cartridges, April 2016, Rev. 6, 3630C (reviewed 10/18/22)*	Definitive	Pesticides	Extraction Cartridge	GEL Laboratories, LLC, South Carolina	GL-OA-E-049
GL-OA-E-066	*Automated Soxhlet Extraction, Aug. 2018, Rev. 9, 3541 (reviewed 10/24/23)*	Definitive	Pesticides	Automated Soxhlet	GEL Laboratories, LLC, South Carolina	GL-OA-E-066
GL-OA-E-070	*Solid-Phase Extraction, Nov. 2023, Rev. 12, 3535A*	Definitive	Pesticides	Solid Phase Extraction	GEL Laboratories, LLC, South Carolina	GL-OA-E-070
GL-LB-E-006	*Toxicity Characteristic Leaching Procedure Preparation, Jan. 2018, Rev 22, 1311 (reviewed 1/25/23)*	Definitive	Pesticides	Rotating Agitation Apparatus	GEL Laboratories, LLC, South Carolina	GL-LB-E-006
GL-GC-E-082	*Acid-Soluble Sulfides, Oct. 2017, Rev. 13, 9030B/9034 (reviewed 10/13/23)*	Definitive	Solids/Acid-soluble analysis	Titration	GEL Laboratories, LLC, South Carolina	GL-GC-E-082
GL-GC-E-112	*Cyanide Determination by SEAL Autoanalyzer 500 Instrument, Oct. 2023, Rev. 1, EPA Method 335.4, Methods 9010B, 9010C, 9012A, and 9012B, 4500 CN- C-2016 and 4500 CN- E-2016*	Definitive	Liquid and solids/Total analysis	SEAL	GEL Laboratories, LLC, South Carolina	GL-GC-E-112

UFP-QAPP WORKSHEET #24
ANALYTICAL INSTRUMENT CALIBRATION

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference
Gamma Spectroscopy	Initial: multi-point	Initially and then Yearly, following repair or loss of control, and upon incorporation of new or changed instrument settings. (MARLAP 18.5.6.2)	+/-10% Verify manufacturer's specifications for gamma peak resolution. (MARLAP 18.5.6.2) Efficiency vs. energy for each geometry/matrix. 95% confidence limit of the fitted function: ≤ 8% over energy range (MARLAP 18.5.6.2) or Peak energy difference is within 0.1 keV of reference energy for all points. Peak Full Width at Half Maximum (FWHM) <2.5 keV at 1332 keV. Energy vs. channel slope equation shall be linear and accurate to 0.5 keV.	Re-Calibrate	Group Leader or Designee	GL-RAD-I-001
		Initially and as required per method	Verification result ± 25% of known value	If the calibration fails a second time, create new calibration sources and re-perform initial calibration.	Laboratory Analyst / Group Leader or Designee	GL-RAD-I-006; GL-RAD-I-016; GL-RAD-I-015, GL-RAD-I-021, GL-RAD-I-012
Gas Flow Proportional Counters	Initial: multi-point	Daily	Alpha/Beta check sources ± 3s	Immediately rerun. If the check fails a second time the instrument is locked out of service and the cause investigated. The instrument status board will be updated to reflect the lockout, the appropriate lockout sign will be placed on the front of the instrument and a logbook entry will be made. The instrument can be returned to service following a successful instrument check.	Laboratory Analyst / Group Leader or Designee	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference
GC/MS	Initial Calibration (ICAL) – five-point ICAL	Initial calibration prior to sample analysis	%RSD<20% all compounds, Relative Response Factor meet method criteria	Repeat calibration	Analyst	GL-OA-E-038, GL-OA-E-009
GC/MS	Second Source Calibration Verification	Once after each initial calibration	Value of second source for all analytes within ±30% of expected	Rerun ICV one time, second failure requires recalibration	Analyst	GL-OA-E-038, GL-OA-E-009
GC/MS	Calibration Verification (CV)	Daily, before sample analysis, and every 12 hours of analysis time	+/- 20%D criteria for all analytes	Re-inject CV; if passes rerun previous 10 samples and continue run; if 2nd CV fails, recalibrate	Analyst	GL-OA-E-038, GL-OA-E-009
GC/MS	Initial Calibration (ICAL) – five-point ICAL	Initial calibration prior to sample analysis	%RSD<20% all compounds, Relative Response Factor meet method criteria	Repeat calibration	Analyst	GL-OA-E-038, GL-OA-E-009
GC/MS	Second Source Calibration Verification	Once after each initial calibration	Value of second source for all analytes within ±30% of expected	Rerun ICV one time, second failure requires recalibration	Analyst	GL-OA-E-038, GL-OA-E-009
GC/MS	Calibration Verification (CV)	Daily, before sample analysis, and every 12 hours of analysis time	+/- 20%D criteria for all analytes	Re-inject CV; if passes rerun previous 10 samples and continue run; if 2nd CCV fails, recalibrate	Analyst	GL-OA-E-038, GL-OA-E-009
ICP-AES	Initial Calibration (ICAL) – minimum one high standard and a calibration blank	Daily initial calibration prior to sample analysis	3 standards and a blank. Correlation Coefficient of ≥ 0.998	Recalibrate	Analyst	GL-MA-E-013
ICP-AES	Second Source Calibration Verification (ICV)	Once after each initial calibration, prior to sample analysis	Value of second source for all analyte(s) within ± 10% of expected	Recalibrate	Analyst	GL-MA-E-013
ICP-AES	Continuing Calibration Verification (CCV)	After every 10 samples and at the end of the analysis sequence	All analytes within + 10% of expected value	Recalibrate – rerun 10 samples previous to failed CCV.	Analyst	GL-MA-E-013
ICP-MS	Initial Calibration (ICAL) – minimum one high standard and a calibration blank	Daily initial calibration prior to sample analysis	3 standards and a blank. Correlation Coefficient of ≥ 0.998	Recalibrate	Analyst	GL-MA-E-014
ICP-MS	Second Source Calibration Verification (ICV)	Once after each initial calibration, prior to sample analysis	Value of second source for all analyte(s) within ± 10% of expected	Recalibrate	Analyst	GL-MA-E-014

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference
ICP-MS	Continuing Calibration Verification (CCV)	After every 10 samples and at the end of the analysis sequence	All analytes within + 10% of expected value	Recalibrate – rerun 10 samples previous to failed CCV.	Analyst	GL-MA-E-014
CVAA	Initial Calibration (ICAL)	Daily initial calibration prior to sample analysis	Correlation coefficient R>=0.995 for linear regression	Recalibrate	Analyst	GL-MA-E-010
CVAA	Second Source Calibration Verification (ICV)	Once after each initial calibration, prior to sample analysis	Value of second source for all analyte(s) within ± 10% of expected value (second source)	Recalibrate	Analyst	GL-MA-E-010
CVAA	Continuing Calibration Verification (CCV)	After every 10 samples and at the end of the analysis sequence.	All analytes within + 20% of expected value	Recalibrate – rerun 10 samples previous to failed CCV.	Analyst	GL-MA-E-010
GC/ECD	Initial Calibration (ICAL) – five-point ICAL	Initial calibration prior to sample analysis	RSD for each analyte <20%	Repeat calibration	Analyst	GL-OA-E-040, GL-OA-E-041
GC/ECD	Second Source Calibration Verification	Once after each initial calibration	Value of second source for all analytes within ± 20% of expected value (initial source)	Rerun ICV one time, second failure requires recalibration	Analyst	GL-OA-E-040, GL-OA-E-041
GC/ECD	Calibration Verification (Initial [ICV] and continuing [CCV])	ICV: Daily, before sample analysis; CCV: After every 12 hours of analysis time and at the end of the analysis sequence	All analytes within ± 20% of expected value from the ICAL	Re-inject CCV; if passes rerun previous 10 samples and continue run; if 2nd CCV fails, recalibrate	Analyst	GL-OA-E-040, GL-OA-E-041
Spectrophotometer	5-point calibration curve (10 ug/L - 100 ug/L)	Daily	R = 0.995, ICV = 90%-110%	Recalibration	Analyst	GL-GC-E-132
Titration	Standardization of titrants	New titrants	79%-102% for LCS	Remake reagents then reprep if LCS fails	Analyst	GL-GC-E-082
SEAL	6-point calibration curve (5 ug/L - 200 ug/L)	Daily	R = 0.995, ICV = 90%-110%	Recalibration	Analyst	GL-GC-E-112

UFP-QAPP WORKSHEET #25
ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Gamma Spectroscopy	Efficiency check	CCV Count	Multi point	Daily	±3 Sigma	Recount	Analyst	GL-RAD-I-001, GL-RAD-I-012
High Purity Gamma Detector	N/A	Weekly Background Count	N/A	Weekly	+/- 3 Sigma	Notify Team/Group Leader	Count Room Analyst	GL-RAD-I-012
High Purity Gamma Detector	N/A	Daily Background Count	N/A	Daily	+/- 3 Sigma	Rerun	Count Room Analyst	GL-RAD-I-012
Gas Flow Proportional Counter	Sample Shelf Cleaning	NA, testing not performed	NA	Weekly	NA	NA	Laboratory Analyst or certified instrument technician	GL-RAD-I-010
GC/MS	Daily items may include septa replacement, injection port items, solvent replenishment, instrument tuning adjustment, etc.	Method 8260	Instrument resolving power, GC performance, and isomer specificity are monitored daily.	Maintenance is ongoing and performed as needed. Preventative maintenance such as septa replacement and solvent replenishment is performed daily.	Successful daily instrument calibration per requirements.	Documentation of item addressed is located in the instruments maintenance logbook. All instrument maintenance items are recorded.	Analyst	GL-OA-E-038, GL-OA-E-009
ICP-AES	Oil the peristaltic pump with silicon spray	Per manufacturer requirements	Verify the pump has adequate oil	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-013 section 13.0
ICP-AES	Replace peripump sample introduction tubing	Per manufacturer requirements	Verify the peripump introduction tubing is working properly	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-013 section 13.0

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
ICP-AES	Check drain waste collection containers and empty as needed	Per manufacturer requirements	Verify the drain collection containers are adequately empty	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-013 section 13.0
ICP-AES	Clean/replace nebulizer	Per manufacturer requirements	Verify nebulizer	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department		
ICP-AES	Change pump hoses on drain systems	Per manufacturer requirements	Verify pump hoses are properly working	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-013 section 13.0
ICP-AES	Clean/replace torch. Align according to manufacturer's specifications Clean/replace air filters	Per manufacturer requirements	Verify the torch and air filters are properly working	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-013 section 13.0
ICP-MS	Clean nebulizer tip after use	Per manufacturer requirements	Nebulizer tip is clean	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
ICP-MS	Replace peripump sample introduction tubing	Per manufacturer requirements	Verify the peripump introduction tubing is working properly	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0
ICP-MS	Check drain waste collection containers and empty as needed	Per manufacturer requirements	Verify the drain collection containers are adequately empty	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0
ICP-MS	Clean/replace nebulizer	Per manufacturer requirements	Verify nebulizer	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0
ICP-MS	Check Neslab water level and add water if required.	Per manufacturer requirements	Verify water level	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0
ICP-MS	Clean/replace interface cones	Per manufacturer requirements	Verify cleanliness of cones	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
	Check/replace water filter	Per manufacturer requirements	Verify filter is clean	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0
ICP-MS	Change pump hoses on drain systems	Per manufacturer requirements	Verify pump hoses are properly working	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0
ICP-MS	Clean/replace torch. Align according to manufacturer's specifications Clean/replace air filters	Per manufacturer requirements	Verify the torch and air filters are properly working	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0
ICP-MS	Change oil in interface rotary pump (or as needed).	Per manufacturer requirements	Verify that oil hs been changed	At least quarterly	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0
ICP-MS	Clean ion lenses 4-6 months (or as needed)	Per manufacturer requirements	Verify that ion lenses are clean	At least quarterly	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
ICP-MS	Clean air filters.	Per manufacturer requirements	Verify air filters are clean	Every six months	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0
ICP-MS	Change pump oil in backing rotary pump. Evaluate/replace EM (electron multiplier)	Per manufacturer requirements	Verify oil has been changed	Every twelve months	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0
ICP-MS	Clean nebulizer tip after use	Per manufacturer requirements	Nebulizer tip is clean	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0
ICP-MS	Replace peripump sample introduction tubing	Per manufacturer requirements	Verify the peripump introduction tubing is working properly	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0
ICP-MS	Check drain waste collection containers and empty as needed	Per manufacturer requirements	Verify the drain collection containers are adequately empty	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
ICP-MS	Clean/replace nebulizer	Per manufacturer requirements	Verify nebulizer	When Needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-014 section 13.0
CVAA	For non-routine maintenance procedures, refer to Perkin Elmer manual for troubleshooting	Per manufacturer requirements	Per manufacturer requirements	As needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-010
CVAA	Whenever instrument is serviced or adjusted, an entry needs to be made in the maintenance log. The entry includes the analyst's initials, date, nature of the problem, and actions taken to correct it	Per manufacturer requirements	Per manufacturer requirements	As needed	System is properly working	If the analyst is unable to fix the instrument, call the GEL Instrument Technician, and if needed, the manufacturer's Service Department	Analyst/Inst. tech	GL-MA-E-010
GC/ECD	Daily items may include septa replacement, injection port items, solvent replenishment, etc.	SW846 8082A	Instrument resolving power, GC performance, and isomer specificity are monitored daily.	Maintenance is ongoing and performed as needed. Preventative maintenance such as septa replacement and solvent replenishment is performed daily.	Successful daily instrument calibration per requirements.	Documentation of item addressed is located in the instruments maintenance logbook. All instrument maintenance items are recorded.	Analyst	GL-OA-E-040, GL-OA-E-041
Wavelength calibration checks	Per manufacturer's requirement	Per manufacturer's requirement	Instrument reads and records	See SOP	+/- 5 nm of selected wavelength	Rerun testing or contact service	Analyst	Wavelength calibration checks
Titration	None	9030B/9034	None	None	None	None	Analyst	GL-GC-E-082

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
SEAL	Change windings and tubing	9012B	Visual	As needed	Flows are re-established and instrument is running optimally	Repeat or contact service	Analyst	GL-GC-E-112

UFP-QAPP WORKSHEETS #26 AND #27
SAMPLE HANDLING, CUSTODY, AND DISPOSAL

Sampling Organization: Cabrera
Laboratory: GEL
Method of sample delivery (shipper/carrier): FedEx (or equivalent)
Number of days from reporting until sample disposal: 30 days minimum

Activity	Responsible Person	SOP Reference
Sample labeling	SRSO	Cabrera OP-3110
Chain of Custody forms	SRSO	Cabrera OP-3203 (OP-008)
Sample Packaging	SRSO	Cabrera OP-3202 (OP-362)
Sample Receipt and Log-In	GEL Personnel	Proprietary Lab SOP
Sample Disposal	GEL Personnel	Proprietary Lab SOP

UFP-QAPP WORKSHEET #28
ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION

Matrix: Soil
Analytical Group: Radionuclides
Analytical Method: Gamma Spec DOE 4.5.2.3(Solids)

QC Sample	Number/Frequency	Method / SOP QC Acceptance Limits	Corrective Action	Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
MB	One per 20 samples	Result < RL	Narrate/Recount/reanalyze batch	Analyst	A means of assessing the existence and magnitude of contamination introduced via the analytical process	Result < RL
LCS	One per 20 samples	75-125%	Recount/reanalyze batch	Analyst	Accuracy	75-125%
Duplicate	One per 20 samples	act<5*MDC, then RPD is 100% or less. If act>5*MDC, then RPD is 20% or less or RER</=3	Recount/reanalyze batch	Analyst	Precision	act<5*MDC, then RPD is 100% or less. If act>5*MDC, then RPD is 20% or less or RER</=3

Notes:
MB – Method Blank
RL – Reporting Limit
LCS – laboratory control sample
MDC – minimum detectable concentration
RPD – relative percent difference
RER – Relative Error Ratio

Matrix: Soil
Analytical Group: Radionuclides
Analytical Method: GFP EPA Method 904.0M

QC Sample	Number/Frequency	Method / SOP QC Acceptance Limits	Corrective Action	Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
MB (Method Blank)	One per 20 samples or analytical batch	Result < RDL or less than 5% associated sample activity.	Narrate/Recount/reanalyze batch	Analyst	A means of assessing the existence and magnitude of contamination introduced via the analytical process	Result < RDL or less than 5% associated sample activity.
LCS (Laboratory Control Sample)	One per 20 samples or analytical batch	75-125%	Recount/reanalyze batch	Analyst	Accuracy/Bias	75-125%
DUP (Duplicate)	One per 20 samples or analytical batch	act<5*MDC, then RPD is 100% or less. If act>5*MDC, then RPD is 20% or less or RER</=3	Recount/reanalyze batch	Analyst	Precision	act<5*MDC, then RPD is 100% or less. If act>5*MDC, then RPD is 20% or less or RER</=3
Stable Carriers	All field and QC samples	Carrier recoveries 25% - 125%.	Re-prep; notify client; qualify or narrate why condition is acceptable.	Analyst		Carrier recoveries 25% -125%.

Notes:
MB – Method Blank
RDL – Reporting Detection Limit
LCS – laboratory control sample
MDC – minimum detectable concentration
RPD – relative percent difference

Analytical Group VOCs
Analytical Method SW846 8260
SOP Reference GL-OA-E-038

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Internal standards	Every field sample and QC samples	RT within ±30 seconds from RT of initial calibration midpoint standard; area counts within -50% to +100% of initial calibration midpoint standard	Correct problem, then re- reanalyze affected samples	Lab Manager/ Analyst	Accuracy	RT within ±30 seconds and area count within -50% to 100%
Method blank	One per preparation batch	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater). No laboratory common contaminants detected greater than RL.	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/ Analyst	Representativeness	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater). No laboratory common contaminants detected greater than RL.

Analytical Group VOCs
Analytical Method SW846 8260
SOP Reference GL-OA-E-038

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Tumble blank (TCLP only)	One per tumble batch	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/ Analyst	Representativeness	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).
MS/MSD	One MS/MSD pair per preparation batch per matrix	EPA 8260: LCS limits specified in the DoD QSM. RPD less than 20% between MS and MSD	Identify problem; if not related to matrix interference, re-reanalyze MS/MSD and all associated batch samples	Lab Manager/ Analyst	Precision/Accuracy	EPA 8260: LCS limits specified in the DoD QSM. RPD less than 20% between MS and MSD
LCS/LCSD	One LCS or LCS/LCSD pair per preparation batch per matrix	EPA 8260: LCS limits specified in the DoD QSM. RPD less than 20% between LCS and LCSD	Correct problem, then re- reanalyze the LCS and all associated batch samples	Lab Manager/ Analyst	Precision/Accuracy	EPA 8260: LCS limits specified in the DoD QSM. RPD less than 20% between LCS and LCSD
Surrogate standards	Every field sample and QC sample	EPA 8260: Surrogate recovery acceptance criteria specified in the DoD QSM	Correct problem, then re- reanalyze all affected samples	Lab Manager/ Analyst	Accuracy	EPA 8260: Surrogate recovery acceptance criteria specified in the DoD QSM

Analytical Group VOCs
Analytical Method SW846 8260
SOP Reference GL-OA-E-038

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
MDL study	Initial setup, once per 12-month period or quarterly MDL verification	Detection limits established will be below the RLs	Correct problem, then repeat the MDL study	Lab Manager/ Analyst	Sensitivity	Follow requirements from 40CFR 136 appendix B
LOD study	Initial setup and quarterly LOD verification	Signal to noise ratio at the LOD will be greater than 3 and meet method requirements	Correct problem, then repeat detection limit study and LOD verification at a higher concentration, or pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration in accordance with DoD QSM requirements.	Lab Manager/ Analyst	Sensitivity	Detection of the analyte

Analytical Group VOCs
Analytical Method SW846 8260
SOP Reference GL-OA-E-038

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
LOQ study	Annually and quarterly LOQ verification	LOQ will be greater than LOD and within calibration range. Laboratory procedure for establishing the LOQ will empirically demonstrate precision and bias at the LOQ.	Correct problem, then repeat the LOQ study.	Lab Manager/ Analyst	Sensitivity	Recovery within established limits.

Notes:
MB – Method Blank
RDL – Reporting Detection Limit
LCS – laboratory control sample
MS – matrix spike
MSD – matrix spike duplicate
TCLP – Toxicity Characteristic Leaching Procedure
MDC – minimum detectable concentration
RPD – relative percent difference
LOQ – limit of quantitation
LOD – limit of detection

Analytical Group: TAL Metals
Analytical Method/ SOP: SW846 6010C
GL-MA-E-013

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method blank	One per preparation batch	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/ Analyst	Representativeness	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).
Tumble blank (TCLP only)	One per tumble batch	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/ Analyst	Representativeness	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).
MS/MSD	One MS/MSD pair per preparation batch per matrix	80-120% per DoD QSM; RPD less than 20%	Identify problem; if not related to matrix interference, re-reanalyze MS/MSD and all associated batch samples	Lab Manager/ Analyst	Precision/Accuracy	80-120% per DoD QSM; RPD less than 20%
LCS/LCSD	One LCS or LCS/LCSD pair per preparation batch per matrix	80-120% per DoD QSM; RPD less than 20%	Correct problem, then re- reanalyze the LCS and all associated batch samples	Lab Manager/ Analyst	Accuracy	80-120% per DoD QSM; RPD less than 20%

Analytical Group	TAL Metals
Analytical Method/ SOP	SW846 6010C GL-MA-E-013

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Calibration Blank	Before beginning a sample run, after every 10 samples, and at end of the analysis sequence	No analytes detected > 2 × MDL	Any sample associated with a blank that fails the criteria checks will be reprocessed in a subsequent preparation batch, except when the sample analysis resulted in a non-detect. If no sample volume remains for reprocessing, the results will be reported with appropriate data qualifying codes.	Lab Manager/ Analyst	Accuracy	No analytes detected > 2 × MDL
Serial dilution	Each new sample matrix	1:5 dilution must agree within ±10% of original determination.	Perform post-digestion spike if serial dilution does not meet criteria	Lab Manager/ Analyst	Accuracy	1:5 dilution must agree within ±10% of original determination.
Post- digestion spike	When serial dilution or matrix spike fails	75-125%	Re-analyze post-digestion spike.	Lab Manager/ Analyst	Accuracy	75-125%
MDL study	Initial setup, once per 12-month period or quarterly MDL verification	Detection limits established will be below the RLs	Correct problem, then repeat the MDL study	Lab Manager/ Analyst	Sensitivity	Follow requirements from 40CFR 136 appendix B

Analytical Group	TAL Metals
Analytical Method/ SOP	SW846 6010C GL-MA-E-013

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
LOD study	Initial setup and quarterly LOD verification	Signal to noise ratio at the LOD will be greater than 3 and meet method requirements	Correct problem, then repeat detection limit study and LOD verification at a higher concentration, or pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration in accordance with DoD QSM requirements.	Lab Manager/ Analyst	Sensitivity	Detection of the analyte
LOQ study	Annually and quarterly LOQ verification	LOQ will be greater than LOD and within calibration range. Laboratory procedure for establishing the LOQ will empirically demonstrate precision and bias at the LOQ	Correct problem, then repeat the LOQ study.	Lab Manager/ Analyst	Sensitivity	Recovery within established limits.

Notes:
MB – Method Blank
RDL – Reporting Detection Limit
LCS – laboratory control sample
MDC – minimum detectable concentration
MDL – minimum detectable limit
MS – matrix spike
MSD – matrix spike duplicate
TCLP – Toxicity Characteristic Leaching Procedure
RPD – relative percent difference
LOQ – limit of quantitation
LOD – limit of detection

Analytical Group: ICP-MS Metals
Analytical Method/ SOP: SW846 6020A / GL-MA-E-014

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method blank	One per preparation batch	No target analytes detected greater than one-half LOQ and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/ Analyst	Representativeness	No target analytes detected greater than one-half LOQ and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).
Tumble blank (TCLP only)	One per tumble batch	No target analytes detected greater than LOQ and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/ Analyst	Representativeness	No target analytes detected greater than LOQ and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).
MS/MSD	One MS/MSD pair per preparation batch per matrix	Recoveries specified in DoD QSM tables	Identify problem; if not related to matrix interference, re-reanalyze MS/MSD and all associated batch samples	Lab Manager/ Analyst	Precision/Accuracy	Recoveries specified in DoD QSM tables
LCS/LCSD	One LCS or LCS/LCSD pair per preparation batch per matrix	Recoveries specified in DoD QSM tables	Correct problem, then re- reanalyze the LCS and all associated batch samples	Lab Manager/ Analyst	Accuracy	Recoveries specified in DoD QSM tables

Analytical Group ICP-MS Metals
Analytical Method/ SOP SW846 6020A
GL-MA-E-014

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Calibration Blank	Before beginning a sample run, after every 10 samples, and at end of the analysis sequence	No analytes detected > 1/2 LOQ	Any sample associated with a blank that fails the criteria checks will be reprocessed in a subsequent preparation batch, except when the sample analysis resulted in a non-detect. If no sample volume remains for reprocessing, the results will be reported with appropriate data qualifying codes.	Lab Manager/ Analyst	Accuracy	No analytes detected > 1/2 LOQ
Serial dilution	Each new sample matrix	1:5 dilution must agree within ±10% of original determination.	Perform post-digestion spike if serial dilution does not meet criteria	Lab Manager/ Analyst	Accuracy	1:5 dilution must agree within ±10% of original determination.
Post- digestion spike	When serial dilution or matrix spike fails	80-120%	Re-analyze post-digestion spike.	Lab Manager/ Analyst	Accuracy	80-120%
MDL study	Initial setup, once per 12-month period or quarterly MDL verification	Detection limits established will be below the RLs	Correct problem, then repeat the MDL study	Lab Manager/ Analyst	Sensitivity	Follow requirements from 40CFR 136 appendix B

Analytical Group	ICP-MS Metals
Analytical Method/ SOP	SW846 6020A GL-MA-E-014

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
LOD study	Initial setup and quarterly LOD verification	Signal to noise ratio at the LOD will be greater than 3 and meet method requirements	Correct problem, then repeat detection limit study and LOD verification at a higher concentration, or pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration in accordance with DoD QSM requirements.	Lab Manager/ Analyst	Sensitivity	Detection of the analyte
LOQ study	Annually and quarterly LOQ verification	LOQ will be greater than LOD and within calibration range. Laboratory procedure for establishing the LOQ will empirically demonstrate precision and bias at the LOQ	Correct problem, then repeat the LOQ study.	Lab Manager/ Analyst	Sensitivity	Recovery within established limits.

Notes:
MB – Method Blank
RDL – Reporting Detection Limit
LCS – laboratory control sample
MDC – minimum detectable concentration
MDL – minimum detectable limit
MS – matrix spike
MSD – matrix spike duplicate
TCLP – Toxicity Characteristic Leaching Procedure
RPD – relative percent difference
LOQ – limit of quantitation
LOD – limit of detection

Analytical Group: Mercury
Analytical Method/ SOP: SW846 7470A, 7471B
GL-MA-E-010

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method blank	One per preparation batch	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/ Analyst	Representativeness	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).
Tumble blank (TCLP only)	One per tumble batch	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/ Analyst	Representativeness	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).
MS/MSD	One MS/MSD pair per preparation batch per matrix	80-120% per DoD QSM; RPD less than 20%	Identify problem; if not related to matrix interference, re-reanalyze MS/MSD and all associated batch samples	Lab Manager/ Analyst	Precision/Accuracy	80-120% per DoD QSM; RPD less than 20%
LCS/LCSD	One LCS or LCS/LCSD pair per preparation batch per matrix	80-120% per DoD QSM; RPD less than 20%	Correct problem, then re- reanalyze the LCS and all associated batch samples	Lab Manager/ Analyst	Accuracy	80-120% per DoD QSM; RPD less than 20%

Analytical Group	Mercury
Analytical Method/ SOP	SW846 7470A, 7471B GL-MA-E-010

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Calibration Blank	Before beginning a sample run, after every 10 samples, and at end of the analysis sequence	No analytes detected > 2 × MDL	Any sample associated with a blank that fails the criteria checks will be reprocessed in a subsequent preparation batch, except when the sample analysis resulted in a non-detect. If no sample volume remains for reprocessing, the results will be reported with appropriate data qualifying codes.	Lab Manager/ Analyst	Accuracy	No analytes detected > 2 × MDL
Serial dilution	Each new sample matrix	1:5 dilution must agree within ±10% of original determination.	Perform post-digestion spike if serial dilution does not meet criteria	Lab Manager/ Analyst	Accuracy	1:5 dilution must agree within ±10% of original determination.
Post- digestion spike	When serial dilution or matrix spike fails	75-125%	Re-analyze post-digestion spike.	Lab Manager/ Analyst	Accuracy	75-125%
MDL study	Initial setup, once per 12-month period or quarterly MDL verification	Detection limits established will be below the RLs	Correct problem, then repeat the MDL study	Lab Manager/ Analyst	Sensitivity	Follow requirements from 40CFR 136 appendix B

Analytical Group	Mercury
Analytical Method/ SOP	SW846 7470A, 7471B GL-MA-E-010

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
LOD study	Initial setup and quarterly LOD verification	Signal to noise ratio at the LOD will be greater than 3 and meet method requirements	Correct problem, then repeat detection limit study and LOD verification at a higher concentration, or pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration in accordance with DoD QSM requirements.	Lab Manager/ Analyst	Sensitivity	Detection of the analyte
LOQ study	Annually and quarterly LOQ verification	LOQ will be greater than LOD and within calibration range. Laboratory procedure for establishing the LOQ will empirically demonstrate precision and bias at the LOQ	Correct problem, then repeat the LOQ study.	Lab Manager/ Analyst	Sensitivity	Recovery within established limits.

Notes:
MB – Method Blank
RDL – Reporting Detection Limit
LCS – laboratory control sample
MDC – minimum detectable concentration
MDL – minimum detectable limit
MS – matrix spike
MSD – matrix spike duplicate
TCLP – Toxicity Characteristic Leaching Procedure
RPD – relative percent difference
LOQ – limit of quantitation
LOD – limit of detection

Analytical Group PCBs
Analytical Method/ SOP SW846 8082A
GL-OA-E-040

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparation batch	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/ Analyst	Representativeness	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).
MS/MSD	One MS/MSD pair per preparation batch per matrix	EPA 8082: LCS limits specified in the DoD QSM RPD less than 20% between MS and MSD	Identify problem; if not related to matrix interference, re-reanalyze MS/MSD and all associated batch samples	Lab Manager/ Analyst	Precision/Accuracy	EPA 8082: LCS limits specified in the DoD QSM RPD less than 20% between MS and MSD
LCS/LCSD	One LCS or LCS/LCSD pair per preparation batch per matrix	EPA 8082: LCS limits specified in the DoD QSM. RPD less than 20% between LCS and LCSD	Correct problem, then re- reanalyze the LCS and all associated batch samples	Lab Manager/ Analyst	Precision/Accuracy	EPA 8082: LCS limits specified in the DoD QSM. RPD less than 20% between LCS and LCSD
Surrogate standards	Every field sample and QC sample	EPA 8082: Surrogate recovery acceptance criteria specified in the DoD QSM	Correct problem, then re- reanalyze all affected samples	Lab Manager/ Analyst	Accuracy	EPA 8082: Surrogate recovery acceptance criteria specified in the DoD QSM
MDL study	Initial setup, once per 12-month period or quarterly MDL verification	Detection limits established will be below the RLs	Correct problem, then repeat the MDL study	Lab Manager/ Analyst	Sensitivity	Follow requirements from 40CFR 136 appendix B
LOD study	Initial setup and quarterly LOD verification	Signal to noise ratio at the LOD will be greater than 3 and meet method requirements	Correct problem, then repeat detection limit study and LOD verification at a higher concentration, or pass	Lab Manager/ Analyst	Sensitivity	Detection of the analyte

Analytical Group	PCBs
Analytical Method/ SOP	SW846 8082A GL-OA-E-040

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
			two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration in accordance with DoD QSM requirements.			

Notes:
DOD QSM – Department of Defense Quality Systems Manual
MB – Method Blank
RDL – Reporting Detection Limit
RL - Reporting Limit
LCS – laboratory control sample
MDC – minimum detectable concentration
MDL – minimum detectable limit
MS – matrix spike
MSD – matrix spike duplicate
TCLP – Toxicity Characteristic Leaching Procedure
RPD – relative percent difference
LOQ – limit of quantitation
LOD – limit of detection

Analytical Group: Hexavalent Chromium
Analytical Method/ SOP: SW846 7196A
GL-GC-E-044

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method blank	One per preparation batch	+/- RL	Correct problem, then re-reanalyze method blank and all samples processed with the contaminated blank	Analyst	Representativeness	+/- RL
LCS	1 per preparatory batch	90%-110%	Identify problem; if not related to matrix interference, re-reanalyze LCS and all associated batch samples	Analyst	Accuracy	90%-110%
Sample Duplicate	1 per preparatory batch per matrix	RPD < 20%	Qualify data	Analyst	Precision	RPD < 20%
Matrix Spike	MS per preparation batch	85%-115%	Qualify data	Analyst	Accuracy	85%-115%
Initial Calibration Verifcation	At the beginning of analytical sequence	90%-110%	Recalibrate and reanalyze	Analyst	Accuracy	90%-110%
Initial Calibration Blank	At the beginning of analytical sequence	+/- RL	Recalibrate and reanalyze	Analyst	Accuracy	+/- RL
Continuing Check	Every 10 samples and at the end of analytical sequence	90%-110%	Rerun samples bracketed by failing CCV	Analyst	Accuracy	90%-110%
Continuing Blank	Every 10 samples and at the end of analytical sequence	+/- RL	Rerun samples bracketed by failing CCB	Analyst	Accuracy	+/- RL
Method blank	One per preparation batch	+/- RL	Correct problem, then re-reanalyze method blank and all samples processed with the contaminated blank	Analyst	Representativeness	+/- RL

Notes:
RL - Reporting Limit

Notes (continued):
MS – matrix spike
RPD – relative percent difference

Analytical Group	SVOCs
Analytical Method/ SOP	SW846 8270D, 8270E GL-OA-E-009

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Internal standards	Every field sample and QC samples	RT within ±30 seconds from RT of initial calibration midpoint standard; area counts within -50% to +100% of initial calibration midpoint standard	Correct problem, then re- reanalyze affected samples	Lab Manager/ Analyst	Accuracy	RT within ±30 seconds and area count within -50% to 100%
Method blank	One per preparation batch	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater). No laboratory common contaminants detected greater than RL.	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/ Analyst	Representativeness	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater). No laboratory common contaminants detected greater than RL.
Tumble blank (TCLP only)	One per tumble batch	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/ Analyst	Representativeness	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).
MS/MSD	One MS/MSD pair per preparation batch per matrix	EPA 8270: LCS limits specified in the DoD QSM. RPD less than 30% between MS and MSD	Identify problem; if not related to matrix interference, re-reanalyze MS/MSD and all associated batch samples	Lab Manager/ Analyst	Precision/Accuracy	EPA 8270: LCS limits specified in the DoD QSM. RPD less than 30% between MS and MSD
LCS/LCSD	One LCS or LCS/LCSD pair per preparation batch per matrix	EPA 8270: LCS limits specified in the DoD QSM. RPD less than 30% between LCS and LCSD	Correct problem, then re- reanalyze the LCS and all associated batch samples	Lab Manager/ Analyst	Precision/Accuracy	EPA 8270: LCS limits specified in the DoD QSM. RPD less than 30% between LCS and LCSD

Analytical Group	SVOCs
Analytical Method/ SOP	SW846 8270D, 8270E GL-OA-E-009

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Surrogate standards	Every field sample and QC sample	EPA 8270: Surrogate recovery acceptance criteria specified in the DoD QSM	Correct problem, then re- reanalyze all affected samples	Lab Manager/ Analyst	Accuracy	EPA 8270: Surrogate recovery acceptance criteria specified in the DoD QSM

Notes:
DOD QSM – Department of Defense Quality Systems Manual
RL - Reporting Limit
LCS – laboratory control sample
MS – matrix spike
MSD – matrix spike duplicate
TCLP – Toxicity Characteristic Leaching Procedure
RPD – relative percent difference

Analytical Group	Pesticides
Analytical Method/ SOP	SW843 8081B GL-OA-E-041

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method blank	One per preparation batch	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/ Analyst	Representativeness	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).
Tumble blank (TCLP only)	One per tumble batch	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Lab Manager/ Analyst	Representativeness	No target analytes detected greater than one-half RL and 1/10 the amount measured in any sample or 1/10 regulatory limit (whichever is greater).
MS/MSD	One MS/MSD pair per preparation batch per matrix	EPA 8081: LCS limits specified in the DoD QSM. RPD less than 30% between MS and MSD	Identify problem; if not related to matrix interference, re-reanalyze MS/MSD and all associated batch samples	Lab Manager/ Analyst	Precision/Accuracy	EPA 8081: LCS limits specified in the DoD QSM. RPD less than 30% between MS and MSD
LCS/LCSD	One LCS or LCS/LCSD pair per preparation batch per matrix	EPA 8081: LCS limits specified in the DoD QSM. RPD less than 30% between MS and MSD	Correct problem, then re- reanalyze the LCS and all associated batch samples	Lab Manager/ Analyst	Precision/Accuracy	EPA 8081: LCS limits specified in the DoD QSM. RPD less than 30% between LCS and LCSD
Surrogate standards	Every field sample and QC sample	EPA 8081: Surrogate recovery acceptance criteria specified in the DoD QSM	Correct problem, then re- reanalyze all affected samples	Lab Manager/ Analyst	Accuracy	EPA 8081: Surrogate recovery acceptance criteria specified in the DoD QSM

Analytical Group	Pesticides
Analytical Method/ SOP	SW843 8081B GL-OA-E-041

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
MDL study	Initial setup, once per 12-month period or quarterly MDL verification	Detection limits established will be below the RLs	Correct problem, then repeat the MDL study	Lab Manager/ Analyst	Sensitivity	Follow requirements from 40CFR 136 appendix B
LOD study	Initial setup and quarterly LOD verification	Signal to noise ratio at the LOD will be greater than 3 and meet method requirements	Correct problem, then repeat detection limit study and LOD verification at a higher concentration, or pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration in accordance with DoD QSM requirements.	Lab Manager/ Analyst	Sensitivity	Detection of the analyte
LOQ study	Annually and quarterly LOQ verification	LOQ will be greater than LOD and within calibration range. Laboratory procedure for establishing the LOQ will empirically demonstrate precision and bias at the LOQ	Correct problem, then repeat the LOQ study.	Lab Manager/ Analyst	Sensitivity	Recovery within established limits.
PEM	DDT and Endrin Breakdown	≤15% for DDT and Endrin	Clean and start over (cannot proceed with sample analysis). The DQI would be exceeding the limit of 15%.	Lab Manager/ Analyst	Sensitivity	≤15% for DDT and Endrin

Notes:
MB – Method Blank
RDL – Reporting Detection Limit
LCS – laboratory control sample
MDC – minimum detectable concentration
MDL – minimum detectable limit
MS – matrix spike
MSD – matrix spike duplicate
TCLP – Toxicity Characteristic Leaching Procedure
RPD – relative percent difference
LOQ – limit of quantitation
LOD – limit of detection
PEM – Photon Emission Microscopy
DDT - Dichlorodiphenyltrichloroethane

Analytical Group	Cyanide
Analytical Method/ SOP	SW846 9012 GL-GC-E-112

QC Sample	Frequency / Number	QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method blank	One per preparation batch	+/- RL	Correct problem, then re- reanalyze method blank and all samples processed with the contaminated blank	Analyst	Representativeness	+/- RL
LCS	1 per preparatory batch	90%-110% liquids, 63%-136% solids	Identify problem; if not related to matrix interference, re-reanalyze LCS and all associated batch samples	Analyst	Accuracy	90%-110% liquids, 63%-136% solids
Sample Duplicate	1 per preparatory batch per matrix	RPD < 20% liquid, < 30% solids	Qualify data	Analyst	Precision	RPD < 20% liquid, < 30% solids
Matrix Spike	MS per preparation batch	78%-126% liquids, 63%-136% solids	Qualify data	Analyst	Accuracy	78%-126% liquids, 63%-136% solids
Initial Calibration Verification	At the beginning of analytical sequence	90%-110%	Recalibrate and reanalyze	Analyst	Accuracy	90%-110%
Initial Calibration Blank	At the beginning of analytical sequence	+/- RL	Recalibrate and reanalyze	Analyst	Accuracy	+/- RL
Continuing Check	Every 10 samples and at the end of analytical sequence	90%-110%	Rerun samples bracketed by failing CCV	Analyst	Accuracy	90%-110%
Continuing Blank	Every 10 samples and at the end of analytical sequence	+/- RL	Rerun samples bracketed by failing CCB	Analyst	Accuracy	+/- RL

Notes:
MB – Method Blank
RL – Reporting Limit
LCS – laboratory control sample

Notes (continued):
MS – matrix spike
RPD – relative percent difference
CCV – continuing calibration verification
CCB – continuing calibration blank

UFP-QAPP WORKSHEET #29
PROJECT DOCUMENTS AND RECORDS

Record	Generator	Verification	Storage Location
Field Log, data collection sheets	SRSO	Project HP	SharePoint folder
Daily QC Reports	SRSO	Cabrera PM	SharePoint folder
Chain of Custody Forms and Air Bills	SRSO	Project Chemist	SharePoint folder
Laboratory Reports	Laboratory Analyst	Project Chemist	SharePoint folder
Verification Checklist	Project HP	Cabrera PM	SharePoint folder
Validation Report	Validata Chemical Services Inc. Data Validator	Cabrera PM	SharePoint folder, Final Project Report
Data Usability Report	Project HP	Cabrera PM	SharePoint folder, Final Project Report

UFP-QAPP WORKSHEETS #31, #32, AND #33
ASSESSMENTS AND CORRECTIVE ACTION

Assessment Type	Responsible Party	Number/Frequency	Estimated Dates	Assessment Deliverable	Deliverable Due Date
Field Observations, Deviations from Work Plans	SRSO	Daily logbook reviews	Daily	E-mail notification to Cabrera PM and Project HP	24 hours
Health and Safety	SRSO	Once, if necessary, based on observed site conditions	As required, to be determined	Letter report to Cabrera PM and Health and Safety Manager	One week after assessment
Data Review	Project HP	Once	End of field work prior to demobilization	Approval to demob, Cabrera PM notified by e-mail data collection activities are complete	End of field work prior to demobilization

UFP-QAPP WORKSHEET #34
DATA VERIFICATION AND VALIDATION INPUT

Item	Description	Verification (completeness)	Validation (conformance to specifications)
	Planning Documents		
1	Approved UFP-QAPP	X	
2	OPs	X	
	Field Records		
3	Field Logbooks	X	
4	Daily Reports	X	
5	Equipment Calibration Records	X	X
6	Chain of Custody Forms	X	X
7	Change Orders/Deviations	X	X
	Laboratory Data Package		
8	Cover Sheet	X	X
9	Case Narrative	X	X
10	Sample Receipt Records	X	X
11	Sample Chronology	X	X
12	Definition of Laboratory Qualifiers	X	X
13	Project Sample Results	X	X
14	QC Sample Results	X	X
15	Corrective Action Reports	X	X
16	Electronic Data Deliverable	X	X

UFP-QAPP WORKSHEET #35
DATA VERIFICATION PROCEDURES

Data Input	Description	Responsible for Verification
Field Logbooks, Daily Reports	Field notes and reports will be prepared daily by the SRSO describing personnel and equipment present at the site, weather conditions, and project activities performed. The SRSO and Cabrera PM will review the documentation for accuracy and completeness. Field logbooks and daily reports will be placed in the project file.	SRSO Cabrera PM
Field Instrument Quality Control	Field instruments quality control records will be prepared daily, or for each use, by the SRSO. These records demonstrate the field instruments were operating as expected before and after field data were collected. The Project HP will review the records for accuracy and completeness.	SRSO Project HP
UFP-QAPP, SOPs	All planning documents will be available to reviewers to allow reconciliation with planned activities and objectives.	All data users
Laboratory Data Package, COCs	Data packages will be reviewed/verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal. All laboratory data will be verified by the laboratory performing the analysis for completeness and technical accuracy prior to submittal to Cabrera. Data packages will be reviewed as to content and sample information upon receipt. Cabrera will evaluate the data packages for completeness and compliance prior to third-party validation.	Laboratory analyst and QA officer, Data Manager, Project HP

UFP-QAPP WORKSHEET #36
DATA VALIDATION PROCEDURES

Third-party full data validation is required for sampling identified in this UFP-QAPP. Data validation will be performed by Validata Chemical Services, Inc. (Validata). Data validation activities to assess data usability including (1) review of the data package for completeness; (2) review of chain-of-custody forms (against laboratory reported information) for signatures, sample condition upon receipt by the laboratory, and sample preservation; (3) review of hold times; (4) review of QC summaries and case narratives; (5) review of blank results for possible field or laboratory contamination; and (6) review of laboratory detection limits for project samples to verify conformance with project objectives (screening levels). Results of the data verification activities will be documented in a memo to the project file.

All data provided by the analytical laboratory will be provided via Level IV data packages. Level IV data validation (full review of sample and QC results, calibrations, and associated raw data) of the sample analyses will be completed within 3 weeks of Validata's receipt of complete analytical data package and electronic data deliverable. Validation will be conducted in accordance with MARLAP Manual Volume 1 (EPA, 2004), "US EPA Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review," (EPA 2020a) and "US EPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Methods Data Review" (EPA 2020b).

UFP-QAPP WORKSHEET #37
DATA USABILITY ASSESSMENT

The Data Usability Assessment will be performed by the Project Health Physicist, or designee. The results of the Data Usability Assessment will be based on comparisons of the data validation results and the DQOs, data quality indicators, and measurement performance criteria provided in Worksheet #12. The results of the Data Usability Assessment will be provided in the final project report and present any limitations on the use of the data. The report will identify deviations from planned procedures, a comparison between planned and observed detection limits, and impacts on data quality and project objectives.

3.0 REFERENCES

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Cabrera 2024a. Project Management Plan, Area 2 of SWMU-11, Dugway Proving Ground, Dugway, Utah. Cabrera Services Inc. Draft Final, April.

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Department of Defense. 2021. *Quality Systems Manual for Environmental Laboratories, Version 5.4*. Based on National Environmental Laboratory Accreditation Conference Institute Standards, Volume 1. October.

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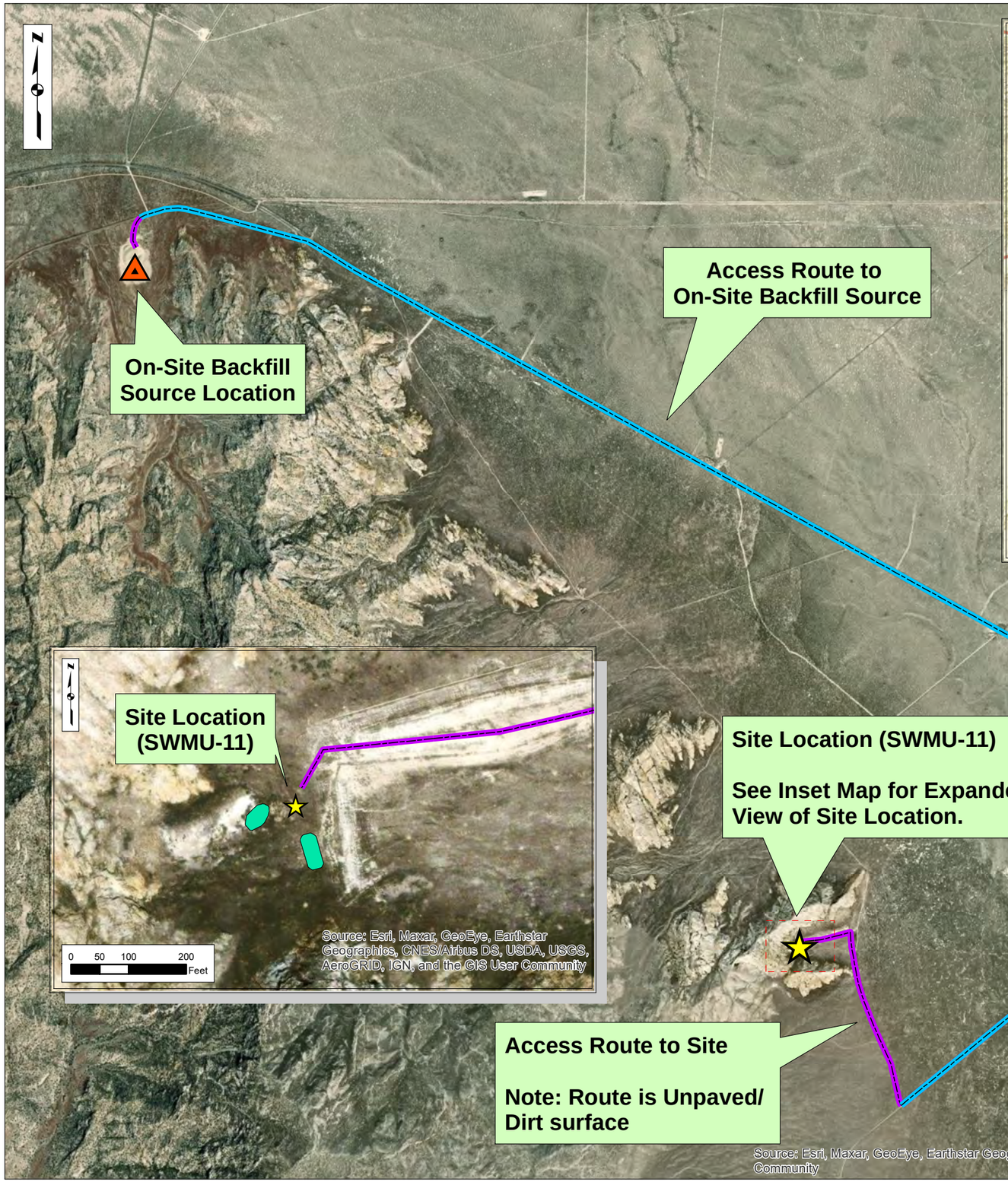
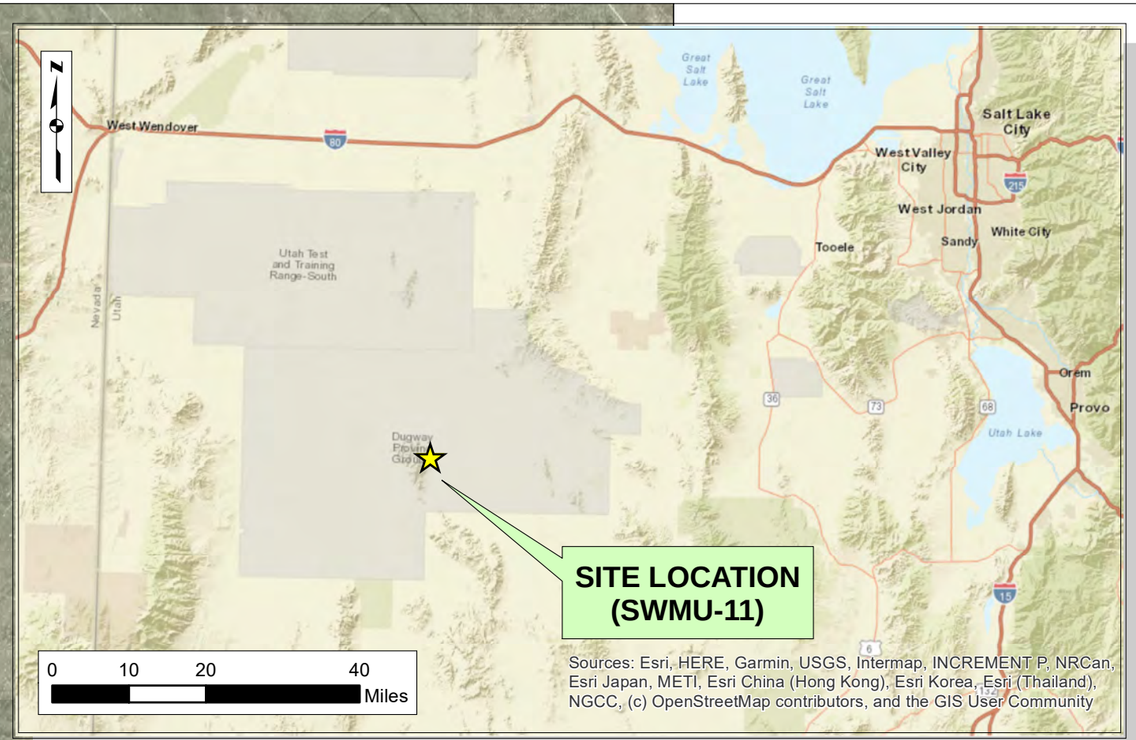
Parsons, 2009, Final Phase II RCRA Facility Investigation: SWMU 11 Addendum, Dugway Proving 886 Ground, Dugway, Utah, Parsons Engineering Science, Salt Lake City, UT, August**.**

FIGURES





SWMU-11 Site Location

On-Site Backfill Source

Site Access Roads

On-Site Dirt Road

On-Site Paved Road

TR-5 & TR-6 Trench Locations

SITE LOCATION

DUGWAY PROVING GROUND
DUGWAY, UTAH

1/2024	GIS ANALYST: S. Owe	FIGURE 1

CABRERA SERVICES
CHALLENGE ACCEPTED

Survey Unit (SU) 2 (Class1)
(TR-6 Excavation Extents)
(118 m2)
(18) Systematic Samples

TR-6 Excavation Details
Depth = 0 to 7 Ft bgs
Note vertical sidewall from
3.0 to 7.0 Ft bgs

Survey Unit (SU) 3 (Class 2)
(RCA/ Buffer Area)
(1,576 m2)
(18) Systematic Samples

Survey Unit (SU) 1 (Class1)
(TR-5 Excavation Extents)
(158 m2)
(18) Systematic Samples

TR-5 Excavation Details
Depth = 0 to 7 Ft bgs
Note vertical sidewall from
3.0 to 7.0 Ft bgs

TR-6

TR-5

4388 4386 4385 4384 4383 4382 4381 4380 4379 4378 4377 4376 4375

4382 - 4379

4377 - 4374

0 10 20 40
Feet

N

Legend

- SU1 Sample Locations
- SU2 Sample Locations
- SU3 Sample Locations
- SU1 Boundary (Class 1)
- SU2 Boundary (Class 1)
- SU3 Boundary (Class 2)
- Trench Limits (TR-5 & TR-6)
- Topographic Contour Elevation

(Contour Interval = 1.0 Ft AMSL)

Notes:
FSS = Final Status Survey
SU = Survey Unit
m2 = square meter
Ft = feet
AMSL = Above Mean Sea Level
bgs = below ground surface

FSS SURVEY UNIT BOUNDARIES & SAMPLE LOCATIONS

AREA 2 OF SWMU-11
DUGWAY PROVING GROUND
DUGWAY, UTAH

8/2024	GIS ANALYST: S. Owe	FIGURE 2

CABRERA SERVICES
CHALLENGE ACCEPTED

ATTACHMENT A

OPERATING PROCEDURES

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

RECORDS MANAGEMENT

OP-187

Revision 0

Prepared by:

_____ 3/16/12

David Wunsch, Quality Assurance Manager Date

Approved by:

_____ _____

Kim Nelson, PG. President/COO Date

1.0 Purpose

The purpose of this procedure is to ensure that all required records are maintained in a consistent manner and compliant with quality and client requirements.

2.0 Applicability

This procedure applies to all CABRERA operating units and their methods to generate, identify, collect, index, access, file, store, maintain, and dispose of records unless specifically directed by contract or license requirements.

3.0 Definitions

3.1 Quality Records – Documents providing evidence that CABRERA quality management system (QMS) and client-related contractual quality requirements have been completed and are operating effectively. These documents would include the approval of required actions, client satisfaction surveys, the completion of required reviews or audit actions (re: OP-190), and the resolution of problems identified in nonconformity reports (re: OP-191). Quality records may be maintained in electronic or hard copy form.

3.2 Technical Records – Accumulations of data and information sufficient to form an audit trail which result from carrying out sampling and/or testing and indicate whether specified quality or process parameters are met. They may include forms, worksheets, workbooks, check sheets, work notes, control graphs, external or internal test reports, calibration certificates, and client feedback. Technical records may be maintained in electronic or hard copy form.

3.3 Master List of Quality Records – Identifies the quality records associated with the QMS. It includes the following information: record owner; format (electronic or paper); location of record; minimum retention period, indexing method, and disposition.

Note: Unless specifically defined as either quality or technical, the term *record* used throughout this procedure will refer to both record types.

4.0 Precautions, Limitations and Requirements

There are no special precautions, limitations or requirements associate with this procedure.

5.0 Equipment

There is no special equipment associated with this procedure.

6.0 Responsibilities

6.1 All CABRERA Staff – Ensure that quality and technical records, within their areas of responsibility, are maintained according to this procedure.

6.2 Quality Assurance Manager (QAM) – Ensures that CABRERA quality records are maintained according to this procedure. Establish, maintain and update

a Master List of Quality Records to meet the requirements of the ISO 9001 standard.

6.3 Program and Project Managers – Controlling project records to include: identifying records to be generated, maintaining custody, indexing, ensuring safe storage, and providing for maintenance, retention and, if required, their transfer or destruction.

6.4 Laboratory Quality Manager (LQM) – Ensures that technical records, associated with laboratory operations, are maintained according to this procedure and assists laboratory staff establish records control practices to comply with the ISO 17025 standard and/or other accreditation requirements.

7.0 Procedure

The following subsections describe the instructions to be followed and procedures to be implemented in the management and control of records.

7.1 Identification

7.1.1 All operating unit and QMS-related staff are to identify quality records within their areas of responsibility using the following criteria:

- Contractual and customer requirements documents (e.g., contracts, task orders).
- Documents that verify the conduct or report results of technical and editorial quality reviews (e.g., Independent Technical Review form).
- Documents that provide evidence of the quality of products or services either received by CABRERA or provided to customers (e.g., customer quality surveys).
- Documents that demonstrate conformance to effective operation of the QMS (e.g., Corrective Action Request).
- Quality record requirements specified by the ISO 9001standards.

7.1.2 Quality records associated with the CABRERA QMS are identified in the Master List of Quality Records. The QAM is responsible for maintaining this list and updates it as needed. The master list includes the following information for each quality record: record owner (department or position); format of record (electronic or paper); location of record; retention period, indexing method, and disposition.

7.1.3 Technical records associated with CABRERA field and laboratory operations are either identified within corporate-wide and site-specific operating procedures or by the following criteria:

- Contractual and customer requirements documents (e.g., contracts, task orders).
- Documentation mandated by client referenced guides, manuals and/or standard laboratory and field methods.
- Any additional documentation of observations or derived data that ensures sample traceability or demonstrates that data quality objectives have been met.

7.2 Generation and Authentication

7.2.1 Records to be generated shall be specified in applicable documents, such as contracts, procurement documents, test methods, operating procedures or design specifications.

7.2.2 Records shall be traceable to associated equipment or activities and accurately reflect the work accomplished or information required.

7.2.3 Records will only be considered valid if stamped, initialed, or signed and dated, unless otherwise authenticated.

7.2.4 Electronic records will be authenticated with comparable information, as appropriate, with identification on the media; or with authentication information contained within or linked to the document itself.

7.2.5 When handwritten, records will be legible and written in permanent ink.

7.2.6 When mistakes occur in records, each mistake will be corrected by striking a single line through the entry and the correct entry made alongside. The record will not be erased, deleted or otherwise made illegible. All alterations to records will be signed/initialed and dated by the person making the correction. When corrections are made for other than transcription errors, the reason for the correction will be documented.

7.3 Collection, Filing and Indexing

7.3.1 All records will be collected, filed and indexed in a manner that ensures they are readily retrievable and auditable; and, with electronic project files organized as directed in OP-106, *Electronic File Structure.*

7.3.2 Quality recordsassociated with the effectiveness of the QMS are collected by the QAM, and filed and indexed according to their associated QMS program.

7.3.3 Project/task records are collected by the project manager, filed in project-specific files (actual and electronic), and indexed in a manner consistent with the work plans and/or site operations.

7.3.4 Laboratory records are collected by laboratory staff, under the management of the laboratory director, and filed and indexed in a manner consistent with client/regulatory requirements and laboratory work flow.

7.4 Access

7.4.1 All records will be held in a secure manner and in confidence to the client. Therefore, access to the processing, storage, and retrieval of records is limited to the authorized personnel listed in Section 7.3, their designees, and CABRERA senior management.

7.4.2 All records will be made available to authorized client personnel, regulatory representatives, and auditing organizations, upon request

7.5 Maintenance and storage

7.5.1 Records will be maintained and stored in a manner that protects them from damage, deterioration, destruction, or loss (e.g., locked metal cabinets). In addition, records stored solely on electronic media will be supported by hardware and software that can ensure their retrieval.

7.5.2 Records generated by or stored on personal computers will have either a hard copy or write-protected backup copies.

7.5.3 Field and laboratory operations will develop and implement a management system for the control, maintenance and storage of notebooks, logbooks or other media used for collecting records while on site. This management system will be documented in project-specific work plans.

7.5.4 Once a project is closed, the project files, including all associated records, will be packed and shipped for the long-term storage in accordance with OP-183, *Document Archiving*. Retrieval of archival records will also follow processes defined in OP-183.

7.6 Retention and Disposal

7.6.1 The retention time for all corporate quality recordsassociated with assessing the effectiveness of the QMS is 5 years.

7.6.2 All project-related records shall be retained for a minimum of 10 years from the date of project closure, except where the duration is specified in a contract or mandated by Federal or

State regulations, where applicable. Retention beyond 10 years will be reviewed on a project-by-project basis.

7.6.3 Records disposal will be implemented such that client or corporate confidentiality is maintained. This could involve either the transfer or destruction of these records, as required or instructed.

8.0 References

- ISO 9001 American National Standard (2008), Section 4.2.4, *Control of Records*
- ISO 17025 International Standard (2005), Section 4.13, *Control of Records*
- DoD Quality Systems Manual Version 4.2 (2010), Section 4.12, *Control of Records*
- ASME NQA-1 American National Standard (2008), Nonmandatory Appendix 17A-1,*Guidance on Quality Assurance Records*
- ASME NQA-1 American National Standard (2008), Nonmandatory Appendix 17A-2,*Guidance for Electronic Records*

9.0 Required Records

Master List of Quality Records – maintained electronically by the QAM on the CABRERA Intranet

10.0 Attachments

There are no attachments associated with this procedure.

OPERATING PROCEDURE

FOR

FIELD ACTIVITY DOCUMENTATION

OP-3001

(FORMERLY OP-359)

Revision 2.0
January 2021

Level of Use:
Information Use

APPROVALS	
Vice President	*B. Lorenz, PE, PMP*
Quality Assurance	*S. Liddy, CSP*
This procedure is the property of Cabrera Services Inc. and is considered approved and effective for the duration it is posted electronically to the Controlled Copy Document Repository.	

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History of Revisions		
Revision	**Month-Year**	**Description**
0.1	August 2007	OP-059 - Initial issue.
1.0	March 2014	Substantial (major) revision to update overall program elements to latest regulations, guidance, and industry practices. Renumbered per 3-digit series to OP-359.
2.0	January 2021	Substantial (major) revision to update overall program elements to latest regulations, guidance, and industry practices. Renumbered per OP-2001 to 4-digit series as OP-3001.

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1.0 PURPOSE

This Operating Procedure (OP) provides the methods Cabrera Services Inc. (Cabrera) personnel shall utilize when documenting field activities. Adherence to this procedure will assure that the field work is properly documented to meet the established project quality objectives by capturing field conditions, details regarding the work performed to include changes or variations to the planned SOW, and other pertinent details regarding the execution of the field effort. Additionally, this documentation will allow for an adequate description of the work performed in subsequent reports.

2.0 SCOPE/APPLICABILITY

Personnel shall utilize this procedure when conducting any field activity. Clear and complete written documentation of field activities is an essential part of a field project. Field notes will become a permanent part of the project records and should be regarded as a client-deliverable document. The keeping of field logs is a requirement under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (USEPA, 1988). Personnel should approach field documentation with the understanding that all of the field work should be able to be written into a report using the field notes alone, by an author who did not take part in field operations.

3.0 DEFINITIONS

3.1 Project Work Plans – A set of work plans usually consisting of a Project Work Plan (PWP), a Field Sampling Plan (FSP), and Quality Assurance Project Plan (QAPP). Other plans may be added to the Project Management Plans depending on the complexity of the project, client needs, and regulatory requirements.

4.0 RESPONSIBILITIES

4.1 Project Manager (PM): The PM is responsible for ensuring that the assigned personnel are familiar with this procedure and that the required aspects of the field work are being properly documented.

4.2 Field Site Manager (FSM) - The FSM is responsible for ensuring that field personnel are entering information into the field notebooks for their assigned tasks. The FSM is responsible for custody of the field forms and field notebooks that are kept by the project team. This responsibility may be delegated to the Cabrera Quality Control System Manager (CQCSM) if that person is on-site.

4.3 Field Personnel - All field personnel are responsible for reading and complying with the provisions of this procedure. All field personnel may make entries to field forms and field notebooks.

5.0 PRECAUTIONS, LIMITATIONS AND PREREQUISITES

Any measurement that is not made on a field form should be entered in the field notebook. Consider making notebook entries that are redundant to field form entries for important measurements.

The notebook must be bound, and entries must be made in ink. Pages must be sequentially numbered. An entry should be made for each day that activities occur at the field site, including mobilization days and demobilization days. Entries must be dated and initialed by the person making the entry. Blank pages should be lined out and initialed.

Field Personnel shall discuss deviations from the Project Work Plans with the Project Manager and receive approval prior to doing such. These actions shall be documented in the project field notebook at a minimum, noting the date and time the change was approved, as well as the name of the individual that approved the change.

6.0 EQUIPMENT

Field notebooks shall be water-resistant and permanently-bound with consecutively-numbered pages (examples include Rite-in-the-Rain Part Numbers 350N, 353N or equivalent).

Although not required by this procedure, field forms may be produced on water-proof paper (Rite-in-the-Rain Part Number 8511 or equivalent).

Indelible ink pens with permanent, black or blue indelible ink, or permanent water-proof fine-point markers should be used.

7.0 INSTRUCTIONS/PROCEDURE

These procedures are to be used by the Cabrera field representative for all field investigations unless project-specific planning documents or other written, approved documents supersede. Should the Cabrera FSM be faced with a situation where alternative field procedures must be used because of site conditions, he/she should notify the PM of the conditions and the suggested alternative procedures.

7.1 Project Documentation

7.1.1 It is essential that all field work be documented completely and correctly because (1) a written record of events in the field is more reliable and accessible than personal memory; and (2) field records could later be used as evidence for litigation. Field documentation is an important part of a project's permanent record, and it should be concise and factual. Emotional, speculative, or humorous statements regarding events, subcontractors,

clients, owners, or site visitors must not be included.

7.1.2 A project field logbook will be kept by the FSM (minimum), and by individual Field Personnel based on the project scope and tasks. The following information must be included in each day's entry:

- The project name, number, and site address will be recorded on the inside front cover of the field logbook.
- Each daily entry shall start at the top of a new page, and include the name of the person (FSM and/or Field Personnel) recording the information, date, time on-site, and the task being recorded.
- Notations in the field logbook will be made in logbook fashion, noting the time and date of all entries. All pertinent information regarding the site will be documented as near to real-time as possible using military-time format (for example, 1:15 pm becomes 1315 hrs).
- Weather conditions shall be noted in the morning and throughout the course of the day to reflect any changes.
- At the conclusion of each day, the person maintaining the field logbook will sign and date the day's documentation entries.
- No blank pages will be permitted. If a page is not completely filled in, a line will be drawn through the blank portion and initialed by the person making the entry.
- Information recorded on other project documentation (boring logs, well installation/development logs) does not need to be repeated in the field logbook at the same level of detail to avoid transcription errors; however, the supplemental log should be referenced in the field notes.
- All field logbooks will be kept in a secure place during the duration of the project.

7.1.3 Mistakes shall not be erased or obliterated. Instead, the mistake shall be crossed out with a single horizontal line and the initials of the reviewer should then be written in along with the date that the mistake was crossed out. Corrections or clarifications can be added to the notebook, but must also contain the initials of the reviewer and the date that the correction or clarification was made.

Additionally, pages shall not be removed from logbooks. Should an entire page of information require omission, the information will be crossed out, dated and initialed as detailed above.

7.2 Data Collection Logs and Forms

7.2.1 Various OPs include forms and/or logs to be used for data collection for specific tasks. Where applicable, these forms should be used as the primary means to document an activity. Several examples include:

- Soil Boring Logs
- Well Construction Forms
- Well Development Forms
- Groundwater Sampling Forms
- Chain of Custody Sheets
- Sampling Data Sheets
- Survey Data Collection Forms
- Safety Inspection Forms
- Incident Reporting Forms

The field log book should contain a reference to the individual data collection logs and forms to ensure they can be tied to the work performed and provide clarity regarding the full level of detail collected from the field effort.

7.3 Daily Reports

7.3.1 The FSM must submit a daily report to the PM describing the day's events, subcontractor(s) time, site visitors, summary of field conditions, change conditions, etc. Based on project specific needs, the agreed-upon format of the Daily Report may vary, but the minimum information required has been included in the attached Cabrera Daily Report (Attachment A).

The level of detail provided within this template will allow the project to accurately record information from the field effort to support any potential change order requests and justify any deviations to the work plans.

7.3.2 Subcontractors may supply field reports and receipts to the FSM. These must be organized by the FSM (or designee) and become part of the Daily Report.

8.0 REFERENCES

- USEPA, 1988, Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, EPA/540/G-89/004

9.0 REQUIRED RECORDS

- Data Collection Logs & Forms
- Field Logbook

10.0 ATTACHMENTS

Attachment A – Cabrera Daily Report

Attachment A

Cabrera Daily Report

OP-3001, Field Activity Documentation

CABRERA DAILY REPORT

1. PROJECT INFORMATION

PROJECT NAME/LOCATION:		DATE:
		REPORT NO.
CONTRACT #:	CABRERA PROJECT #:	TASK #:
FIELD SITE MANAGER:		PROJECT MANAGER:

2. WEATHER

TEMPERATURE RANGE:		WIND SPEED/DIRECTION:	
PRECIPITATION LAST 24 HOURS: ☐ YES ☐ NO		TYPE:	AMOUNT:
BAROMETRIC PRESSURE:	HUMIDITY:	HEAT INDEX RANGE:	
WEATHER DELAYS: ☐ YES ☐ NO		DELAY TIME (HOURS):	

3. SUMMARY OF WORK

4. MATERIALS & EQUIPMENT BROUGHT ON-SITE

Receipt inspection required & completed? ☐ **Yes** ☐ **No**

5. INSPECTIONS		
TYPE	DESCRIPTION	ACTION
PREPARATORY		
INITIAL		
FOLLOW-UP		

ARE ANY DEFICIENCIES NOTED IN FOLLOW-UP INSPECTIONS? ☐ YES ☐ NO – IF YES, EXPLAIN:

6. DEFICIENCIES CORRECTED			
DEFICIENCY #	REPORT REFERENCE	DESCRIPTION	ACTION

7. TESTS PERFORMED		
SPECIFICATION REFERENCE	TYPE	TEST & RESULT

ARE TEST RESULTS ATTACHED? ☐ YES ☐ NO ☐ NA – IF NO, EXPLAIN:

8. CABRERA PERSONNEL ON-SITE		
EMPLOYEE NAME	TITLE	TASK(S) PERFORMED

9. SUBCONTRACTOR PERSONNEL ON-SITE				
SUBCONTRACTOR NAME	JOB DUTY	TASK(S) PERFORMED	# OF PERSONNEL	MAN-HOURS

TOTALS		

10. EQUIPMENT & MATERIALS ON-SITE

VENDOR	EQUIPMENT	SERIAL #.	ACTIVE OR IDLE	DATE RECEIVED	DATE RETURNED

11. MATERIAL GENERATED/STORED ON-SITE

MATERIAL ID	SOLID, LIQUID, OR MIXED	DESCRIPTION OF MATERIAL	CONTAINER TYPE	DISPOSITION OR LOCATION OF MATERIAL	AMOUNT* (CY OR TONS)
				Totals	

ATTACH SEPARATE PAGES AS NEEDED. SEPARATE PAGES INCLUDED? ☐ **YES** ☐ **NO**

12. SAMPLE COLLECTION & ANALYSIS

Sample ID	Media (Soil Water, Other)	Sampler Initials	On-Site or Off-Site Lab	Analyses / Type	Date Results Due	Freight Tracking #

ATTACH SEPARATE PAGES AS NEEDED. SEPARATE PAGES INCLUDED? ☐ **YES** ☐ **NO**

13. CHANGES/DELAYS/CONFLICTS

ANY CHANGES IN SITE CONDITIONS OCCUR TODAY? ☐ **Yes** ☐ **No**

IF YES, EXPLAIN:

DID A DELAY OR WORK STOPPAGE OCCUR TODAY? ☐ **Yes** ☐ **No**

IF YES, EXPLAIN:
HAS ANYTHING DEVELOPED IN THE WORK WHICH MAY LEAD TO A CHANGE? ☐ **Yes** ☐ **No**
IF YES, EXPLAIN:

14. VERBAL INSTRUCTIONS RECEIVED:

15. HEALTH & SAFETY SUMMARY	
SAFETY BRIEFINGS	
WAS A SAFETY MEETING HELD? ☐ **YES** ☐ **NO**	**TOPIC DISCUSSED:**
SAFETY INSPECTIONS	
WAS A SAFETY INSPECTION CONDUCTED? ☐ **YES** ☐ **NO**	
DEFICIENCIES NOTED: ☐ **YES** ☐ **NO**	**DESCRIBE:**
CORRECTIVE ACTIONS TAKEN: ☐ **YES** ☐ **NO**	**DESCRIBE:**
SUMMARY OF WORK PERFORMED	
TYPE OF WORK:	
CHEMICALS USED:	
PPE LEVEL:	
INCIDENT & NEAR MISS/OBSERVATION REPORTING	
ANY INCIDENTS ON-SITE TODAY? ☐ **YES** ☐ **NO**	**DESCRIPTION:**
CABRERA INCIDENT REPORTING FORM ATTACHED: ☐ **YES** ☐ **NO** **CLIENT SPECIFIC INCIDENT REPORTING FORM ATTACHED:** ☐ **YES** ☐ **NO**	
ANY NEAR MISSES/OBSERVATIONS ON-SITE TODAY? ☐ **YES** ☐ **NO**	**DESCRIPTION:**
H&S RECOMMENDATIONS	

16. REMARKS

17. VERIFICATION STATEMENT	
This report is complete and correct and all materials and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications except as noted above.	
NAME/TITLE:	**SIGNATURE:**
DATE:	

18. PROJECT MANAGER REVIEW & ACCEPTANCE	
REMARKS AND/OR EXCEPTIONS TO REPORT:	
ACCEPTANCE	
NAME/TITLE:	**SIGNATURE:**
DATE:	

OPERATING PROCEDURE

FOR

WIPE SAMPLING PROCEDURE

OP-3102

(FORMERLY OP-312)

Revision 2.0
April 2021

Level of Use:
Information Use

APPROVALS	
President	*R.Flowers, PMP, CHMM*
Quality Assurance	*S. Liddy, CSP*
Health Physics	*M. Winters, CHP*
This procedure is the property of Cabrera Services Inc. and is considered approved and effective for the duration it is posted electronically to the Controlled Copy Document Repository.	

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History of Revisions		
Revision	**Month-Year**	**Description**
0	May 2012	OP-311 - Initial issue.
1.0	June 2020	Substantial (major) revision to update overall program elements to latest regulations, guidance, and industry practices. Updates to equipment list and procedure for dry and wet wipe sampling.
2.0	April 2021	Substantial (major) revision to update overall program elements to latest regulations, guidance, and industry practices. Includes formatting and numbering update per OP-2001. Renumbered to OP-3103. Subject Matter Experts for this revision are Dr. Brian Tucker, Stephan Owe, B. Badoui, and Gordon McElheny.

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1.0 PURPOSE

This procedure provides the methods Cabrera Services Inc. (Cabrera) personnel will use when conducting wipe sampling of material surfaces in support of project activities such as radiological characterization, gathering of health and safety information, and Department of Transportation (DOT) requirements. Adherence to this procedure will help to provide assurance that the analyses performed have reproducible results.

2.0 SCOPE/APPLICABILITY

Surface contamination can be evaluated by direct and indirect methods of measurement. Direct measurements are carried out with surface contamination meters and monitors which respond to the removable plus fixed surface contamination. Indirect evaluation is generally carried out by means of wipe tests by which only removable surface contamination can be evaluated. Wipe testing is an indirect sampling technique that is used to identify removable surface contamination.

3.0 DEFINITIONS

3.1 Direct Measurement of Surface Contamination: Measurement of surface activity by means of a contamination meter or monitor.

3.2 Dry Wipe Test: A test to determine if removable contamination is present through wiping the surface with a dry material, followed by evaluation of the wipe material for removable contamination.

3.3 Fixed Surface Contamination: Contamination adhering to a surface in such a way that it is not transferable under normal working conditions.

3.4 Indirect Evaluation of Surface Contamination: Evaluation of the removable activity on the surface by means of a wipe sample.

3.5 Surface Contamination: Contamination of surfaces with radioactive substances.

3.6 Wet Wipe Test: A test to determine if removable contamination is present through wiping the surface with a wet material, followed by evaluation of the wipe material for removable contamination (ISO-7503-2, 2016). Typically, a sample taken over a known area (usually 10cm x 10cm) on a hard surface with a wiping of known size partially saturated with known solvent that will be provided by an off-site vendor laboratory analysis such as tritium (H-3), as well as C-14, Ni-63, Tc-99, Pu-241, Pb-210, Pm-147, and other radionuclides.

3.7 Removable Surface Contamination: Radioactive material that can be removed from surfaces by non-destructive means, including casual contact, wiping, or washing (ISO-7503-2, 2016).

3.8 Wipe Test: Taking of a sample with dry or wet material and the subsequent evaluation of the activity transferred to the material used to wipe the surface.

3.9 Wiping Efficiency: Ratio of the activity of the radionuclides removed from the surface by one wipe sample to the activity of the radionuclides of the removable surface contamination prior to this sampling (ISO-7503-2, 2016).

3.10 Template: An outline of the area to be sampled usually made of paper or other non-contaminating materials.

4.0 RESPONSIBILITIES

4.1 Project Manager (PM) – Sets the technical capability requirements and assessment criteria for site personnel and ensures that personnel assigned to perform wipe sampling are properly qualified to perform wipe sampling.

4.2 Site Safety and Health Officer – Ensures all site workers (Cabrera and subcontractors) have been adequately trained on the requirements of the Site Safety and Health Plan and the applicable requirements of approved plans are met during the conduct of all site activities.

4.3 Radiation Safety Officer - The RSO is responsible for establishing and overseeing the effective implementation of established radiation protection plans, manuals, and procedures, as applicable. The RSO is also responsible for ensuring required monitoring programs and radiological controls (engineering, administrative, protective clothing) are implemented, as required.

4.4 Field Site Manager (FSM) – Supervises daily activities by site personnel and, for this task, is responsible for:

- Ensuring the field personnel are briefed on conducting wipe sampling in accordance with project requirements and this procedure;
- Ensuring all necessary equipment, including safety equipment, is available and functioning properly before project operations begin; and
- Coordinating and consulting with the PM on decisions relating to unexpected issues and deviations from this standard operating procedure.

4.5 Field Personnel – Perform the wipe sampling activities and generating documentation, maps, sample point locations, chains-of-custody, and related items.

5.0 PRECAUTIONS, LIMITATIONS AND PREREQUISITES

5.1 Precautions

- Direct measurements may be especially difficult or impossible to perform when inactive liquid or solid deposits are present on the surface or if an interfering radiation field is present. The indirect method is more generally applicable particularly when the surfaces are not accessible for the direct measurement because of difficult location or configuration. However, the indirect method cannot assess fixed contamination, therefore the indirect method is used only for detection of removable contamination.
- Rough surfaces are very difficult to sample representatively. The texture of the sampled surface should always be noted in the field log. If cotton or gauze are used, care must be taken so that the material does not tear or shred and remain on the sampling surface.
- When collecting radiological samples, the wipe test area should be cleaned of any debris such as paint chips and excessive dust by sweeping the area prior to wipe sample collection.
- For wet wipe test: the scintillation vial is an optical surface. Any markings or material on the outside of the scintillation vial will interfere with the detection of scintillation. These should be removed prior to analysis by wiping the vial with a lint-free lab wipe and alcohol. All labeling must be done on the cap of the vial.
- Excessive dust can interfere with wet wipe test by absorbing the solvent and preventing proper wetting of the surface. To reduce this problem, the cotton filter may be held over the scintillation vials and carefully rinsed during the sampling process. Care should be taken when using the sampling areas, especially in dusty areas, to avoid contaminating the sample field with falling dust.
- Make sure that the filter sample used will not react with the sample material or solvent used and that the proper solvent is being used for the desired analyte as directed by the off-site vendor laboratory.

5.2 Limitations and Prerequisites

Wipe sampling is an indirect method which cannot assess fixed contamination. Therefore, the indirect method is used only for detection of removable contamination.

Perform all required direct measurements at the location **prior** to performing indirect dry wipe or wet wipe sample collection.

6.0 EQUIPMENT

The following equipment is typically used for wipe sampling:

- Non-powdered latex or nitrile sample gloves

- Dry wipes/smears
- Wet wipe material used for liquid wipe tests
- Laboratory scintillation vials
- Deionized/Distilled Water (wetting agent for wet wipes)
- Surface area templates (usually 4” x 4”) when precise area coverages are needed to meet data quality objectives
- Sample labels
- Lint free wipe and alcohol (vial cleaning)
- Field logbook
- Indelible ink pen and marker
- Sample location maps
- Tape measure (for establishing and recording wipe locations)
- suitable waste container (e.g., small bag)
- Shipping container and packing materials to transport samples to the offsite analytical laboratory
- Filters (approximately 37mm) are the most common size used in liquid scintillation wipe tests.
- Scintillation vials -20 mL
- Sample labels and Chain of Custody

Specific lab requirements for sampling (e.g., packaging, media, etc.) may be prescribed/provided by the lab and should be verified for equivalency against task/project-specific sampling objectives prior to use.

Project work plans, sampling and analysis plans, and quality assurance project plans may include specific equipment requirements.

7.0 INSTRUCTIONS/PROCEDURE

7.1 Preparation for Sampling

Determine the amount of samples required and identify locations where wipe tests will be performed as identified in the approved work plans or using professional judgment. The wipe sample areas are 100 square centimeters (cm^2), (approximately 4-inches by 4-inches) unless otherwise specified. Record wipe sample locations and any deviations from planned wipe sample locations in the field logbook.

Note: Refer to project documents for any additional sampling of removed debris.

Consult with the Site Safety & Health Officer/Radiation Safety Officer to determine the level of hazard and radiological controls for the wipe

sample/testing locations, ensuring conformance to the approved project health and safety plans and the applicable permits.

Detection and evaluation of surface contamination can be carried out using one or more dry or wet wipe samples.

When taking wipe samples, the following shall be taken into consideration to determine the distribution of contamination:

- The wipe material should be chosen to suit the surface to be evaluated for removable surface contamination (for example, filter paper for smooth surfaces or cotton textile for rough surfaces).
- The wipe should be pressed moderately against the surface to be checked using fingertips or by means of a holder which is designed to ensure uniform and constant pressure.
- When appropriate, circular filter papers should be used as the wipe material.
- If more than one indirect measurement is required at a specific location, for example a wet wipe and dry wipe for alpha and beta removable activity, establish adjacent 100 cm^2 areas for each indirect measurement, making sure there is no overlap between areas

7.2 Dry Wipe Sampling

Dry wipe samples are taken on surfaces that have the potential for removable contamination that characteristically emit radioactive energies that are capable of being detected with the use of field instruments such as portable handheld detectors or a wipe/smear counter to determine activity levels.

- When practical and unless otherwise specified in the approved plans, the area to be wiped shall measure 100 cm^2 (4”x4”).
- If dry wipe samples will be measured in the field, refer to Cabrera Procedure OP-3408*, Alpha-Beta Counting Instrumentation.*
- If dry wipe samples will be transported, complete the Chain-of-Custody and analysis request forms and release samples for transport; refer to Cabrera Procedure OP-3203, Sample Management & Shipping.
- Prepare shipping container for transportation in accordance with Cabrera Procedure OP-3203, *Sample Management & Shipping.*

7.3 Wet Wipe Sampling

Wet wipe samples are typically taken when the radiological contaminant of concern is hard to detect utilizing field detection equipment. Samples are collected by wiping the surface with a wet material, followed by transport or shipment of the samples to an accredited laboratory for isotopic analyses.

Results indicate the concentration of removable isotopic contamination on the wipe. The following guidelines for this process are recommended.

- Typically, wet wipe tests are performed to monitor the presence of removable surface contamination from low energy beta-emitting radionuclides such as H-3 and Ni-63. There is no other practical alternative to monitor for the response of weak beta-emitters, then by swipe testing followed by liquid scintillation counting.
- A liquid scintillation counter will be used by an off-site laboratory to detect low-level beta radiation such as those emitted by H-3 and Ni-63. Mixing a radioactive sample with scintillation cocktail results in a solution that emits photons of light. The number of photons emitted is directly proportional to the amount of activity present in the sample. However, due to photon self-absorption, color, impurities, sample matrix and other factors, the amount of light emitted from the vial may be reduced. This reduction is known as “Quenching”. The offsite laboratory is programmed to apply the quenching correction factor automatically.

- When practical and unless otherwise specified in the approved plans, the area to be wiped shall measure 100 cm^2 (4”x4”).
- If a wetting agent is used for moistening the wipe material, the wetting agent should not exude from the material.

Note: Since contamination may be absorbed into the structure of porous surface material or may be covered by residual moisture, the use of a wetting agent may lead to underestimation of removable contamination in the case of alpha emitters.

- Make sure that the template being used will not react with the sample material.
- Make sure the proper wetting agent is being used for the desired analyte. Use deionized or distilled water as the wetting agent for radionuclides unless otherwise specified in the approved project plans.
- Moisten the dry wipe material with a minimum amount of wetting agent.

Note: Care must be taken to maintain the correct volume of wetting agent for liquid scintillation counting of wet wipe samples.

- Wipe the area of interest gently using light pressure.
- Place the wet wipe into the labelled sample container.
- When using scintillation vials as sample containers, any markings or material on the outside of the scintillation vial will interfere with the detection of radiation-generated scintillation. Outside surfaces of scintillation vials should

be free of all markings therefore, all labeling must be done on the cap of the vial.

- If wet wipe samples will be measured using field instruments, refer to manufacturer specifications for counting system.
- If wet wipe samples will be transported, complete the Chain-of-Custody and analysis request forms and release samples for transport and prepare shipping container for transportation in accordance with Cabrera Procedure OP-3203, *Sample Management & Shipping.*

8.0 REFERENCES

- Cabrera Procedure OP-3203, *Sample Management & Shipping*
- Cabrera Procedure OP-3408*, Alpha-Beta Counting Instrumentation*
- ALS, 2017, ALS Standard Operating Procedure 704, *Analysis of Tritium and other beta-emitting nuclides by liquid scintillation counting* - Method EPA 906.0
- ISO 7503-2:2016(E), *Measurement of Radioactivity-Measurement and Evaluation of Surface Contamination-Part 2: Test Method Using Wipe-Test Samples*

9.0 REQUIRED RECORDS

- Field Notebook
- Alpha-Beta Counting Forms
- OP-3203, *Cabrera Chain of Custody Checklist*
- OP-3203, *Chain of Custody/Analysis Record*

10.0 ATTACHMENTS

None.

OPERATING PROCEDURE

FOR

SURFACE SOIL SAMPLING

OP-3110

(FORMERLY OP-351)

Revision 1.0
April 2021

Level of Use:
Information Use

APPROVALS	
President	*R. Flowers, PMP, CHMM*
Quality Assurance	*S. Liddy, CSP*
Health Physics	*M. Winters, CHP*
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History of Revisions		
Revision	**Month-Year**	**Description**
0	May 2012	OP-351 - Initial issue.
1.0	April 2021	Substantial (major) revision to update overall program elements to latest regulations, guidance, and industry practices. Formatting and renumbering per OP-2001. Renumbered to OP-3110. Subject Matter Experts for this revision are Dr. Brian Tucker and Ted Toskos, PG.

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1.0 PURPOSE

This procedure provides the methods that personnel will use when sampling surface soil. Adherence to this procedure will provide assurance that the analyses performed have accurate and reproducible results.

2.0 SCOPE/APPLICABILITY

This procedure applies to all Cabrera Services Inc (Cabrera) employees and operations. Personnel will utilize this procedure to sample surface soil for laboratory analysis unless otherwise directed through the Project Work Plans (WPs) [e.g. Field Sampling Plan (FSP), or Quality Assurance Project Plan (QAPP)]. Personnel must assure that the specifications of this OP agree with the specifications listed in the Project WPs. .

3.0 DEFINITIONS

3.1 Bucket Auger – Bucket augers (Exhibit 1) consist of a stainless steel "T" handle, detachable handle extensions, a helical cutting head and a bucket to collect the cuttings. They are an excellent choice for sample collection because they provide a relatively large sample volume in a short time and can sample discrete depth intervals. They are the recommended hand sampler for subsurface soil sampling beyond a depth of 6 inches to one foot.

Exhibit 1: Bucket Augers

3.2 Post-Hole Digger – Post-hole diggers (Exhibit 2) have limited utility for subsurface soil sample collection because they are designed to cut through fibrous, rooted, and rocky soils. They cannot be utilized below a depth of approximately three feet.

Exhibit 2: Post-Hole Digger

3.3 Sampling Station – The exact spot from where the sample will be collected.

3.4 Seven Sample Wheel Method – A composite sampling method designed to determine the average concentration representative of the soil at a specific location.

3.5 Surface Soil – The uppermost layer of unconsolidated material at the ground surface. Unconsolidated material that is normally under water is considered sediment rather than soil. Wetlands, which don't have water at the ground

surface for most of the year, have hydric soil, while marshes, which do have surface water for most of the year, have sediment.

For the purposes of environmental sampling, the thickness of the surface soil layer is typically designated by an applicable regulation. For example, in Pennsylvania and New York, surface soil is defined as extends extending from ground surface to two feet below ground surface. The Nuclear Regulatory Commission regards the upper 15 centimeters [6 inches] as the surface soil layer. Some projects define surface samples in different ways; verify the appropriate sampling horizon based on site/client-specific definitions of surface and subsurface samples in applicable work plans or as directed by the PM/FSM.

4.0 RESPONSIBILITIES

4.1 Project Manager (PM) – The PM ensures that personnel are adequately trained in the use of this procedure and have access to a current copy (available on CCDR). The PM Provides the environmental scientist or technician with the specific scope of work for the monitoring event and will also provide the historical data necessary to inform the scientist or technician as to the conditions to expect.

4.2 Field Site Manager (FSM) – The FSM is responsible for: the execution of field activities in coordination with the PM; correctly applying the well construction, inspection and decommissioning guidance within this OP and entering information into the field notebooks.

4.3 Project Geologist/Lead Environmental Scientist – The Project Geologist, or Lead Environmental Scientist, is responsible for reading, understanding, and complying with the provisions of this procedure, and any state, or other regulatory requirements for the activities in this procedure. Any deviations from the prescribed protocols established with the project work plans shall be discussed with the PM and FSM, and changes documented in the project field notebook.

4.4 Project Personnel - Under the direction of the FSM, responsible for reading and complying with the provisions of this procedure. They must also be familiar with the Site Safety and Health Plan (SSHP) and the Project Work. Any deviations from the prescribed protocols established with the project work plans shall be discussed with the PM and FSM, and changes documented in the project field notebook.

5.0 PRECAUTIONS, LIMITATIONS AND PREREQUISITES

5.1 Precautions

The potential exposure to contaminants should be addressed in the SSHP and/or AHA, specifically the sections concerning personal protective equipment and respiratory protection. At a minimum, an unused pair of nitrile gloves will be donned prior to sampling at each station.

Sample media may contain residual radioactivity at sites were radionuclides are known/potential concerns. When radiological hazards are suspected, sampling must be done in accordance with the radiological elements of the SSHP/work plan or, for licensed activities, in accordance with the applicable Radiation Protection Program requirements – Consult with the RSO for guidance when radiological concerns may be present

Contact the State 'One Call' or 'Call-before-you-dig' service (dial 811 in most states) at least 48 hours in advance to have underground utilities marked. State regulations vary on the minimum excavation depth where prior notification is required, and site elevations can change over time, so locator services advise to contact them for line marking before any intrusive work regardless of depth. Use 'One Call' regardless of depth of sampling to limit liability.

"One Call" addresses only public utilities in public right-of-way. Some utilities (e.g. municipal sewers) do not participate in the "One Call" system. Invidual connections and private utilities on private property (e.g. underground conveyance lines at a factory site) will not be marked by "One Call". Engage the services of a private utility locator for these cases per accordance with OP-5608, Utility Clearance Isolation.

Samples suspected of containing high volatile organic compound (VOC) concentrations will be collected, handled and stored separately.

Samplers must use new, verified/certified-clean disposable or non-disposable equipment cleaned according to procedures contained in OP-3801 *Field Equipment Decontamination*, or otherwise as specified in the work plan.

5.2 Limitations

Certain options must be selected in advance. They include:

- Specify the sample depth interval, which is typically from 0 to 6 inches but may vary to a maximum depth of one to two feet. Certain analytical fractions (e.g. volatile organic compounds) are typically collected 18 to 24 inches below grade. Any such limitations should be defined in the sampling plan.If the station will be sampled as a discrete (or 'grab') sample or as a composite, in which case the 'seven sample wheel' method should be used.
- The method by which the sample will be collected (e.g. hand auger, geoprobe, hand trowel, etc).
- If the sample depth interval will be biased (based on field meter readings) or systematic (based on a pre-determined depth interval).

Determine whether there is conflicting client guidance with this method. Certain state regulations may prohibit the compositing of samples, while other state guidance has specific guidelines beyond the scope of this SOP. Federal guidelines for PCB sampling have specific requirements that are beyond the scope of this SOP.

5.3 Prerequisites

Review the project work plans (typically the Field Sampling Plan, Quality Assurance Project Plan, and Site Specific Health and Safety Plan). Equipment decontamination should be addressed in the work plans, which may reference OP-3801 *Field Equipment Decontamination*. Disposition of Investigation Derived Waste (IDW) must also be considered in the work plans, which may reference OP-3704 *Investigation Derived Waste Management*.

6.0 EQUIPMENT

Soil samples may be collected using a variety of methods and equipment. The methods and equipment used are dependent on the depth of the desired sample, the required sample type (disturbed vs. undisturbed), and the soil type. Near-surface soils may easily be sampled using a spade, trowel, or scoop. Sampling at greater depths may be performed using a hand auger, or by direct-push technology. Soil sampling equipment may include the following:

- Sampling plan
- Maps/plot plan
- PPE
- Survey equipment
- Tape measure
- Survey stakes or flags
- Camera and film
- Stainless steel bowls
- Sample containers (usually provided by the analytical lab)
- Ziploc plastic bags
- Logbook
- Labels
- Chain-of-custody form
- Field data sheets
- Cooler(s)
- Ice (for most non-radiological samples)
- Vermiculite and/or bubble wrap
- Decontamination supplies and equipment
- Plastic sheet
- Spade or shovel
- Spatula
- Scoop
- Plastic or stainless steel spoons
- Trowel
- Sampling wheel (see Figure 2-1)
- Bucket auger
- Post-hole digger

7.0 INSTRUCTIONS/PROCEDURE

7.1 General Requirements

7.1.1 The work plans should specify which of the three following methods will be used to acquire surface soil samples.

- Spoon sampling is an efficient method for collecting loose soils from the upper six inches. Spoon sampling is not appropriate for sampling volatile organic compounds.

- Auger sampling allows more precise collection of surface samples at greater depth and where soils are more consolidated.
- The Seven Sample Wheel Method is preferable when contaminants are suspected of being heterogeneously distributed at the sample point.

7.1.2 Reused equipment must be decontaminated between each use. Determine in advance whether single-use or decontaminated equipment will be used.

7.1.3 Unused sample may be returned to the sample hole from which it came unless otherwise directed by the work plans.

7.1.4 Always proceed from the least contaminated to the most contaminated station when sampling surface soil to minimize the potential for cross-contamination.

7.1.5 All sampling locations will be documented with a temporary marker so that sampling locations can be properly mapped.

7.1.6 All samples will be logged for lithology and other relevant information, such as evidence of contamination using Attachment A.

7.1.7 In most cases, samples will be homogenized after retrieval (except for VOC sampling). To improve the quality of the homogenized sample, follow the compositing considerations offered in *ASTM D6051-15 Standard Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities*. Two possible homogenization options to consider for soil are the cone and quarter technique or use of a riffle splitter.

7.2 Spoon Sampling

7.2.1 Place a sheet of plastic on the ground near the sample station to work on.

7.2.2 Remove vegetation at the sample station by cutting or scraping it away with a pre-cleaned stainless steel trowel.

7.2.3 Use a pre-cleaned stainless steel spoon or trowel to scoop out a cylindrical sample of the soil to a depth of 6 inches (or to the depth specified in the work plans).

7.2.4 If sampling for VOCs, take a field reading for VOCs, using a PID or FID, and collect 5 grams of soil using an Encore™ sampler.

7.2.5 For sampling all other analytes, place the soil sample into a plastic bowl (if dedicated) or stainless steel bowl (which must be cleaned between uses). Take readings from the sample using the field meters specified in the work plans. Remove vegetation and stones larger than 1.25 inches (32 mm). If the sample consists of 30% or more of stones larger than this, consult with the PM. Do not sample surface cover materials, such asphalt or concrete, unless directed.

7.2.6 Mix the soil thoroughly to obtain a homogeneous, representative sample.

7.2.7 Using pre-cleaned stainless steel equipment or a disposable scoop, fill sample container(s). Wipe soil away from the lip and threads of the container and secure the cap(s).

7.2.8 Label the container, prepare Chain-of-Custody form and document your observations in the field logbook.

7.3 Auger Sampling

7.3.1 Place a sheet of plastic on the ground next to the sampling station to work on.

7.3.2 Use a pre-cleaned bucket auger or post-hole digger to remove a cylindrical sample of the soil throughout the specified sample interval.

7.3.3 A VOC sample may be collected from the middle of the depth interval. Take a PID or FID reading and collect 5 grams of soil using an Encore™ sampler.

7.3.4 Place the soil sample into a plastic bowl (if dedicated) or stainless steel bowl (which must be cleaned between uses). Remove vegetation and stones larger than 1.25 inches (32 mm). If the sample consists of 30% or more of stones larger than this, consult with the PM. Do not sample surface cover materials such asphalt or concrete unless directed.

7.3.5 Mix the soil thoroughly to obtain a homogeneous sample that represents the entire surface soil interval.

7.3.6 Using pre-cleaned stainless steel equipment or a disposable scoop, fill sample container(s). Wipe off the lip and threads of the container and secure the cap(s).

7.3.7 Label the container, prepare Chain-of-Custody form, and document your observations in the field logbook.

7.4 Seven Sample Wheel Method

7.4.1 Sampling wheels must be prepared in advance (Exhibit 3). These consist of templates cut from a plastic sheet or other impermeable material.

7.4.2 Place the sampling wheel over the sampling station so that the station aligns with the center hole of the wheel.

7.4.3 For VOC sampling, collect 5 grams of soil from each of the 7 substations of the sampling wheel using an Encore™ sampler. These subsamples must be mixed in the laboratory.

7.4.4 Proceed with the steps for either spoon sampling or auger sampling, except that all aliquots from seven substations are placed into the bowl. Each aliquot must have the same volume.

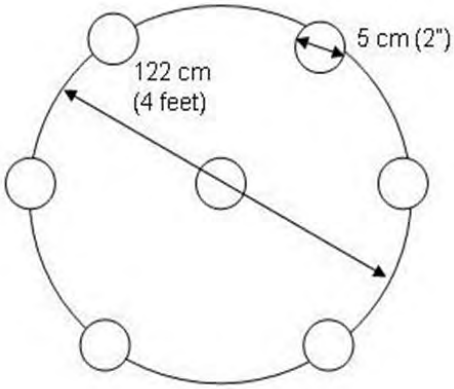


Exhibit 3: Sampling Wheel

7.4.5 Thoroughly mix the soil, removing vegetation and rocks larger than 1.25 inches. If the sample consists of 30% or more of stones larger than this, consult with the PM. Do not sample surface cover materials such asphalt or concrete unless directed.

7.4.6 Using pre-cleaned stainless steel equipment or a disposable scoop, fill sample container(s). Wipe off the lip and threads of the container and secure the cap(s).

7.4.7 Label the container, prepare a Chain-of-Custody form, and document your observations in the field logbook.

8.0 REFERENCES

- Cabrera OP-3704, *Investigation Derived Waste Management*
- Cabrera OP-3801, *Field Equipment Chemical Decontamination*
- Cabrera *OP-5608, Utility Clearance Isolation*
- *ASTM D6051-15, Standard Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities*.

9.0 REQUIRED RECORDS

- Field Log Book
- Field Data Record – Surface/Subsurface Soil Sampling
- Chain-of-Custody forms

10.0 ATTACHMENTS

Attachment A – Field Data Record Surface/Subsurface Soil Sampling (Example)

Attachment A

Field Data Record
Surface/Subsurface Soil Sampling

CABRERA SERVICES
RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

FIELD DATA RECORD
SURFACE / SUBSURFACE SOIL SAMPLING

PROJECT _____ JOB NUMBER _____ DATE _____

LOCATION ID _____ ACTIVITY TIME START _____ END _____ CONTAINER TIME _____

FIELD SAMPLE ID _____ QC SAMPLES COLLECTED _____

SAMPLE DATA

DEPTH OF SAMPLE _____ FT (BGS)

TYPE OF SAMPLE: ☐ DISCRETE ☐ COMPOSITE

LOCATION COORDINATES _____

TYPE OF SOIL: ☐ ORGANIC ☐ SAND ☐ GRAVEL ☐ CLAY ☐ OTHER

EQUIPMENT INFORMATION

EQUIPMENT USED: ☐ HAND CORER / AUGER ☐ S.S. SPOON ☐ S.S. SHOVEL / TROWEL ☐ S.S. SPATULA ☐ GEOPROBE ☐ OTHER _____

DECON FLUIDS USED: ☐ DI WATER N2 PURGE ☐ POTABLE WATER ☐ LIQUINOX SOLUTION ☐ OTHER _____

RINSATE BLANK ID _____

RADIOLOGICAL MEASUREMENTS AT SAMPLE LOCATION

BEFORE SAMPLE COLLECTION _____ cpm

AFTER SAMPLE COLLECTION _____ cpm

DETECTOR Type: _____ Serial No.: _____

METER Type: _____ Serial No.: _____

SAMPLE OBSERVATIONS (e.g., location, texture, color, odor, etc.)

SAMPLE ANALYSES

	PARAMETER	METHOD NUMBER	PRESERVATION METHOD	BOTTLE TYPE/ VOLUME REQUIRED	SAMPLE COLLECTED
☐	DEPLETED URANIUM (GAMMA SPEC)	EPA 901.1M	None	1 @ 16 oz. plastic	☐
☐					☐
☐					☐
☐					☐
☐					☐

NOTES

SAMPLED BY: _____

RECEIVED BY: _____

CABRERA SERVICES
RADIOLOGICAL • ENGINEERING • REMEDIATION

OPERATING PROCEDURE

FOR

VOLUMETRIC AND MATERIAL SAMPLING WITHIN RADIOLOGICAL CONTROL AREAS

OP-005

REVISION 2.0

Reviewed by:

David Wunsch, Quality Assurance Manager — 4/12/13 Date

Approved by:

Henry Siegrist

Henry Siegrist, CHP, PE, Radiation Safety Officer — 4/12/2013 Date

1.0 PURPOSE

This procedure provides the methods Cabrera Services Inc. (CABRERA) personnel will utilize to collect volumetric and material samples for radiological analysis. Adherence to this procedure will provide assurance that personnel exposures will be As Low As Reasonably Achievable (ALARA), personnel will remain free of contamination, and contamination will not be spread beyond the designated contaminated area.

2.0 APPLICABILITY

This procedure is applicable to all volumetric and material samples collected by CABRERA personnel to fulfill sampling requirements.

3.0 DEFINITIONS

3.1 Geiger-Mueller (G-M) Counter – A radiation detection and measuring instrument. It is sometimes called a G-M counter, or Geiger counter, and is the most commonly used portable radiation instrument. It consists of a gas-filled tube containing electrodes between which there is an electrical voltage but no current flowing. When ionizing radiation passes through the tube, a short, intense pulse of current passes from the negative electrode to the positive electrode and is measured or counted. The number of pulses/second measures the intensity of the radiation field.

3.2 Global Positioning System (GPS) – A satellite-based global navigation system that consists of: a collection of 24 satellites in orbit above the Earth; several in-orbit spares; and a ground-based control segment. The satellites transmit signals that are used for three-dimensional (latitude, longitude, and elevation) global navigation. A GPS-derived position determination is based on the arrival times, at an appropriate receiver, of precisely timed signals from the satellites above the user's radio horizon.

3.3 Impacted Area – According to MARSSIM, impacted areas have a potential for radioactive contamination (1) based on historical data or (2) they contain radioactive contamination based on past or preliminary radiological surveillance. This includes areas where radioactive materials were used and stored; records of spills, discharges, or other unusual occurrences resulted in the spread of contamination; and, areas where radioactive materials were buried or disposed. Areas immediately surrounding or adjacent to these locations are included in this classification due to the potential for inadvertent spread of contamination.

3.4 Ionizing Radiation – Radiation that has sufficient energy to remove electrons from atoms which produces ions. Examples include alpha, beta, gamma, and X-rays.

3.5 Minimum Detectable Concentration (MDC) – The net concentration that has a specified chance of being detected; it is an estimate of the detection capability of a measuring protocol and is calculated before measurements are taken. For purposes of this procedure, MDC for removable radioactive contamination is defined as the smallest amount of sample activity that will yield a net count, with a 95% confidence level, based upon the background count rate of the counting instrument used.

3.6 Sediment – According to MARSSIM, sediment includes soil and other solid material that has settled to the bottom of a liquid (e.g., water).

3.7 Site Safety and Health Plan (SSHP) – The SSHP provides evacuation routes for the site and its immediate area, as well as the names and telephone numbers of common emergency contact personnel for the worksite.

3.8 Subsurface Soil – According to MARSSIM, subsurface soil includes any soil not considered surface soil. It is typically anything greater than 15 centimeters (6 inches) below the ground surface.

3.9 Surface Soil – According to MARSSIM, surface soil includes the top layer of soil that is available for direct exposure, growing plants, re-suspension of particles for inhalation, and mixing from human disturbances. According to Title 40 of the Code of Federal Regulations, Part 192 (40 CFR 192), this layer is represented as the top 15 centimeters (6 inches) of soil.

3.10 Volumetric Sample – A sample of material taken to determine the radioactivity content in units of activity per unit volume or mass. It does **NOT** apply to loose surface material sampled using a cloth smear/wipe or to activity present only on the surface of solid materials.

3.11 Water Sample – A sample of surface water, groundwater, drinking water, or other hydrological system sampled to determine radioactivity content in units of activity per unit volume or unit mass.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

4.1.1 Special situations will be evaluated and incorporated in site-specific work plans (e.g., evaluating trends for airborne deposition, determining contamination profiles via down-hole measurements, measuring non-radiological contaminants, etc.).

4.1.2 Personnel will not exceed the load ratings stamped on shipping containers to prevent container degradation during shipment. Prior to shipment, personnel will consult with the analytical laboratory for

approved packaging materials and shipping methods. Deviations from approved work plans will be brought to the attention of the Site Radiation Safety Lead.

4.1.3 Personnel will utilize a field-sampling logbook to document sampling information.

4.1.4 Samples that require alpha or beta spectroscopy or isotopic discrimination will be sent to an approved laboratory for analysis. If onsite gamma spectroscopy is utilized, quality control (QC) samples may be sent to an approved laboratory for analysis, in accordance with the approved site-specific work plan.

4.1.5 Individuals collecting volumetric and material samples will be familiar with the requirements set forth in the current, approved version of this procedure.

4.1.6 Personnel will decontaminate radiologically contaminated sampling equipment in accordance with *Decontamination of Equipment and Tools* (OP-018). Equipment that is contaminated with non-radiological waste will adhere to decontamination techniques discussed in *Field Equipment Decontamination* (OP-373).

4.2 Limitations

4.2.1 Sample media containing radiological contamination may also contain non-radiological contamination that will not affect the radiological components of a sample. Therefore, personnel will follow the stricter guidelines associated with non-radiological contamination, if present. If only radiological contamination is present, it is unnecessary to adhere to guidelines governing non-radiological contamination.

4.2.2 It may be necessary to place samples on ice should a non-radiological component be present. Most radiological samples are unaffected by and therefore ***do not*** need to be placed on ice. It is unnecessary for personnel to collect separate samples for radiological and non-radiological components.

Note: Samples containing tritium (^{3}H) or carbon-14 (^{14}C) contamination may convert to gaseous components resulting in sample loss from biological activity. Ice will always be used to preserve this type of radiological contamination. An exception is airborne ^{3}H sampling utilizing distilled water and bubbler collection equipment.

4.3 Requirements

4.3.1 Instrumentation used in surveys will be checked with standards daily and verified to have current valid calibration.

4.3.2 Personnel will perform direct surface radiation measurements prior to sampling at each location. They may identify gross contamination, which could require samples and sampling equipment to be treated as radioactive for transport purposes.

4.3.3 Personnel will utilize the following documentation when performing volumetric and material sampling:

- Record forms
- Sample chain-of-custody (COC) forms
- Field-sampling logbook

4.3.4 Records will be maintained in accordance with *Records Management* (OP-187).

5.0 EQUIPMENT

5.1 The following is a list of the minimum equipment required to perform field volumetric sampling under this procedure:

- A Lietz level log book 8152-50 or the equivalent
- Survey form(s)
- Chain-of-Custody forms
- Sample containers
- Indelible ink marker
- Tap water
- Clean paper towels
- Brushes for decontamination, as needed
- Sample location markers
- Digging implement: garden trowel, shovel, spoons, post-hole digger, etc.
- Applicable sampling equipment
- Re-sealable plastic bags (approximately one-gallon capacity)
- Twist-ties
- Masking or duct tape

5.2 In addition to the above list, water sample collection may also require the following:

- Instrumentation to make water quality measurements that include: dissolved oxygen, pH, temperature, conductivity, and oxidation-reduction potential. This data may assist in the interpretation of analytical data and

the selection of sampling sites.

- Preservative(s), per analytical laboratory recommendations.

5.3 The following is a list of the minimum required equipment to perform sample packing and shipping under this procedure:

- Ludlum model 3 rate-meter with Ludlum model 44-9 G-M detection probe or equivalent
- Smears for removable activity and Ludlum 2929 smear counter or equivalent
- Micro Rem Ion chamber dose rate instrument or equivalent
- Boxes, coolers, or similar shipping containers for samples
- Clear packing tape
- Zipper-locking plastic bags
- Packaging material (e.g., plastic, vermiculite, preformed poly-foam liner, or equivalent)
- “Fragile” and “This Side Up” self-adhesive labels
- Mailing labels

5.4 The following is a list of sampling equipment that may be used for specific types of materials:

- Drains or pipes: plumber’s snake, swabs
- Residues: trowels, scoops
- Concrete or asphalt: core boxes, hammer, and chisel
- Metals: emery cloth or scraping tool
- Dusts: scraping tool and plastic bags

6.0 RESPONSIBILITIES

6.1 Corporate Radiation Safety Officer (RSO) – Will monitor compliance and ensure that personnel who collect volumetric and/or material samples are qualified by training and experience to perform this procedure.

6.2 Radiation Protection Technicians (RPT) – When collecting volumetric and/or material samples, are responsible for knowing and complying with this procedure.

6.3 Project Manager (PM) - Responsible for the radiological safety of all personnel on site, ensuring that if they collect volumetric and/or material samples, that

they are adequately trained, understand this procedure, and have access to a copy of procedures for reference.

6.4 Sample Collectors - Personnel who collect volumetric and material samples and are responsible for understanding and complying with this procedure.

6.5 Site Radiation Safety Lead (SRSL) – Acts as the RSO's duly authorized representative for radiological issues when the RSO and their duly authorized representative are not onsite. The SRSL will be onsite when work is in progress, will perform the requirements established in this procedure, and ensure that they are implemented during field assignments. The SRSL has the responsibility to stop work if: any unsafe condition exists in the work area, non-compliance with procedural requirements occurs, or if significant changes in radiological conditions occur.

7.0 PROCEDURE

7.1 General Volumetric and Material Sample Collection

This section is applicable to the collection of all volumetric and material samples.

7.1.1 Outside sample locations will be identified and documented with GPS data and survey maps, where practical. Survey maps will be used to document survey results related to the samples (e.g., loose surface activity of sample container or sampling equipment).

7.1.2 Personnel will use survey maps to clearly illustrate sample locations inside buildings.

7.1.3 Personnel will delineate sampling locations that need to be relocated with an appropriate marker (e.g., stake, pin flag, spray paint, etc.) and label them with a unique number.

7.1.4 Prior to collecting a sample, personnel will ensure that they have the correct container type and size by contacting the analytical laboratory for sample size requirements based on the desired detection sensitivity.

7.1.5 Personnel will adhere to the following techniques when collecting volumetric and material samples:

- Perform loose surface activity surveys on sampling equipment that contacts sampling media to ensure no removable contamination exists. Document the results on the appropriate survey form.
- Samples that can fit into a $^{1}/_{8}$-inch by 2-inch planchette, and require gross alpha and/or beta/gamma results, may be counted in a Ludlum 2929 smear counter or equivalent. Ensure that minimum counting system sensitivity requirements are met by calculating MDC values for alpha and beta, as applicable.

- Place the sample into a planchette with the surface to be measured facing up.
- Count the sample for the appropriate length of time to meet MDC values described by work plans or other documents.
- Record count and counting time data, and calculate activity estimates on the appropriate survey form.
- If the collected sample is suspected to contain radioactivity above background levels, then survey sampling equipment for loose surface activity prior to collecting additional samples with the same equipment. Document the results on the appropriate survey form.
- Decontaminate sample equipment as necessary.

7.2 Surface and Subsurface Soil Sample Collection

Personnel will refer to *Surface Soil Sampling* and *Subsurface Soil Sampling* (OP-351 and OP-352, respectively) for more detailed techniques, as well as adhering to both Section 7.1 of this procedure and the following steps when sampling surface and subsurface soil:

7.2.1 Collect surface and subsurface soil samples by utilizing appropriate sampling equipment as detailed site work plans(e.g., spade, shovel, spatula, scoop, plastic or stainless steel spoons or split spoons, trowel, bucket auger, post-hole auger, etc.).

7.2.2 Carefully remove the soil layer correlating to the desired sample depth.

7.2.3 Place sample into the appropriate container and mix thoroughly to obtain a homogenous sample representative of the sampling interval. Remove large rocks, vegetation, and foreign objects which may be collected as separate samples. **Note:** It may be necessary to use a sieve or screen to remove them.

7.2.4 Fill sample container(s) to the top with sampling media.

7.3 Surface Water and Sediment Sample Collection

Personnel will refer to *Surface Water and Sediment Sampling* (OP-349) for more detailed techniques, as well as adhering to both Section 7.1 of this procedure and the following when sampling sediment and surface water:

7.3.1 Collect sediment and surface water samples by utilizing appropriate sampling equipment. When collecting sediment samples, personnel may utilize the following: spade, shovel, spatula, scoop, trowel, bucket auger, tube auger, sediment coring device, Ponar or Ekman dredge,

etc. When collecting surface water samples, personnel may utilize the following: ladle, scoop, pond sampler, funnel, etc.

Note: It is important to minimize disturbance of the sediment caused by sampling activities. Move slowly and approach sampling location(s) downstream for moving water and downwind for stationary water.

7.3.2 Continue with one the following steps depending on whether sediment or surface water is being collected:

- **Sediment**: Remove desired sediment thickness and volume slowly and gently from water using appropriate sampling equipment. Place sediment sample into appropriate container and mix thoroughly to obtain a homogenous sample representative for sampling interval. Decant surface water from sample or homogenization container prior to sealing or transfer. Use care to retain the fine sediment fraction during this procedure. Remove large rocks, vegetation, and foreign objects, all of which may be collected as separate samples. (**Note:** It may be necessary to use a sieve or screen to remove them.) Fill sample container(s) to the top with sediment.

- **Surface Water**: If surface water is deep enough, then it may be collected by dipping the sample container directly into the water. Fill sample container(s) to the top with surface water gently and slowly. While multi-parameter water quality measurements (i.e., dissolved O_2, pH, temperature, conductivity, oxidation-reduction potential, etc.) are not required for radiological analysis, they may assist in analytical data interpretation if non-radiological contaminants are present onsite. The PM will determine the necessity of these measurements.

7.4 Groundwater Sample Collection

Personnel will refer to “Groundwater Sampling” (OP-350) for more detailed techniques, as well as adhering to both Section 7.1 of this procedure and the following, when sampling groundwater:

Note: Low-flow sampling is a comprehensive technique that is not discussed within this procedure. Low-flow groundwater sampling will be conducted in accordance with *Low-Flow Groundwater Sampling Procedures* (OP-355).

7.4.1 Collect groundwater samples by utilizing appropriate sampling equipment (e.g., bailer, submersible pump, non-contact gas bladder pump, inertia pump, suction pump, etc.).

Note: It highly suggested to use dedicated sampling equipment (e.g., bailers) at each sampling location or well to prevent cross-contamination.

Note: It is important to minimize disturbance of the sediment caused by sampling activities. Lower all sampling equipment into the water column as slowly as practical, and ***do not*** allow the equipment to free-fall within the well.

7.4.2 When purging with a pump (not a bailer), the pump will be set at the screened interval. The sample will also be collected from the depth at which the pump was set.

7.4.3 All monitoring wells will be pumped prior to sampling. Purge water will be containerized onsite or handled as specified in the site work plan. Evacuation of a minimum of one (preferably three to five) volume(s) of water in the well casing is recommended for a representative sample. In a high-yielding groundwater formation that has no stagnant water above the screened section of the well, evacuation prior to sample withdrawal is not critical. Evacuation is, however, recommended when monitoring data will be used for enforcement actions.

7.4.4 Fill sample container(s) to top with water.

7.4.5 If non-radiological contaminants (i.e., metals) are present that require an acidified sample, then test the pH of the water sample. If the pH is greater than 2.0, add acid to reduce the pH to 2.0 or less. This should align it with the analytical laboratory protocols.

7.5 Material Sampling

Personnel will adhere to both Section 7.1 of this procedure and the following techniques when conducting material sampling:

7.5.1 Determine sample collection using sample media characteristics. Care will be taken to limit the potential for spreading contamination during sample collection. Determine sample quantities using the following criteria:

- Type of analyses required;
- Number of analyses requested;
- Detection sensitivity required of analytical result; and
- Estimated activity level of material.

7.5.2 Remove the material to be sampled by using the tools required and contamination control techniques to prevent loss of material from the sampled area.

7.6 Collection of Other Samples

7.6.1 For the purposes of this procedure, ‘other’ refers to any media type not previously defined in this document.

7.6.2 Prior to collecting the sample, consult with the analytical laboratory and SRSL for specific instructions on taking any ‘other’ sample types.

7.6.3 Removed foreign objects which are not representative of the desired sample matrix or which may affect the laboratory analysis.

7.7 Sample Packing and Shipping

7.7.1 The sample collector will use indelible ink in identifying sample media and location in assigning a unique number to the sample container label. Sample collectors are responsible for initiating the chain-of-custody form, in accordance with *Chain-of-Custody* (OP-008).

7.7.2 Personnel will adhere to the following techniques when labeling samples:

- Label container(s).
- Record sample identification, date, and time of sample collection on label.
- If sample containers contain water or are preserved with ice, then place clear plastic tape around the label.
- Wipe outside of sample container.

7.7.3 Personnel will adhere to the following techniques when preparing containers for shipment:

- Tape container openings such as box seams and cooler drains (when used) shut.
- Affix “This Side Up” labels on all four sides, and “Fragile” labels on a minimum of 2 sides of the container (e.g., box, cooler, etc.).
- Place mailing label with laboratory address on container(s).
- When shipping samples for analysis, line the shipping container(s) with plastic prior to placing samples inside. If shipping liquid samples, fill the bottom of the shipping container(s) with approximately 3 inches of an approved absorbent material (i.e., vermiculite, preformed poly-foam liner, etc.).
- It may be necessary to preserve non-radiological samples at temperatures not exceeding 4°C. If ice is required for preservation, then it will be packaged within two zipper locking bags and placed on and around sample containers.
- Arrange decontaminated sample containers in groups by sample

number.

- Arrange samples in shipping containers so that they do not touch and the potential for motion is minimized.
- Fill remaining spaces with absorbent material.
- Sign chain-of-custody form (or obtain signature) and indicate air bill number, if applicable. Seal the correct chain-of-custody copy in a zipper locking plastic bag and tape it to the inside of the shipping container top or lid.
- If a cooler serves as the shipping container, close the lid and secure latch. Tape the container shut on both ends, making several complete revolutions with packing tape.
- Use tamperproof seals provided by the analytical laboratory to securely seal shipping container and initial and date the seal.
- Conduct surface scan of shipping container. Record results on appropriate survey form and include a copy with the shipping label.
- Relinquish samples to the shipper and retain sample collection and shipment documentation for project file.

CAUTION: Shipments of samples containing potentially hazardous or radioactive materials may require specific packaging and shipping precautions not specified above. Consult the SRSL or analytical laboratory for instruction when shipping these samples.

Note: Do not exceed load rating for containers when shipping samples to prevent degradation of the container during shipping.

7.8 Sample Equipment Decontamination

Personnel will decontaminate sampling equipment to prevent cross-contamination between sample collections. The most common decontamination materials include: long-handled brushes, Masslinn cloth or similar wipes, tap water, paper towels, disposal container/bags.

Note: This procedure is not written in compliance with *Sampling Equipment Decontamination* (EPA SOP 2006). EPA's procedure pertains to the presence of chemical contamination, which may include volatile organic compounds. These can readily cross-contaminate sampling media. Radiological decontamination will therefore be in accordance with *Decontamination of Equipment and Tools* (OP-018).

7.9 Recordkeeping

7.9.1 Information will be documented clearly, neatly, accurately, and concisely, and prepared in dark, waterproof ink. Data will not be

obliterated by erasing, with whiteout, or by any other means. To make a correction, a single line will be struck through the error, and the corrector will initial and date the line.

7.9.2 The RPT, or designee, will review applicable forms for accuracy and completeness, and date and initial entries to validate the survey.

8.0 REFERENCES

- *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM),* DoD, DOE, EPA and NRC, Revision 1 (2000).
- Radiation Safety Program, Cabrera Services Inc., Manual
- AP-005, *ALARA*, Cabrera Services Inc., Operating Procedure
- OP-008, *Chain-of-Custody*, Cabrera Services Inc., Operating Procedure
- OP-018, *Decontamination of Equipment and Tools*, Cabrera Services Inc., Operating Procedure
- OP-187, *Records Management*, Cabrera Services Inc., Operating Procedure
- OP-351,*Surface Soil Sampling*, Cabrera Services Inc., Operating Procedure
- OP-352, *Surface Soil Sampling*, Cabrera Services Inc., Operating Procedure
- OP-355, *Low-flow Groundwater Sampling Procedures*, Cabrera Services Inc., Operating Procedure

9.0 REQUIRED RECORDS

- Field-sampling logbooks
- Record forms
- Sample chain-of-custody (COC) forms
- Sample Status Log

10.0 ATTACHMENTS

There are no attachments associated with this procedure

CABRERA SERVICES

RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

RADIATION SAFETY PROCEDURE

FOR

CHAIN-OF-CUSTODY

OP-008

REVISION 1

Approved by: Henry Siegrist
Henry Siegrist, CHP, PE, Corporate Health Physicist
Date: 6/1/2006

Approved by: David J. Watters
Dave Watters, CHP, Senior Vice President, Operations
Date: 6/1/2006

1.0 PURPOSE

This procedure provides the methods Cabrera Services, Inc. (CABRERA) personnel shall utilize to transfer samples collected for characterization and/or final status surveys to a certified laboratory for analysis. Adherence to this procedure will provide assurance that appropriate analyses are requested, and that proper association between sample ID, sample location, and other pertinent sample parameters are documented and tracked by a known organization.

2.0 APPLICABILITY

This procedure will be used at all CABRERA work sites that require sample analysis to facilitate collection of data to be used in the official evaluation of the radionuclide or hazardous material content of the sample.

3.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

3.1 Precautions

3.1.1 Samples sent to an offsite analytical laboratory for analysis shall be returned to the site after processing for disposal if this is the condition of the laboratory contract. There may be occasions where the laboratory will hold and/or dispose of the samples.

3.1.2 Samples containing licensed radioactive material may only be sent to laboratories approved to handle such samples. Personnel shall use caution to assure sample radioactivity does not exceed the laboratory's license quantities.

3.2 Limitations

3.2.1 Personnel shall contact the contracted analytical laboratory to verify if they have their own required chain-of-custody. If the laboratory has its own, then personnel shall utilize their provided form, not the one used in this operating procedure.

3.3 Requirements

3.3.1 The chain-of-custody provided as an attachment to this procedure is based on an electronic CABRERA template. The version included in this procedure is provided as an example, not for use at a worksite. Personnel who use it shall ensure that they are using the most updated electronic template.

4.0 REFERENCES

- CABRERA Radiation Safety Program (RSP)
- AP-001 Record Retention

5.0 DEFINITIONS AND ABBREVIATIONS

5.1 Custody Seal - Custody seals are tamper-indicating devices. They record if access has occurred, they are not meant to resist it.

6.0 EQUIPMENT

Custody seals

7.0 RESPONSIBILITIES

7.1 Corporate Radiation Safety Officer/Health Physicist (RSO or Corp. HP) - The RSO or Corp. HP shall ensure that personnel who work with radioactive material are trained, and have an adequate understanding in the use of this procedure.

7.2 Health Physics Technicians (HPT) - The HPT are responsible for the control of radioactive material, coverage of radiation workers, and general safety protection. The HPT are responsible for knowing and complying with this procedure.

7.3 Project Manager (PM) - The PM is responsible for the radiological safety of all personnel onsite, ensuring that if they work in radiologically controlled areas, that they are familiar with this procedure, adequately trained in its use, and have access to a copy of procedures.

7.4 Sample Collector - Sample collectors are responsible for following the SRSO's instructions to ensure compliance with this procedure.

7.5 Site Radiation Safety Officer (SRSO) - The SRSO acts as the RSO's and Corp HP's duly authorized representative for radiological issues when neither are onsite. The SRSO shall be onsite when work is in progress and shall perform the requirements established in this procedure, and ensure that they are implemented during field assignments.

8.0 INSTRUCTIONS

8.1 General Instructions

8.1.1 The sample collector shall initiate a chain-of-custody form by filling in the requested information. Personnel may utilize the "Chain-of-Custody Checklist" (supplied in Attachment OP-008-01) to verify they

have completed CABRERA's chain-of-custody (supplied in Attachment OP-008-02) completely.

8.1.2 Proper chain-of-custody is maintained when the sample is controlled under the direct surveillance of an individual; in a controlled access facility, or the sample is in a tamper-resistant container.

8.1.3 If the sample is to be transported by any means other than hand delivered by the custodial individual, custody seals shall be used.

8.1.4 Upon transfer of the samples to another individual, that individual shall sign as recipient. A copy of the chain-of-custody form shall be maintained for record keeping purposes while the original will remain with the sample.

8.1.5 Upon arrival of the sample at the laboratory, the laboratory recipient shall inspect the sample for signs of tampering. If indication of tampering is noted, the laboratory shall notify site personnel who may need to collect another sample as conditions merit.

8.1.6 Once the sample is in the custody of the laboratory, it shall be maintained in accordance with the laboratory's chain-of-custody and quality assurance procedures.

8.2 Recordkeeping

8.2.1 Information shall be documented clearly, neatly, accurately, and concisely, and prepared in dark, waterproof ink. Data shall not be obliterated by erasing, with whiteout, or by any other means. To make a correction, a single line shall be struck through the error, and the corrector shall initial and date the line.

8.2.2 The HPT or designee shall review applicable forms for accuracy and completeness, and date and initial entries to validate the survey.

8.2.3 Records shall be maintained in accordance with "Record Retention" (AP-001).

9.0 ATTACHMENTS

- OP-008-01 CABRERA Chain-of-Custody Checklist
- OP-008-02 Chain-of-Custody/Analysis Record

OP-008-01 - CABRERA Chain-of-Custody Checklist

REQUIRED INFORMATION	DESCRIPTION AND INSTRUCTIONS	COMPLETED?
Page: of		
Project #:		
Lab Quote #:	Supplied by analytical laboratory	
COC #:		
PO #:		
Project/Site Name:		
Collected By:	Sample collectors	
Send Results to:	Project manager for site	
Custody Seal #:	As applicable, some laboratories do not require this	
Laboratory:	Complete analytical laboratory name, address, phone #, and fax #	
Should this sample be considered:	Check box to appropriate sample ID as to whether the sample should be considered radioactive and/or TSCA regulated	
Preservative Type:	Refer to footnote 5, and fill in appropriate information	
Sample Analysis Requested:	Refer to footnote 4 and fill in appropriate information, list the appropriate number of sample containers in the appropriate Sample ID row	
Sample ID	List each sample ID being shipped under this Chain-of-Custody	
Date Collected	Document date sample was collected in mm-dd-yy format	
Time Collected	Document time sample was collected in military time (hhmm)	
QC Code	Refer to footnote 1, and fill in appropriate information	
Field Filtered	Refer to footnote 2, and fill in appropriate information	
Matrix Code	Refer to footnote 3 , and fill in appropriate information	
Comments:	List any comments regarding samples	
Requested Turnaround Time:	Provided by project manager	
Fax Results:	Circle Yes or No	
Email Results, when available to:	Enter PM's email address	
Remarks:	List any remarks	
Chain-of-Custody Signatures	Sign under relinquished by and document date and time when relinquishing shipping container to shipper	
Sample Shipping and Delivery Details	Fill in the laboratory PM, method of shipment (i.e., FedEx, UPS, etc.), date shipped, and airbill #.	

OP-008-02 - Chain-of-Custody/Analysis Record

Page: of	**CABRERA Chain-of-Custody and Analytical Request**	Laboratory:
Project #:		Address:
Lab Quote #:		
COC #:		Phone #:
PO #:		Fax #:

Client Name: Cabrera Services, Inc.	Custody Seal #:						Should this sample be considered:		Preservative Type (5)												**Comments**	
Address: 473 Silver Lane East Hartford, CT 06118	Phone #: (860) 569-0095 Fax #: (860) 569-0277																				Note: Extra sample is required for sample-specific QC	
Project/Site Name:							Radioactive	TSCA Regulated	Sample Analysis Requested (4) (Fill in the number of containers for each test)													
Collected by:	Send Results to:																					
Sample ID	Date Collected (mm-dd-yy)	Time Collected (Military) (hhmm)	QC Code(1)	Field Filtered(2)	Matrix Code(3)																	

Requested Turnaround Time: Normal: __ Rush: ____ Specify: ____ (subject to surcharge) | Fax Results: Yes / No | Email Results, when available to:

***Remarks*:** *Are there any known hazards applicable to these samples? If so, please list:*

Chain-of-Custody Signatures					**Sample Shipping and Delivery Details**	
Relinquished By (Signature)	Date	Time	Received By (Signature)	Date Time	Laboratory PM:	
1			1		Method of Shipment:	Date Shipped:
2			2		Airbill #:	
3			3		Airbill #:	

1.)	QC Codes: **N**: Normal Sample; **TB**: Trip Blank; **FD**: Field Duplicate; **EB**: Equipment Blank; **MS**: Matrix Spike Sample; **MSD**: Matrix Spike Duplicate Sample; **G**: Grab; **C**: Composite	***For Lab Receiving Use Only***
2.)	Field Filtered: Only applicable to liquid matrices. Answer **Y** if the sample was field filtered or **N** if the sample was not field filtered.	*Custody Seal Intact?*
3.)	Matrix Code: **DW**: Drinking Water; **GW**: Groundwater; **SW**: Surface Water; **SO**: Soil; **SD**: Sediment; **SL**: Sludge; **SOW**: Solid Waste; **O**: Oil; **F**: Filter; **P**: Wipe; **U**: Urine	*YES NO*
4.)	Sample Analysis Requested: Analytical method requested (i.e., **8260B**, **6010B/7470A**) and number of containers provided for each analysis	
5.)	Preservative Type: **Hcl**: Hydrochloric Acid; **NI**: Nitric Acid; **SH**: Sulfuric Acid; **AA**: Ascorbic Acid; **HX**: Hexane; **ST**: Sodium Thiosulfate; **C**: Cool; *If **no preservative** is added, then leave the field blank.*	*Cooler Temp: _____ ˚C*

CABRERA SERVICES
RADIOLOGICAL • ENGINEERING • REMEDIATION

OPERATING PROCEDURE

FOR

SAMPLE MANAGEMENT & SHIPPING

OP-362

REVISION 2.0

Prepared by:

_____ April 13, 2015

Carl Young, PG — Date
Project Manager

Approved by:

_____ April 13, 2015

Sean Liddy, CSP — Date
Quality Assurance Manager

1.0 PURPOSE

The purpose of this Operating Procedure (OP) is to provide Cabrera Services Inc. (Cabrera) personnel the methods to utilize when managing and shipping field samples. Adherence to this procedure will provide the following:

- Consistency in sampling labeling/numbering.
- Assurance that the results are traceable to a specific sample location, type and matrix.
- Track disposition of samples and associate quality control samples with primary samples.
- Assure the safe handling of samples during the shipping process through proper packaging
- Assurance that the analyses performed have reproducible results.

2.0 APPLICABILITY

This procedure applies to all Cabrera Services Inc (Cabrera) employees and operations. Personnel shall utilize this procedure for all environmental field samples unless specified otherwise through the project specific Field Sampling Plan (FSP), or Quality Assurance Project Plan (QAPP). Personnel must assure that the specifications of this SOP agree with the specifications listed in the Project Work Plans.

3.0 DEFINITIONS

3.1 Project Plans - For the purposes of this procedure, a generic term describing the project implementing plans that contain the information associated with the requirements for mandated sampling. These include, but are not necessarily limited to:

3.2 Project Work Plan (PWP) - The over-arching project plan used to manage both project execution and project controls. A primary use is to document planning assumptions and decisions including quality assurance and quality control (QA/QC) measures regarding data gathering and deliverables.

3.3 Field Sampling Plan (FSP) - Provides specific directions for conducting each separate field sampling activity and presents the rationale and design, for the work, as well as the field procedures for each specific activity required. Field operations and documentation are also described and may include discussions on field logbooks, photographic records, sample documentation, field analytical records, and procedures for their management and retention.

3.4 Quality Assurance Project Plan (QAPP) - Focuses primarily on the analytical methods and QA/QC procedures that are used to analyze and manage environmental samples and their resulting data. The QAPP also presents the

project organization, objectives, procedures, functional activities, and specific QA/QC activities associated with sampling, data management and record retention.

3.5 Site Safety and Health Plan (SSHP) – Provides evacuation routes for the site and immediate area; site-specific safety information; MSDS for any relevant chemicals of concern; and names and telephone numbers of common emergency contact personnel for the worksite. In addition, the SSHP may also contain sampling activities required to monitor worksite safety and health.

3.6 Quality Assurance (QA) - All procedures, practices, records, and other documentation required to provide confirmation that project activities are completed in a manner compliant with regulations, specifications, and/or contract requirements.

3.7 Quality Control (QC) - For the purposes of this procedure, actions taken to control the variable attributes of the sampling and analytical processes to meet the data quality objectives described in the project plans.

3.8 Sample Tracking Log - A quality control form that lists all of the samples collected, list the analyses to be performed, and tracks their destination.

3.9 Chain of Custody - The Chain of Custody lists and describes a shipment of samples that leave the custody of the sampler and are transferred to the custody of the laboratory. For additional information, please refer to OP-008, Chain of Custody.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

Many environmental field samples are preserved using concentrated acids. These preservatives are typically placed in otherwise empty containers by the laboratory. Personnel must wear appropriate PPE and exercise appropriate care when handling sample containers. Preservative may leak from containers during shipment, or may be released into packaging from broken containers. Preservative can be splashed into the air when containers are opened.

When environmental samples are preserved (i.e., acidification or alkalinization), this is accomplished by adding a regulated hazardous material to the sample. Despite the addition of these preservatives, the samples will not be considered regulated hazardous materials, as long as the following concentrations are complied with:

Preservative		Desired in Final Sample		Quantity of Preservative (mL) for specified container				
		pH	Conc.	40 mL	250 mL	500 mL	1 Liter	1 Gallon
HCl	3N	<2	0.04%	0.15	1	2	3	10
HNO_3	4.5N	<2	0.15%	-	3	6	12	Not Authorized
H_2SO_4	18N	<2	0.35%	-	1	2	4	16
NaOH	30%	>12	0.08%	-	0.5	1	2	8

Derived from requirement of 49 CFR Part 172 and 40 CFR Part 136.3.

Samples taken for analyses that are anticipated to be relatively low in concentration (i.e., in the low ppm range for total contaminants) are generally not subject to the requirements of the DOT regulations, however; if the samples contain any free-phase layer or exhibit characteristics found in Hazard Class 1 through 9, the sample must be shipped as a regulated hazardous material (please refer to OP-391, HAZMAT/DG Shipping and contact Cabrera's HAZMAT Shipping Expert for additional Guidance). DOT / IATA Shipper Training is required in order to package and ship hazardous materials.

Even though environmental samples, as defined by this procedure, are not regulated by the US Department of Transportation (DOT), they must be packaged and shipped in accordance with good product stewardship practices. Samples must be packaged properly to avoid breakage, including the use "secondary containment" in the form of plastic zipper storage bags on sample sets, and the use of a plastic "trash" bag as a liner within the cooler. US DOT and common carriers may levy severe penalties if fluids of any kind are found to be leaking from coolers.

All samples should be stored/maintained in a location with adequate ventilation. Samples having significant VOC or SVOC concentrations can slowly release vapors into a confined space over time such that local concentrations may exceed action limits.

4.2 Limitations

Onsite storage may not be appropriate for samples having short holding times. The Field Site Manager (FSM) must take into account the time required for sample shipment, receiving, and sample extraction/preparation in order to determine appropriate onsite holding times.

The Cabrera field representative who delivers (or arranges delivery of) the samples to the laboratory is responsible for ensuring that sufficient cooling material (e.g. ice) is present in the shipment container so that the sample temperature is maintained during transportation to the laboratory. This is especially critical if the samples are being transported via overnight common courier (such as FedEx) during the middle

of the summer. Always err on the side of caution by placing as much ice as possible in the shipment container; re-sampling will always be more expensive than an extra bag of ice.

4.3 Requirements

4.3.1 Sample names are unique identifiers. Sample codes must be assigned such that they discriminate a sample from any other samples.

4.3.2 Sample numbers must be recorded in at least four places:

1) On the sample container
2) On the Chain-of-Custody
3) On a Sample Control Log
4) In the field notebook.

4.3.3 Personnel using this procedure shall be familiar with the Project Work Plans.

4.4 Field Personnel shall discuss deviations to the Project Work Plans with the Project Manager. Any deviations, plus conversations with the PM, shall be documented in the project field notebook.

5.0 EQUIPMENT

- Either pre-printed or on-site printed sample labels
- Bubble wrap
- Ice
- Gallon-size water-tight freezer bags
- Trash bags
- Coolers
- Packing tape
- Custody seals
- Shipping labels
- Sample tracking log
- Field notebook
- Secured staging area with appropriate ambient temperatures and access controls

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) - The PM is responsible for implementing and ensuring compliance with the contents of the project plans, and hence the design of the sample numbering system. They also must ensure that project personnel have been trained and are qualified to implement this procedure.

6.2 Field Site Manager (FSM) - The FSM is responsible for: the execution of field activities in discussion with the PM; correctly applying the sample numbering system; and, entering information into the field notebooks.

6.3 Project Personnel - All Cabrera personnel are responsible for reading, understanding, and complying with the provisions of this procedure prior to engaging in sampling activities. In addition, site workers should discuss any deviations from the prescribed sampling protocols with the PM or FSM, and document that conversation in the project field notebook.

7.0 PROCEDURE

Environmental samples usually consist of environmental media (soil, water, air) that may have been impacted by source area materials, but not to an extent that they would contain any free product or hazardous concentrations of contaminants. Examples of these types of samples might include soils with no visible staining or strong odors, surface and groundwater samples with no floating product, and air samples collected on sorbent tubes or filters.

The following subsections outline the requirements for the proper labeling, numbering, tracking, storage, packaging, and shipping of environmental samples on Cabrera project sites. All samples are to be handled by as few people as possible and the chain of custody form must document the change of possession by the appropriate dated signatures.

7.1 Sample Labeling

Sample labels provide specific information that is permanently affixed to the sample container using a water-proof label and are necessary to prevent misidentification of samples. Preprinted sample labels are to be used unless alternative labels are approved by the PM. Where necessary, the label will be protected from water and solvents with a clear covering of transparent tape. Use an ink pen or water-proof marker when writing on labels. Each label will contain the following information:

- Name or initials of the collector
- Date and time of collection
- Job name and number
- Sample number and/or boring number and depth
- Preservative (if required).

7.2 Sample Numbering

The sample numbering process consists of the assignment of a unique sample identification number to be placed on sample labels or tags, and chain-of-custody form. Primary samples and QC samples will each be assigned unique sample identification (ID) numbers as outlined below, unless an alternate numbering process is specified in a site-specific FSP or QAPP. The sample ID will be composed of six components separated by dashes, as shown below:

[_ _] - [_ _] - [_ _] - [_ _] - [_ _] - [_ _]

1 2 3 4 5 6

7.2.1 Component 1 - Defines the location or area of interest, as designated in the PWP. This component must be a small combination of letters and/or numbers (i.e., alphanumeric) without special characters. For example:

- If the site is divided into two “areas of concern,” you might use AOC1 and AOC2 as the location descriptors; or
- If the site contains 12 “survey units,” you might use SU01 – SU12 as the location descriptors. (Consider using the symbol ”Ø” instead of “0” in this context to avoid misidentification by the laboratory.)

Note: At a site with a single sampling area, this numbering component should be eliminated unless another unique discriminator is required. Do not use a site abbreviation as this is common to all samples collected.

7.2.2 Component 2 – Defines the station type:

BF	=	Backfill
CPT	=	Cone Penetrometer
D	=	Drum
EXB	=	Excavation – bottom sample
EXE	=	Excavation – east sidewall sample
EXN	=	Excavation – north sidewall sample
EXS	=	Excavation – south sidewall sample
EXW	=	Excavation – west sidewall sample
MW	=	Monitor Well
P	=	Pipe
SB	=	Soil Boring (includes groundwater acquired from borings)
SP	=	Stockpile
T	=	Tank

7.2.3 Component 3 - Identifies the station number in the area of interest. Number sequences start from 001 in each area [component 1].

7.2.4 Component 4 – Defines the sample matrix using letters:

A	=	Air or soil gas
E	=	Effluent (waste water)
S	=	Soil sample in general or Subsurface Soil Sample
SS	=	Surface Soil Sample
SD	=	Sediment Sample
GF	=	Groundwater Sample – Filtered
GU	=	Groundwater Sample – Unfiltered
W	=	water sample in general or Surface Water Sample

7.2.5 Component 5 – Defines either the primary or QC sample collected:

P	=	Primary Sample
MS	=	Matrix Spike
MSD	=	Matrix Spike Duplicate
DUP	=	Duplicate
EB	=	Equipment (Rinsate) Blank
TB	=	Trip Blank
FB	=	Field Blank
QA	=	QA Split

7.2.6 Component 6 – Identifies the depth at which the sample was taken:

- For soil and sediment samples, it will designate the top of the sample interval, in feet.
- For groundwater samples, it will designate the depth below ground surface for the entry point of the sampling device (for example, the depth of tubing placement for a peristaltic pump).
- For surface water samples, it will designate the depth below water surface from which the sample was collected.

To maintain a unique sample ID, the sample database should be reviewed to identify the last sample number used for each station.

Sample Naming Convention Examples:

- The 16th primary soil sample collected at Building 23 from a soil boring and collected from a depth of 8 feet would be named 23-SB-16-S-P-08.
- The field duplicate, for the sample above, would be named 23-SB-16-S-DUP-08.
- The equipment blank, for the sample above, would be named 23-SB-16-W-EB-08.

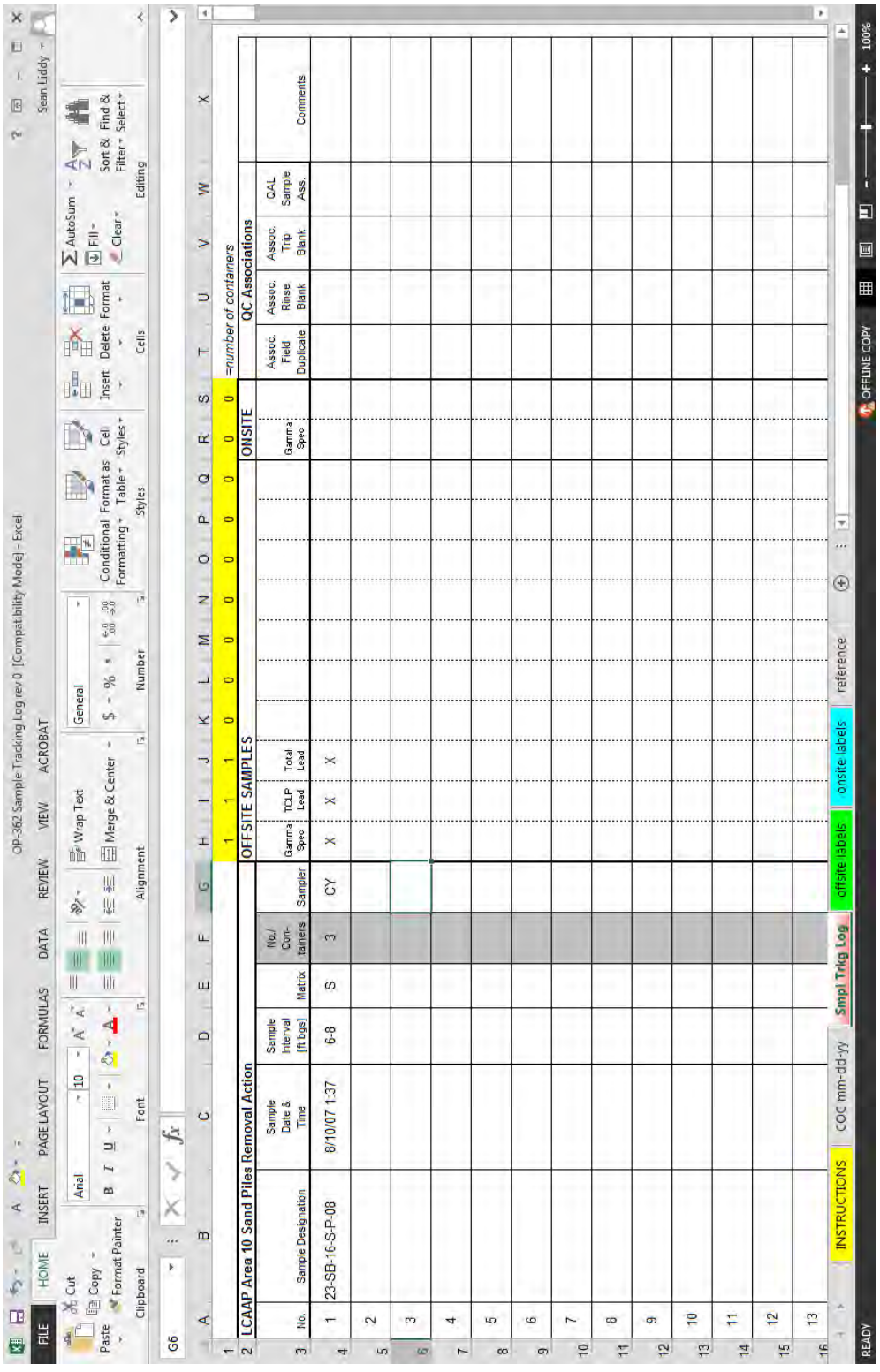
7.3 Sample Tracking

The tracking of samples shall be completed by making accurate record of the samples collected in a field log book, a sample tracking log, and through the use of a Chain of Custody. The QAPP should specify whether the lab's Chain of Custody should be used or whether a Cabrera chain of custody should be used. Information on how to complete a Chain of Custody may be found in Cabrera OP-008, Chain of Custody.

Sample tracking provides assurance that appropriate analyses are requested, and that the sample can be entered into the site data set. Cabrera's Sample Tracking Log is an electronic tool (Excel File) used to capture information about the sample, including associated Quality Control samples, and includes options for generating sample labels and printing chain of custodies.

The electronic Sampling Tracking Log is especially useful for large sampling projects. A Work Instruction on its use is been included as Attachment A.

An example of the Sample Track Log from the Excel workbook is below:



Example of Sample Tracking Log in Excel Workbook.

7.4 On-site Sample Storage

The typical uses for onsite sample storage include: holding samples when they cannot be shipped, holding sample splits pending decisions on additional analysis, holding samples following onsite analysis pending decisions on final sample disposition.

Samples must be maintained in the custody of the FSM or his designee. In order to maintain a chain-of-custody, the sample storage area must not be accessible by unauthorized personnel, either through the use of custody seals or locks.

The sample storage area must have the proper environmental controls to keep the samples within an acceptable temperature range.

The FSM shall use the Sample Tracking Log, or similar means, to monitor the location of each of the samples.

7.5 Sample Packaging

The procedures to be employed by the Cabrera field representative for sample packaging will vary based on the types of samples, containers, and method of shipment to the laboratory. Cabrera's procedures for sample packaging are as follows unless site-specific planning documents (such as a QAPP) require alternate procedures:

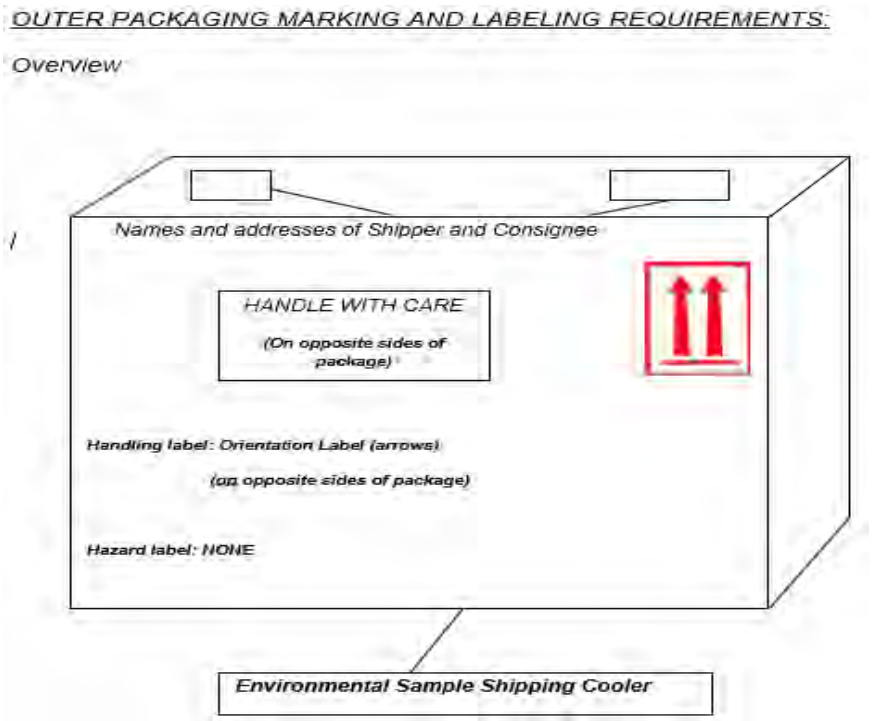
- For 40 ml volatile organic analysis (VOA) sample bottles, the Cabrera field representative should either have a foam block for the samples or sufficient plastic bags and shipping material (such as bubble wrap). The foam block is preferable for protecting the VOA bottles from breaking. Otherwise, the Cabrera field representative must wrap VOA bottles in bubble wrap and place a maximum of three wrapped VOA bottles into a plastic zipper storage bag. For each shipping container, sufficient cooling material is placed into the container (see next bullet), and the container is filled with plastic zipper storage bags of samples. The chain of custody form is to be signed by the person delivering the samples to the laboratory and the form is sealed into a plastic zipper storage bag and taped to the inside lid of the shipping container. Lastly, the container is taped shut and, if required, custody seals are placed on the container.
- If samples are to be shipped, it is extremely important that ice be packed in such a way the water from melting ice is prevented from leaking out of the coolers. Cooler drains shall be taped shut. A trash bag should be placed in the empty cooler before any samples or other packaging is used. Ice should be placed in a double layer (double bagged) of water-tight plastic zipper storage bags.
- For other types of samples and containers, the process is generally the same except that each sample bottle should be wrapped in a protective

layer of material and placed into separate, sealed plastic zipper storage bags, if possible.

- If the samples are very high concentration (total chemical concentration greater than or equal to 15 percent) and are to be shipped by overnight common courier, the use of shipment cans and vermiculite is required for safe transportation. Also note that labeling of these types of high concentration samples (cans and coolers) must comply with Department of Transportation (DOT) labeling requirements.
- The chain-of-custody should be placed in the cooler on top of any packaging. Protect the chain-of-custody inside a plastic zipper storage bag. If the cooler has been scanned, smeared and cleared for potential radioactive contamination, place a copy of the survey in the bag along with the chain-of-custody.
- Seal the cooler closed with packing tape. Apply orientation arrows and "Handle with Care" stickers on at least two sides of the cooler, along with two custody seals, intercalated within the layers of packing tape.

The figure below illustrates the above procedure. If any steps in this procedure do not apply to your situation or you cannot follow each step due to technical concerns, consult your local HAZMAT Shipping Specialist or OH&S Manager for additional details.

Environmental Sample Package / Label Example



The Cabrera field representative is responsible for properly and safely following the procedures presented in this section so that holding times are not exceeded, proper preservation temperatures are maintained during shipment (≤4°C per 40 CFR Part 136), and the samples are packaged so sample containers are not broken during transportation to the laboratory.

7.6 Sample Shipping

For shipment of samples, it is important to make the arrangements for transporting the samples to the laboratory before starting any sampling episode. If the samples are to be sent by overnight common courier, the prior arrangements include obtaining pickup service or determining where and when the samples can be dropped off. It may also be necessary to modify the sampling schedule to match the latest pickup/drop off times for overnight delivery.

For samples collected or shipped on Friday, Saturday, or Sunday, the Cabrera field representative should ensure that laboratory personnel will be present to accept the shipment. If sample coolers sit on a loading dock for a day or more sample integrity may be compromised as the ice melts. The project manager and/or the Cabrera field representative should also check with the laboratory to be used for the project and determine if they have a dedicated courier service. While there may be a fee for this service, in some circumstances this service will be the most cost-effective method of shipment.

If samples are to be shipped via FedEx or UPS, place address label with both the shipped from and ship to address on the top of the cooler. Complete standard airbill and attach to cooler. Maintain Sender's copy until samples have been received by the laboratory.

When shipping environmental samples, the transporter (Federal Express) may require a "NOT RESTRICTED" declaration to be completed by the shipper and ask that the package be labeled accordingly. These declarations can be completed providing that the package contains only environmental samples.

8.0 REFERENCES

- Cabrera OP-008, Chain of Custody
- Cabrera OP-391, HAZMAT/DG Shipping
- 40 CFR, Part 136, Guidelines Establishing Test Procedures for the Analysis of Pollutants (2003)

9.0 REQUIRED RECORDS

- Chain-of-Custody forms
- Sample Control Log
- All field notebooks and/or sample documentation

10.0 ATTACHMENTS

Attachment A – Sample Tracking Log Instructions

Attachment A

Sample Tracking Log Instructions

Sample Tracking Log Instructions

The sample tracking log is an Excel spreadsheet that contains numerous linked cells. Employees that are expected to enter data into this form should be familiar with this procedure to ensure quality information.

1.0 Instructions Tab

The first page of the file presents detailed information on how to use the Excel tool.

2.0 COC Tab

The Cabrera office address and phone and fax numbers should be entered in column C, rows 1 through 3.

Enter the project specific information in column A, rows 5 through 8. This information typically includes:

- Project Name
- Project Number
- Cabrera Contact name, phone and fax numbers

Enter the analysis names (row 9) and methods (rows 5 through 8) needed in columns H through Q. It's best to group the soil analyses separately from the water analyses for the sake of clarity. The analysis names and method numbers will then be automatically updated onto the Sample Tracking Log.

The ‘sample description’, rows 10 through 34 of the COC, are to be pasted in from Columns B through Q of the Sample Tracking Log. Column A “Lab ID” is for the use of the lab and they will assign their own numbers in this column. The COC accommodates 25 samples on Page 1 and an additional 25 samples on Page 2. Make a copy of the COC spreadsheet for use the next day.

The COC has been set up in ‘portrait’ format rather than the customary ‘landscape’ format in order to accommodate more samples (see Figures in Section 23.0).

To print the COC, if you have more than 25 samples, simply select the ‘Print’ icon. If there are 25 samples or less, do not use the ‘print’ icon, but instead select ‘\File \Print…’ from the drop-down menus, then print only Page 1 of the COC.
After the COC is printed, unused columns and rows are typically ‘lined through’ to prevent the addition of unwanted information. Cells can be ‘lined through’ in Excel by changing the ‘fill color ‘of the unused rows and columns to gray.

The COC must be printed twice in order to send the ‘original’ to the lab and to retain a copy for project records. If a copier isn’t available, any handwriting made on the original must be exactly duplicated on the copy. Alternatively, if the only

handwriting needed on the COC is in the signature box, the COC may be signed digitally using Adobe Acrobat, then only one paper original needs to be printed, and the 'copy' can be saved digitally.

3.0 Sample Tracking Log Tab

The Sample Tracking Log is set up by entering the number of containers needed for each analysis type in Row 1 (these cells are shaded yellow). The analysis names are automatically entered from the COC.

Once in the field, enter pertinent data onto the sample tracking log. Enter the sample name and sample time, which must be entered in 'mm/dd/yy hh:mm' Excel format. Enter sample depths and codes for matrices as specified in the project work plans.

The total number of containers associated with each sample (Column F) is updated automatically. Associate duplicates with primary samples by typing in the row number of the duplicate into Column T of the primary sample row – vice versa for the duplicate sample row. Associate trip blanks and rinse blanks by typing in the row numbers for these blanks into Column T of every pertinent primary and field duplicate.

Enter the sampler's initials into column G. Then select which analyses will be performed by placing an 'X' in the appropriate column.

4.0 Labels (On and Off-Site) Tabs

Labels have been formatted to print onto 2" x 4" shipping labels using a label printer. This type of label is thermally-printed and therefore water-resistant. A label printer has advantages over laser printers in that only the labels needed are printed, and they can be printed in the field instead of in advance of field work.

The 'label' tabs have been set up to print all of the labels needed for a single row of information entered onto the sample tracking log. Contents of the sample tracking log are automatically pasted into Row 3 of the 'label' tab, starting at Colum K. The 'container' and 'preservative' information are set up to be automatically pasted from the 'reference' tab. One can simply type this information directly, if desired. Bar-code information is updated automatically. The bar codes are in Code 39 format and are intended to be used by the lab to reduce data transcription errors.

To print a label, enter the number from column A on the Sample Tracking Log corresponding to the sample one wishes to label into cell F3 (which is shaded green) on the 'label' tab. The sample information is then entered automatically onto the label. For the Dymo LabelWriter 400 printer, select 'landscape'. For paper size, select the no. 30323 'shipping label'.

5.0 Reference Tab

An 'analysis summary' should come from the project FSP or from the client's Scope of Work. The Reference tab contains an example of a typical analysis summary list, which includes the analyses, analyses methods, sample containers, preservatives, and hold times. The project specific analysis summary should be pasted into the Reference Tab (see Figures in Section 23.0) replacing the example. It is also acceptable to adapt the example to reflect the project requirements.

The analysis type, container and preservative are used on the sample labels. The workbook links some of the label cells to the reference cells, so be very careful that the appropriate cell is linked before printing off the labels.

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

HEALTH PHYSICS INSTRUMENT GENERAL QUALITY CONTROL PROCEDURE

OP-358

Revision 1.0

Revised by:

Michael S. Winters, Principal CHP — 8/27/13 Date

Approved by:

David Wunsch, Corporate QA Manager — 8/27/13 Date

1.0 PURPOSE

The purpose of this Operating Procedure (OP) is to provide the steps necessary to properly perform and document quality control (QC) measurements on Cabrera Services Inc. (CABRERA) field health physics instrumentation.

2.0 APPLICABILITY

This procedure provides the requirements and proper techniques to perform initial and daily QC measurements on a variety of CABRERA field health physics (HP) instruments after the instrument has been received from formal calibration in accordance with ANSI N323A. Actual instrument calibrations are performed in accordance with ANSI/ANS N323A by a third-party and are outside the scope of this procedure. Determinations of Instrument efficiency, source efficiency, and total efficiency using the ISO-7503 approach are addressed in separate Cabrera OP-380. This procedure is to be used in conjunction with other applicable instrument use procedures.

3.0 DEFINITIONS

3.1 Acceptance Criteria – Calculated operability for a given instrument, based on the initial quality control measurements, typically represented in percentage format (i.e., ± 20%) or in terms of standard deviations from the mean (i.e., ± 2-sigma).

3.2 Chi-Square Test (X^2) – A statistical test used to determine how well experimental data fit a series of counts to a Poisson distribution. Chi-square is used for health physics instruments to test for biases that could impact the accurate reporting of the random nature of radioactivity.

3.3 Control Chart – A plot of the results of an instrument's quality control measurements, along with the calculated acceptance criteria shown as upper and lower boundaries.

3.4 Qualitative Instrument – A count rate or dose rate survey instrument that is used for general survey purposes and not for official or release survey purposes. Examples include the Ludlum Measurements, Inc. (Ludlum) Model 3 ratemeter coupled with a Ludlum Model 44-9 Geiger-Mueller (G-M) tube, typically used for routine surveys and general contamination control at step off pads. The Bicron Microrem dose rate meter is also administered as a Qualitative instrument, even though its output may be used for official release purposes.

3.5 Quantitative Instrument – A scaler-capable instrument that is used for demonstrating compliance with established standards or derived release criteria, e.g. disintegrations per 100 square centimeters (dpm/100 cm^2). Examples include the Ludlum Model 2929 dual-scaler alpha-beta counter and a Ludlum Model 2224 ratemeter/scaler coupled with a 43-93 dual phosphor scintillator.

3.6 Sigma (σ or Standard Deviation) – A measure of the dispersion or spread of sample data about the mean of the data. Standard deviation is the square root of the variance.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

4.1.1 Health physics instruments operate at high voltage, between 500 and 2000 volts direct current. Caution should always be used when working with these instruments as shocks can occur.

4.1.2 If any instrument inconsistencies are observed (e.g., unusually high or low background counts or source checks outside acceptance criteria), remove the instrument from use and report the condition to the Site Radiation Safety Lead (SRSL) or other duly authorized representative.

4.1.3 Response check sources should be handled carefully to prevent damage to the radiation source or cross-contamination. Report any suspected damage to a standard to the CABRERA Radiation Safety Officer (RSO), or authorized representative, immediately.

4.2 Limitations

4.2.1 Ensure that the sources energy type (i.e., alpha, beta, gamma, and neutron) and overall activity are appropriate for the detector in use.

4.2.2 The worksheets discussed in this procedure are meant to be completed on a PC or portable device and maintained as electronic records. If security or technology limitations prevent use of/access to the electronic files, an alternate hard copy approach may be approved by the PHP or RSO on a case-by-case basis.

4.2.3 Instrument efficiency is not determined using this procedure. The Four-Pi (4π) Instrument efficiency value(s) are typically provided by the calibration organization on the provided label and calibration certificate. Efficiency values, based on the ISO-7503 approach, are determined by Cabrera under separate OP-380. Applicable efficiency/emission energy values will be used as directed by the PHP or Corporate RSO on a project-by-project basis.

4.3 Requirements

4.3.1 Specific protocols in this procedure may be superseded by client/project-specific plan requirements or per direction from the RSO (e.g., efficiency calculations, QC frequency, instrument-specific application as Qualitative vs. Quantitative, MDAs and count times, etc.).

4.3.2 Survey instrument calibrations shall be performed by a U.S. Nuclear Regulatory Commission (NRC) or Agreement State licensed calibration facility.

4.3.3 Out-of-Service equipment shall be clearly tagged or labeled to prevent unauthorized use.

4.3.4 All radioactive sources shall be kept in secure locations and handled in accordance with all CABRERA Radiation Safety Program (RSP) documents.

4.3.5 Instruments used to perform radiological measurements will be operated in accordance with the respective CABRERA OPs or manufacturer's recommendations.

4.3.6 Instruments used to perform radiological measurements will have a current calibration certificate (i.e., one received within the past 12 months).

4.3.7 Active Project QC worksheets shall be reviewed weekly by the assigned SRSL, or designee.

4.3.8 Electronic versions of MS Excel© workbooks shall be backed up from the field computer to semi-permanent media (CD-ROM, thumb drives, CABRERA office hard drives) at least once per week.

5.0 EQUIPMENT

There is no equipment associated with this procedure.

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) – Ensuring that personnel assigned the task of instrument quality control know and understand this procedure, are adequately trained in its use, and have easy access to a copy.

6.2 (Corporate) Radiation Safety Officer (RSO) – Manages CABRERA's Radiation Safety Program, responsible for the management and upkeep of all Radiation Safety Procedures and approved electronic instrument QC spreadsheets.

6.3 Project Health Physicist (PHP) – Serves as the senior-most HP representative assigned to a Project/Task.

6.4 Site Radiation Safety Lead (SRSL) – During field assignments, the SRSL is responsible for ensuring that this procedure is properly implemented and will ensure the safekeeping and review of all project instrument QC data. The SRSL is responsible for the oversight of all health physics-related project field technical aspects. The SRSL will act as the NRC's authorized representative for radiological issues and onsite NRC interactions. Only the SRSL or the (Corporate) RSO may act as an authorized user.

6.5 Radiation Protection Technician(s) (RPTs) – The RPT(s) responsible for the QC of health physics instrumentation are responsible for knowing and complying with this procedure and collecting/documenting instrument QC information.

7.0 PROCEDURE

7.1 Instrument Inspection

7.1.1 Upon receipt, each instrument shall be matched with the coinciding calibration certificate(s). Verify the calibration date on each certificate and if any instruments will need to be calibrated during the duration of the project. If any instrument is out of calibration, mark as “Out of Service” (OOS). Ensure the instrument serial number(s), correct detector(s), and cable length(s) (as appropriate) match with those provided on the certificate. Also, ensure that operating voltages are as shown on the calibration sheet. Notify the SRSL if any discrepancies noted in above steps.

7.1.2 Visually inspect each instrument for damage and other defects that may affect instrument performance (e.g., noticeable dents [but not superficial scratches or dings] or loose wires). If damage is present, inform the SRSL and mark the appropriate instrument as OOS.

7.1.3 Obtain the latest appropriate OP-380 QC Worksheet template from the Controlled Copy Document Repository and complete the basic instrument and source information.

7.2 Initial QC Setup and Measurements

7.2.1 Once the instrument is found to be in proper working condition, it shall be set up according to relevant use procedure and the manufacturer’s instructions.

7.2.2 Designate a static location free of obstructions to conduct the daily QC checks for all field instruments. This location shall be posted as a radioactive area and the area clearly marked with radiation tape. Standard radiation area rules apply.

7.2.3 Use an indicator or “jig” to designate where each source and detector is to be placed when conducting QC counts. Use this same position each time the instruments are QC’d to ensure reproducibility. The source should be positioned in the jig so as to align with the effective center of the detector.

7.2.4 Conduct 10 initial background counts for each instrument and record the counts in the respective workbook tabs. The count time is based on project minimum detectable activity (MDA) requirements and should be provided in the project Work Plan, the Field Sampling Plan, or as directed by the SRSL.

7.2.5 Conduct 10 initial source counts for each instrument and record the counts in the respective workbook tabs. The check sources will be determined by instrument type and/or specific project requirements. The count time should be based on project MDA requirements as provided in the project Work Plan, the Field Sampling Plan, or as directed by the SRSL.

7.2.6 Chi-Square calculations will be performed for each AC-powered (onsite counting lab) counting system or for systems/instruments as directed by the project-specific plans or the RSO (Due to their expected performance limitations the Chi-Square Test is not typically performed on battery powered field radiation survey instruments).

Enter the 10 initial source counts for each Instrument and source used into the blue cells in the Chi-Square MS Excel© workbook. Perform 10 additional counts for each instrument and source for a total of 20 counts to complete the calculation. Chi-Square evaluations are performed to evaluate whether the collected data exhibits an expected random variability. If the results of the Chi-Square fall outside the 8.91-32.8 acceptance criteria, there may be conditions (internal or external to the detector) that are introducing counting biases. Consult the SRSL for guidance.

7.2.7 Using the initial QC data and the calculated results in the applicable QC spreadsheet, fill out the “Instrument Pass/Fail Criteria” sheet in the Instrumentation Logbook and post near the instrument QC area in plain view.

NOTE: Posting the Instrument Pass/Fail criteria is done to provide a quick evaluation of each morning’s instrument QC count without the need of entering the data into the MS Excel© spreadsheet. However, it is NOT intended to take the place of definitive instrument PASS/FAIL determinations or instrument trending performed in the various MS Excel© workbooks.

7.3 Daily QC

7.3.1 At a minimum, instrument QC checks shall be conducted prior to each day’s first use.

7.3.2 The instrument background count shall be conducted prior to the source count(s).

7.3.3 For Qualitative Instruments, if the recorded background or source response check result falls outside the acceptance criteria, the instrument will *“Fail”* and a recount must be performed prior to using the instrument. If a recount *“Fail”* condition occurs, the instrument shall be taken OOS and the SRSL notified.

7.3.4 For Quantitative Instruments, the following steps shall be performed:

- If the daily count is found to be outside of the $\pm 2\sigma$ criteria, a *"Question"* note will appear in the "Alpha Beta Counting and Smear Worksheet.xls" and may be used for that day, pending concurrence by the SRSL. However, if a *"Question"* condition occurs on consecutive days for similar behavior (i.e., falls outside in the same direction), a recount must be performed and recorded as such. If a recount *"Question"* or *"Fail"* condition occurs, the instrument shall be taken OOS and the SRSL notified.
- If the daily count is found to be outside of the $\pm$ 3s criteria, a *"Fail"* note will appear in the "Alpha Beta Counting and Smear Worksheet.xls" and a recount must be done immediately and recorded as such. If a recount *"Fail"* condition occurs, the instrument shall be taken OOS and the SRSL notified.

7.3.5 If an instrument is taken OOS using steps defined in this procedure, concurrence with corrective actions must be obtained by the SRSL before the instrument may be brought back into service.

7.3.6 Recounts and OOS actions shall be noted in the remarks section for the day's QC worksheet entry.

8.0 REFERENCES

- Radiation Safety Program, Cabrera Services, Inc., Manual
- OP-020, *Operation of Contamination Survey Meters*, Cabrera Services, Inc., Operating Procedure.
- OP-021, *Alpha-Beta Counting Instrumentation*, Cabrera Services, Inc., Operating Procedure.
- OP-022, *Operation of Ionization Chambers*, Cabrera Services, Inc., Operating Procedure.
- OP-023, *Operation of micro-R Meters*, Cabrera Services, Inc., Operating Procedure
- OP-187, *Records Management*, Cabrera Services, Inc., Operating Procedure
- OP-380, *Calculating Alpha and Beta Total Efficiency for Field Instruments*, Cabrera Services Inc., Operating Procedure
- U.S. Nuclear Regulatory Commission, Consolidated Guidance about Material Licenses, *Vol. 11 – Program-Specific Guidance about Licenses of Broad Scope*, NUREG-1556, (1999).
- American National Standards Institute, Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments, ANSI N323A , (1997 w/ 2004 errata)

9.0 REQUIRED RECORDS

The following records generated during implementation of this procedure, as required by contract or quality management protocols, are to be kept and archived, as part of the project file, and comprise the quality record:

- Instrument calibration certificates for all instruments used on a project. Electronic copies of instrument calibration certificates are acceptable as a quality record.
- Source calibration certificates for all radiological sources used to calculate instrument efficiencies. Electronic copies of source calibration certificates are acceptable as a quality record.
- Quality Control (QC) forms containing the results of all measurements of radiological sources. Electronic files documenting QC measurements are acceptable as a quality record.
- All total efficiency calculations signed and dated by the reviewer.

10.0 ATTACHMENTS

None

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

CALCULATING ALPHA AND BETA TOTAL EFFICIENCY FOR FIELD INSTRUMENTS

OP-380

Revision 0

Prepared by:

Scott Hay

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Scott Hay, Principal Health Physicist — Date

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Kim Nelson

5/10/13

Kim Nelson, P.G, President/COO — Date

1.0 Purpose

The purpose of this procedure is to define requirements and acceptable methods for calculating total efficiencies for field instruments used by Cabrera Services Inc. (CABRERA) personnel to perform radiological measurements.

2.0 Applicability

2.1 This procedure applies to all radiological instruments used to perform field measurements of alpha and beta surface contamination, including instruments – owned by CABRERA; acquired for temporary use by CABRERA personnel (e.g., rental equipment); and, instruments used by CABRERA subcontractors, to perform measurements, on projects managed CABRERA.

2.2 This procedure applies to alpha radiation and beta radiation with maximum energy greater than 0.15 MeV. Refer to ISO-7503-2 for complete instructions on measuring tritium surface contamination, but this procedure applies to determining total efficiency for tritium static measurements. Refer to ISO-7503-3 for instructions on calculating efficiencies for beta radiation with maximum energy less than 0.15 MeV.

2.3 This procedure is an interim set of instructions to be used until the guidance in ISO-7503-1 can be fully implemented.

3.0 Definitions

3.1 Surface emission rate of a source – Number of particles of a given type, above a given energy, emerging from the front face of the source per unit time. This is a 2-π emission rate.

3.2 Efficiency of a source – Ratio between the number of particles of a given type, above a given energy, emerging from the front face of a source, or its window, per unit time (surface emission rate); and, the number of particles, of the same type, created or released within the source (for a thin source), or its saturation layer thickness (for a thick source), per unit time. Also referred to as source efficiency or a surface efficiency.

3.3 Instrument efficiency – Ratio between the instrument net reading and the surface emission rate, of a source, under given geometrical conditions. For a given instrument, the instrument efficiency depends on the energy of the radiations emitted by the source.

3.4 Total efficiency – The product of the efficiency of a source and the instrument efficiency.

4.0 Precautions, Limitations and Requirements

4.1 Precautions

4.1.1 NIST traceable standards should be handled carefully to prevent damage to the radiation source. Report any damage to a standard to the CABRERA RSO, or authorized representative, immediately.

4.1.2 Instrument and total efficiencies, 2-π and 4-π, reported by instrument calibration companies and instrument manufacturers, may not use comparable methods for calculating and reporting efficiencies. Whenever possible, the instrument efficiency values should be verified using multiple methodologies (see Section 7 of this procedure).

4.2 Limitations – There are no limitations associated with this procedure.

4.3 Requirements

4.3.1 Instruments used to perform radiological measurements will be operated in accordance with the respective CABRERA operating procedures or manufacturer's recommendations.

4.3.2 Instruments used to perform radiological measurements will have a current calibration certificate (i.e., one received within the past 12 months).

5.0 Equipment

5.1 Radiation instrument – typically consisting of a radiation detector combined with a ratemeter, scaler, or data logger.

5.2 NIST traceable radiation source – unless otherwise specified in the project documentation (e.g., statement of work, work plan) CABRERA instruments will be calibrated using:

- ^{90}Sr/Y to represent beta radiation with a maximum energy greater than 0.4 MeV,
- ^{99}Tc to represent beta radiation with a maximum energy between 0.15 and 0.4 MeV, and
- ^{230}Th to represent alpha radiation

5.3 Jig, for maintaining the source and detector geometry, if required by the project.

6.0 Responsibilities

6.1 Project Manager (PM) – Ensures that personnel, assigned the task of performing instrument total efficiency calculations, know and understand this procedure, are adequately trained, and have ready access to this procedure.

6.2 Radiation Safety Officer (RSO) – Monitors compliance with this procedure and trains personnel in performing total efficiency calculations. The RSO can also assist in the interpretation of measurement results and the final determination of total efficiencies.

6.3 Radiological Field Supervisor (RFS) or Site RSO – Ensures that this procedure is properly implemented during field activities.

7.0 Procedure

The calculation of the total efficiency requires both the instrument efficiency and the efficiency of a source as defined in the following Sections.

7.1 Determining Instrument Efficiency

7.1.1 The Empirical Method

- Select a NIST traceable source of radiation representative of the contamination being measured during field activities. Use the source radionuclide specified in the project documentation. If no source radionuclide is specified: for alpha emitting radionuclides use ^{230}Th; for beta emitters, with maximum energy greater than 0.4 MeV, use ^{90}Sr/Y; and, for beta emitters, with maximum energy greater than 0.15 MeV and less than 0.4 MeV, use ^{99}Tc.
- Place the NIST traceable source of radiation, on a flat surface, in a low-background area. The label, or markings, identifying the source should be facing down.
- Do not touch the surface of the source. If the source appears scratched or damaged, notify the RSO or designee before proceeding.
- Position the detector directly over the source, keeping the source as close to the center of the detector, as practical. Use a jig, if necessary, to maintain the source and detector geometry.
- Perform a series of ten 1-minute counts of the source. Reposition the source and detector, after each count, to simulate repeated measurements.
- Record the results, of the source measurements, on the instrument QC form. These counts are also used to establish the baseline of operational performance, for the instrument, for comparison with daily operational checks.
- Remove the source and place it back in its container.
- Reposition the detector on the surface and perform a series of ten 1-minute background counts.

- Record the results, of the background measurements, on the instrument QC form. These counts are also used to establish the baseline of operational performance, for the instrument, for comparison with daily operational checks.
- Refer to the source calibration certificate to obtain the 2-π surface emission rate of the source.
- Calculate the instrument efficiency by dividing the net counts per minute (cpm) by the 2-π surface emission rate, as shown in the following equation:

$$\varepsilon_i = \frac{N_S - N_B}{2\pi\ emission\ rate}$$

Where

ε_I = instrument efficiency

N_S = average source count rate in cpm

N_B = average background count rate in cpm

2-π = source emission rate in cpm

7.1.2 The Calibration Certificate Method

Refer to the instrument calibration certificate and find the 2-π instrument efficiency, for the radionuclide representing the energy and type of radiation being measured, for the project. For alpha emitting radionuclides, use ^{230}Th; for beta emitters, with maximum energy greater than 0.4 MeV, use ^{90}Sr/Y; and, for beta emitters, with maximum energy greater than 0.15 MeV and less than 0.4 MeV, use ^{99}Tc.

Note: Some calibration certificates do not include 2-π instrument efficiencies.

7.1.3 The Plateau Check Method

- Refer to the instrument calibration certificate.
- The certificate will list the recommended high voltage setting based on a series of alpha and beta counts. Find the alpha source counts, beta source counts, alpha background counts, and beta background counts for the recommended high voltage setting.
- Find the radionuclide and the source activity used to perform the plateau check.

Note: Not all radionuclides are used to perform plateau checks.

- If the source activity is only listed in disintegrations/minute (dpm), convert the activity to a 2-π emission rate using the following equations:

$$beta\ cpm = \frac{beta\ dpm * 1.25}{2}$$

$$alpha\ cpm = \frac{alpha\ dpm * 1.015}{2}$$

- Calculate the instrument efficiency by dividing the net counts per minute by the 2-π surface emission rate, as shown in the following equation:

$$\varepsilon_i = \frac{N_S - N_B}{2\pi\ emission\ rate}$$

Where

ε_I = instrument efficiency

N_S = average source count rate in cpm

N_B = average background count rate in cpm

2-π = source emission rate in cpm

Note: The uncertainty of this method is higher than the other methods because of the shorter count time of one minute.

7.2 Determining Efficiency of a Source

The efficiency of a source is determined based on the type of radiation being measured (i.e., alpha or beta) and the energy of the beta radiation being measured.

- The efficiency of a source of beta radiation, with maximum beta energy greater than or equal to 0.4 MeV, will be 0.5.
- The efficiency of a source of beta radiation, with maximum beta energy greater than or equal to 0.15 Mev and less than 0.4 MeV, will be 0.25.

The efficiency of a source of alpha radiation will be 0.25.

7.3 Total Efficiency Calculation

7.3.1 Calculate the total efficiency by multiplying the instrument efficiency by the efficiency of the source.

7.3.2 Calculate a total efficiency, for each combination of instrument and radionuclide of concern, for the project.

7.3.3 If there are multiple radionuclides and the fraction of total activity is known or can be estimated for each radionuclide, calculate a weighted total efficiency (see MARSAME Table 3.1 for an example). Weighted efficiencies are calculated, for each radionuclide of concern, by multiplying the fraction of total activity by the total efficiency for that radionuclide. The weighted total efficiency is the sum of the individual weighted efficiencies.

7.3.4 Typical values for instrument and total efficiencies, for field instruments, are listed in Exhibit 1.

Exhibit 1: Typical Instrument and Total Efficiencies for Field Instruments

Radiation and Energy	Typical Instrument Efficiency	Source Efficiency	Total Efficiency
Alpha (all energies)	0.4	0.25	0.1
Beta (0.15<b max<0.4 MeV)	0.4	0.25	0.1
Beta (≥0.4 MeV)	0.5	0.5	0.25

8.0 References

- ISO-7503-1:1988(E), *Evaluation of surface contamination - Part 1: Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters*, International Organization for Standardization, 1988.
- ISO-7503-2:1988(E), *Evaluation of surface contamination - Part 2: Tritium Surface Contamination*, International Organization for Standardization, 1988.
- ISO-7503-3:1996(E), *Evaluation of surface contamination - Part 3: Isomeric Transition and Electron Capture Emitters, Low Energy Beta-Emitters ($E_{\beta max}$ < 0.15 MeV)*, International Organization for Standardization, 1996.
- NUREG-1575, Supp. 1, *MARSAME (Multi-Agency Radiation Survey and Assessment of Materials and Equipment)*, U.S. Nuclear Regulatory Commission, 2009.

9.0 Required Records

The following records generated during implementation of this procedure, as required by contract or quality management protocols, are to be kept and archived, as part of the project file, and comprise the quality record:

- Instrument calibration certificates for all instruments used on a project. Electronic copies of instrument calibration certificates are acceptable as a quality record.
- Source calibration certificates for all radiological sources used to calculate instrument efficiencies. Electronic copies of source calibration certificates are acceptable as a quality record.
- Quality Control (QC) forms containing the results of all measurements of radiological sources. Electronic files documenting QC measurements are acceptable as a quality record.
- All total efficiency calculations signed and dated by the reviewer.

10.0 Attachments

There are no attachments associated with this procedure.

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

OPERATION OF CONTAMINATION SURVEY METERS

OP-020

REVISION 1.0

Reviewed by:

David Wunsch, Quality Assurance Manager — 4/112/13 — Date

Approved by:

Henry Siegrist

Henry Siegrist, CHP, PE, Radiation Safety Officer — 4/12/2013 — Date

1.0 PURPOSE

This procedure provides the methods for Cabrera Services Inc. (CABRERA) to use when operating alpha/beta survey meters in performing contamination surveys. Adherence to this procedure will provide a reasonable assurance that the surveys performed have reproducible results.

2.0 APPLICABILITY

This procedure will be used by CABRERA personnel to measure fixed and removable alpha and/or beta/gamma emitting radioactive material on facility surfaces, equipment, waste packages, personnel, personnel protective clothing, etc.

3.0 DEFINITIONS

3.1 Restricted Area – An area containing radioactive material(s) to which access is controlled, by the licensee, to protect individuals from exposure to ionizing radiation.

3.2 Alpha/Beta Contamination Survey – A survey technique used to determine fixed and removable alpha/beta contamination.

3.3 Acceptance Range – A range of values that describe an acceptable daily instrument source check result.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

4.1.1 Ensure that thin Mylar or mica windows on the probe face are protected from punctures, during survey operations.

4.1.2 In the case of the 44-110 tritium windowless meter, very fragile anode wires are behind the screen. **Note:** Do not allow objects to pass beyond the protective wire screen as damage to the detector can occur.

4.1.3 If any instrument inconsistencies are observed (e.g., unusually high or low background readings, source checks outside the acceptable range, etc.), remove the instrument from use, label it “OUT OF SERVICE” and report the condition to the Radiation Safety Officer (RSO), Site Radiation Safety Lead (SRSL), or a duly authorized representative.

4.2 Limitations

Typical operating temperature ranges for detectors are -20 to 50 degrees Celsius (°C) [-4 to 122 degrees Fahrenheit (°F)].

4.3 Requirements

4.3.1 Calibration sources must be traceable to the National Institutes of Science and Technology.

4.3.2 A battery check, general observation of instrument condition, high voltage check, and source response check will be performed each day before instrument use. An end of daily work activities final verification of instrument operability may also be provided, as required by site work plans.

4.3.3 Survey instrument calibrations will be performed by a calibration facility licensed by the Nuclear Regulatory Commission or an Agreement State.

4.3.4 Instruments used to perform routine surveys will be used in accordance with the applicable CABRERA administrative and operational procedures. Authorized suppliers of properly calibrated and maintained equipment will supply/calibrate instruments.

4.3.5 Prior to field mobilization, project SRSL and identified radiological leads will review approved work plans to ensure identified survey equipment is appropriate. Where practical, equipment familiarization with expected ranges to be used, typical efficiency of detection, and templates to be used in the field with the particular instrument are desired.

4.3.6 Personnel performing the survey will ensure that this procedure is the most current and approved revision.

4.3.7 Personnel performing the survey will review QC records to ensure that the instrument passed the source-check prior to use.

4.3.8 The RSO or their duly authorized representative will review any applicable completed forms and templates for accuracy and completeness.

4.3.9 All entries documented on pertinent forms must be dated and initialed by personnel performing the survey to be valid.

5.0 EQUIPMENT

5.1 Equipment counting efficiencies should be determined by qualified CABRERA personnel to verify efficiencies of calibrated instruments prior to use. Routine survey equipment includes, but is not limited to:

5.1.1 Alpha Surveys – Ludlum Model 43-5 probe and Ludlum Model 3 survey meter or equivalent meter/probe combination.

5.1.2 Beta/Gamma Surveys – Ludlum Model 44-9 probe and Ludlum Model 3 survey meter or equivalent meter/probe combination.

5.2 Proportional meters may be advantageous for use in situations where the suspected contamination type is unknown or the contamination contains mixed alpha and beta/gamma components. Alpha and beta/gamma contamination can be detected simultaneously with proportional meters. Proportional meters that may be used for a contamination survey include, but are not limited to:

5.2.1 Hand-held meters – Ludlum Model 43-93 probe coupled with a Ludlum Model 2360 meter or an equivalent meter/probe combination.

5.2.2 Gas proportional floor meters – Ludlum Model 43-37 probe coupled with a Ludlum Model 2360 meter or an equivalent meter/probe combination.

5.2.3 Radionuclide-specific meters – Includes meters such as a tritium contamination meter: Ludlum Model 44-110 probe coupled with a Ludlum Model 2221 meter or equivalent meter/probe combination.

5.3 Contamination survey meters will be selected based on job-specific requirements identified in site work plans.

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) – Ensuring that personnel assigned the task of operating contamination survey meters know and understand this procedure, are adequately trained, and have access to a current copy.

6.2 Radiation Safety Officer (RSO) – Verifying that personnel comply with this procedure and are trained in the use of the contamination survey meters described in this procedure.

6.3 Site Radiation Safety Lead (SRSL) – During field assignments, the SRSL is responsible for ensuring that this procedure is properly implemented and will review approved work plans to ensure identified survey equipment is appropriate. When the RSO is not on site, the SRSL will act as the RSO's duly authorized representative for radiological issues.

6.4 Radiation Protection Technician (RPT) – The RPT operating contamination survey meters is responsible for knowing, understanding, and complying with this procedure and may be required to review approved work plans to ensure identified survey equipment is appropriate.

7.0 PROCEDURE

7.1 Instrument Inspection

7.1.1 Select the contamination survey meter and probe to be used in the survey.

7.1.2 Before each use, perform the following checks:

- Verify the probe/meter has a current calibration label.
- Visually inspect the probe/meter for physical damage or defects.
- Position the meter switch to “BAT” and check to see that the needle falls within the “Bat Test” checkband.
    - If the needle falls below the “Bat Test” checkband, install new battery(ies).
    - If the needle still falls outside the “Bat Test” checkband after the installation of new batteries, tag the instrument “OUT OF SERVICE” and notify the RSO or their duly authorized representative.
- Check alpha detectors for light leaks by pointing the Mylar window of the detector towards a light source (preferably sunlight) and observing for a change in the meter indication.

7.1.3 Remove and tag the instrument “OUT OF SERVICE” if it fails any of the criteria in steps 7.1.1 and 7.1.2 and notify the RSO or their duly authorized representative.

Note: Any defects, damages, or other physical abnormalities require that the instrument be removed from service and the RSO or their duly authorized representative be notified.

7.2 Initial Preparations

7.2.1 Assure that the necessary daily quality control (QC) checks have been performed prior to instrument use.

7.2.2 Obtain the necessary forms, smears, and protective clothing that will be used during the survey. This information can be obtained from the Radiation Work Permit (RWP) or the SRSL.

7.2.3 Position the meter fast/slow (“F/S”) switch to “S” as appropriate.

7.2.4 Position the meter switch to the appropriate range scale.

7.2.5 Ensure that the QC acceptance range has been calculated utilizing CABRERA count rate templates. Current templates can be obtained from the RSO and may be found in the CCDR.

7.3 Daily QC Check

7.3.1 Ensure both the source and detector are in documented, reproducible positions which will be used each time this check is performed.

7.3.2 Allow the instrument reading to stabilize (approximately 30 seconds) and place the QC source on its designated position, near the detector, and record the value on the QC template.

7.3.3 Compare the reading to the acceptance range and response check criteria on the count rate QC template. If the response reading falls outside of the acceptance range, tag the instrument "OUT OF SERVICE" and notify the RSO or their duly authorized representative.

7.4 Contamination Survey Techniques

CAUTION*:* The window area of the detectors is covered with either a very thin layer of aluminized Mylar or mica. In the case of the tritium windowless detector, small anode wires are present behind the protective screen. Windows and fragile anode wires can be easily punctured or broken when surveying areas that have protruding fragments. Ensure that care is used and that such potentially damaging fragments are removed, prior to performing surveys, or avoided.

Note: To maintain the calibrated detection efficiency, the detector must be held at the appropriate height when surveying, which is determined during calibration. For example, if a beta probe's efficiency was calculated at ½ inch from the calibration source, the detector must be held at ½ inch from the surface being surveyed to maintain calibrated detection efficiency.

Avoid contacting the detector probe to the area being surveyed. This potentially could contaminate the probe.

7.4.1 Initially, verify the instrument selector switch is in the x0.1 position or on the lowest scale. Scale settings may change during surveys.

7.4.2 For a stationary reading, place the detector over the area to be measured and allow the meter to stabilize. Record the average meter indication in either counts per minute (cpm) or total counts recorded on the ratemeter, in a set time interval, on the radiological survey form/template.

7.4.3 For a scan survey, move the detector slowly over the surface, at the rate described in the site work plan and record data, as described by the plan.

7.5 Final Verification

If required by the site work plan, upon completion of work activities, repeat steps 7.1.1 and 7.1.2 as a final verification that the instrument is working properly.

8.0 REFERENCES

- Radiation Safety Program, Cabrera Services Inc., Manual
- OP-187, *Records Management*, Cabrera Services Inc., Operating Procedure
- OP-001, *Radiological Surveys*, Cabrera Services Inc., Operating Procedure
- OP-009, *Use and Control of Radioactive Sources*, Cabrera Services Inc., Operating Procedure

9.0 REQUIRED RECORDS

Results will be documented electronically in the “Alpha Beta Counting and Smear Worksheet” and Smear and/or Static worksheets should be printed out and filed along with the radiological Survey Form in Attachment B of OP-001. All records, including electronic records, must be managed in accordance with OP-187.

10.0 ATTACHMENTS

None

OPERATING PROCEDURE

FOR

ALPHA-BETA COUNTING INSTRUMENTATION

OP-3408

(FORMERLY OP-021)

Revision 2.0
January 2021

Level of Use:
Information Use

APPROVALS	
President	*R. Flowers, PMP, CHMM*
Quality Assurance	*S. Liddy, CSP*
Health Physics	*M. Winters, CHP*
This procedure is the property of Cabrera Services Inc. and is considered approved and effective for the duration it is posted electronically to the Controlled Copy Document Repository.	

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History of Revisions		
Revision	**Month-Year**	**Description**
0	January 2000	OP-021 - Initial issue.
1.0	April 2013	Substantial (major) revision to update overall program elements to latest regulations, guidance, and industry practices.
2.0	January 2021	Substantial (major) revision to update overall program elements to latest regulations, guidance, and industry practices. Includes reformatting and renumbering to OP-3408, per accordance with OP-2001.

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1.0 PURPOSE

This procedure provides instruction on the operation and setup of an alpha/beta sample counter. Adherence to this procedure will provide a reasonable assurance that the surveys performed have reproducible results. The purpose of this Operating Procedure (OP) is to describe the use of Alpha/Beta (α/β) sample counting systems for various radiological Project site. The instruments are used to detect alpha (α) and beta (β) radiation for a variety of health physics (HP) survey tasks such as surface contamination surveys and in-field sample analysis.

This procedure implements provisions of the following regulatory requirements:

- 10 CFR § 20, Standards for Protection Against Radiation
- U.S. Department of Energy Standard, DOE-STD-1098-2008, "Radiological Control."
- 10 NYCRR § 16.5, Responsibility of radiation safety
- 10 NYCRR § 16.10, *Inspections, Surveys, Checks and Tests; Vacating Installations; Securing Radiation Sources.*
- 10 NYCRR § 16.17, *Records*
- 12 NYCRR § 38.22, Surveys, checks and tests
- DOE Order 458.1, *Radiation Protection of the Public and the Environment*
- NUREG-1575, Supp. 1, *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME)*
- OP-3401*, HP Instrument General Quality Control Procedure*
- OP-3402*, Calculating Alpha and Beta Total Efficiency for Field Instruments*
- OP-3601*, Radiological Surveys*
- OP-3802, Unconditional Release of Materials and Equipment from Radiological Controls
- 17 CCR § 30253, Standards for Protection Against Radiation

2.0 SCOPE/APPLICABILITY

This procedure will be used by Cabrera Services Inc. (Cabrera) personnel operating an alpha/beta sample counter during surveys. Types of surveys that may use an alpha/beta sample counter are:

- Smear surveys performed to determine the removal of alpha and beta contamination on facility surfaces, soil samples, equipment, waste, source packages, etc.
- Air sample surveys performed in a worker's breathing zone, a work area, or around the perimeter of a work site to determine alpha and beta air concentrations.

3.0 DEFINITIONS

3.1 Restricted Area – An area to which access is controlled to protect individuals against undue risks from exposure to radiation and radioactive materials.

3.2 Smear Sample Survey – A technique using a two-inch diameter filter paper to

determine removable contamination of alpha and/or beta emitting radioactive material over a 100 cm^2 area.

3.3 Air Sample Survey – A technique where particulates are collected, from a known volume of air drawn through a filter paper, and the concentrations of airborne alpha and beta activity, associated with the particulates, are determined by sample counting.

3.4 Chi-Square Test – A statistical test used to evaluate the operation of a sample counter by determining how data fit a series of counts to a Poisson distribution.

3.5 Calibration – The process of adjusting instrument settings as necessary to ensure that the instrument responds properly to a known source of radioactivity traceable to the National Institute of Standards and Technology (NIST). Vendors shall perform the necessary calibration of their instruments. Instruments shall not be accepted from vendors unless they have been calibrated immediately prior to shipment by the vendor. Certificates of calibration and calibration data shall be included with instrument use records. Instruments should be calibrated across their operating range (energy and intensity) before use.

3.6 Count - When alpha or beta particle disintegration is detected by the instrument the result is called a count. The sum of the counts is interpreted as a pulse which is the statistical interpretation of the sum of the counts based on the detected energy of the particle and the number of detections.

3.7 Planchet: Circular disc with a rim for holding filter/swipe samples for analysis.

4.0 RESPONSIBILITIES

4.1 Radiation Safety Officer (RSO) – Interprets, oversees implementation and, monitoring compliance with this procedure and the associated training of personnel who work under this procedure.

4.2 Authorized User (AU) – During field assignments, the AU is the RSO's duly authorized representative for radiological issues when the RSO is not onsite and is responsible for ensuring that this procedure is properly implemented, and personnel are trained in the use of the contamination survey meters and to provide support in the area of radiation instrumentation availability and reliability.

4.3 Radiation Safety Support Staff (RSSS) – The RSSS performing and verifying the operations of the Alpha-Beta survey meters and responsible for knowing, understanding, and complying with all provisions of this procedure.

4.4 Radiation Worker and Ancillary Personnel - responsible complying with the directions of RSSS and for knowing, understanding, and complying with all provisions of this procedure, if applicable to an assigned job function.

5.0 PRECAUTIONS, LIMITATIONS, AND PREREQUISITES

5.1 Precautions

If any instrument inconsistencies are observed (e.g., unusually high, or low background counts, source checks outside the tolerance range), remove the

instrument from use and report the condition to the RSO or AU or other duly authorized representative.

5.2 Limitations

This instrumentation should be set up for use in a low background area, as determined by the RSO or AU or other duly authorized representative.

5.3 Prerequisites

5.3.1 Calibration sources will be traceable to the National Institutes of Science and Technology (NIST).

5.3.2 Survey instrument calibrations will be performed by a calibration facility licensed by the Nuclear Regulatory Commission (NRC) or Agreement State.

5.3.3 A battery or power source check, general observation of instrument condition, background check, and source check will be performed each day before instrument use. A second daily quality check that includes all of the above can be performed at the end of daily work activities, if determined to be necessary on a project site.

5.3.4 The alpha/beta sample counter will be checked for proper calibration daily with a NIST-traceable source, when in use.

5.3.5 Chi-Square tests will be verified and noted as currently valid, when performed.

5.3.6 The AU or RSSS will ensure that the attachment forms are the most current and approved revisions.

5.3.7 The AU or RSSS will review completed forms for accuracy and completeness; all entries must be dated and initialed, by the RSSS, to be valid.

5.3.8 The RSO or their duly authorized representative will review any applicable, completed forms for accuracy and completeness.

5.3.9 Any instrument/detector failing the above inspections shall not be used until corrective action has been made. If the calibration is in question, tag the instrument out-of-service until corrective actions have been completed and a new calibration performed.

5.3.10 The background (BKG) count shall utilize the same counting geometry as the samples to be analyzed (i.e., a clean blank smear if smears are the media to be analyzed).

5.3.11 The geometry of the source should be consistent with the samples being counted (typically 47mm for a disc swipe or common area air filter).

5.3.12 Chi-squared tests shall use 20 points of reference; both background and source counts. An acceptable value obtained from the Chi-squared test must fall between the values 10.12 and 30.14. Values outside these limits indicate the instrument/detector is not functioning correctly. The instrument/detector shall not be used for data collection until corrective action has been taken and an acceptable Chi-squared value has been

obtained.

5.3.13 An acceptable range for background and source efficiency shall be established prior to operational data collection.

5.3.14 Use gloves to handle the electroplated check sources. The use of tweezers may result in scratching the source and subsequent loss of activity.

6.0 EQUIPMENT

Ludlum Model 2929 sample counter, or equivalent, coupled to a Ludlum Model 43-10-1 alpha/beta scintillation detector with sample tray. Equivalent instruments, based on project need, can be utilized (i.e., Ludlum Model 3030, Canberra Tennelec).

NIST traceable radiation source – unless otherwise specified in the project documentation (e.g., statement of work, work plan) CABRERA instruments are typically calibrated using:

- ^{90}Sr/Y to represent beta radiation with a max. energy greater than 0.4 MeV,
- ^{99}Tc to represent beta radiation with a max. energy between 0.15 and 0.4 MeV
- ^{230}Th to represent alpha radiation

7.0 INSTRUCTIONS/PROCEDURE

7.1 Instrument Inspection

7.1.1 Before each use, perform the following checks:

- Verify that the instrument has a current calibration label.
- Visually inspect the instrument for physical damage and defects.
- Verify that the high voltage and high voltage potentiometer settings agree with the calibration sheet.

7.1.2 Remove and tag the instrument “OUT OF SERVICE” if it fails any of the above criteria and notify RSO or AU.

Note: Any defects, damages or other physical abnormalities require that the instrument be removed from service and the RSO, or other duly authorized representative, be notified.

7.2 Chi-Square Test

Note: The Chi-Square Test is not always required but is a good verification check on the instrument operability and count setup routines, at the beginning of a project. A Chi-Square Test is only required whenever significant changes have been made to the equipment, such as a detector tube (Model 43-10-1) change out and subsequent recalibration or decontamination of the equipment. Contact the RSO for guidance.

7.2.1 Set up the instrument in a low background area.

7.2.2 Ensure the high voltage potentiometer is positioned according to the posted instrument label. Adjust if necessary.

7.2.3 Set the time multiplier switch to “x1”.

7.2.4 Set the instrument-preset timer to one (1) minute.

7.2.5 Insert the alpha calibration standard into center of the sample tray, slide the sample tray under the detector and depress the “COUNT” button to obtain a one-minute count.

7.2.6 Upon completion of the count, record digital counts appearing in the alpha display in the “X_i” column on the Chi-Square Data Sheet (Attachment A).

Note: Approved electronic templates may be used in place of this form as long as the equivalent information is provided as described in this procedure.

7.2.7 Repeat counting sequence, ensuring that the count source is removed and repositioned within the count holder, thus ensuring count position variability consistent with actual use counting. No instrument settings can be changed during this count sequence. Continue until a total of 20 counts have been taken and recorded in the “X_i” column on the Chi-Square Data Sheet (Attachment A).

7.2.8 Add the 20 counts recorded in the “X_i” column and record in the “Sum” column. Then divide by 20 to obtain the mean number of counts (X_m) and record on the line “X_m. “

7.2.9 Calculate the individual count “X_i” difference from the mean (X_m) value and record in the “(X_i-X_m)” column the Chi-Square Data Sheet for all 20 values.

7.2.10 Calculate $(X_i-X_m)^2$, sum the “$(X_i-X_m)^2$ ” column, and record on the Chi-Square Data Sheet.

7.2.11 Calculate the value of Chi- Square using the following formula:

$$X^2 = \frac{\sum (X_i - X_m)^2}{X_m}$$

7.2.12 The value of Chi-Square should be between 8.91 and 32.8 (represents a probability between 0.025 and 0.975). Record this value at “X^2“. If the Chi-Square value falls outside this range, contact the SRSL or other duly authorized representative for further instructions.

7.2.13 Sign and date the Daily Calibration Check form (Attachment B) and forward the results to the RSO or AU for review. Keep an electronic copy in the project files.

7.3 Initial Quality Control Check

7.3.1 Ensure the high voltage potentiometer is positioned according to the posted

instrument label. Adjust slowly, if necessary.

7.3.2 Set time multiplier switch to “x1.”

7.3.3 Set the instrument-preset timer to the pre-determined background count time set by the RSO. Counter MDAs need to be setup for 50% of the release limit for the given isotope.

7.3.4 Record the source type to be used and corresponding serial number on the proper line indicated on the Daily Calibration Check form. Use separate rows of the form for each source efficiency to be calculated.

Note: Approved electronic templates may be used in place of this form as long as the equivalent information is provided, as described in this procedure.

7.3.5 Insert a blank sample into the center of the sample tray, slide the sample tray under the detector and depress the “COUNT” button to obtain a background count.

7.3.6 Record the background count rate in the cell labeled “Bkg Count Time” on the Daily Calibration Check form.

7.3.7 Repeat the counting sequence until a total of 10 counts have been taken and recorded in the “Bkg” row on the Daily Calibration Check form. Calculate the average of the 10 counts and the standard deviation (σ) for the average count.

7.3.8 Reset the instrument-preset timer to the pre-determined source count time set by the SRSL.

7.3.9 Remove the blank sample and insert the alpha or beta calibration standard into the center of the sample tray, slide the sample tray under the detector and depress the “COUNT” button to obtain a source count.

Note: Be sure to turn the source approximately 90 degrees with every count as this will give a wider range since not all sources are uniform in nature.

7.3.10 Record the source count rate in the columns labeled “Source #1 Count Time” and “Source #2 Count Time,” respectively, on the Daily Calibration Check form

7.3.11 Repeat the counting sequence until a total of 10 counts have been taken and recorded for both alpha and beta check sources in the “Source #1” and “Source #2” rows on the Daily Calibration Check form. Calculate the average of the 10 counts for each source and (σ) for the average counts.

7.3.12 Remove calibration standards and place in source holders.

7.3.13 Initial and date the Daily Calibration Check form and forward the results to the RSO or AU, for review.

7.3.14 Record all data electronically in an alpha/beta counting spreadsheet and keep in project files. All records, including electronic records, must be

managed in accordance with OP-1106 (Records Management).

7.4 Daily Calibration Check

7.4.1 Ensure the high voltage potentiometer is positioned according to the posted instrument label. Adjust slowly, if necessary.

7.4.2 Set time multiplier switch to “x1”.

7.4.3 Set the instrument-preset timer to the pre-determined background count time, typically prescribed in a work controlling document or by the AU/PHP/RSO.

7.4.4 Record the source type to be used and corresponding serial number on the proper line indicated on the Daily Calibration Check form. Use separate rows of the form, for each source efficiency, to be calculated.

7.4.5 Insert a blank sample into the center of the sample tray, slide the sample tray under the detector and depress the “COUNT” button to obtain a background count.

7.4.6 Calculate and record the background total counts and count rate in the columns labeled “Bkg” and “Bkg Count Time” respectively on the Daily Calibration Check form. The background count rate in CPM (counts per minute) can be calculated as follows:

$$CPM = \frac{Total\ Counts}{Total\ Time}$$

7.4.7 Remove the blank sample and insert the alpha or beta calibration standard into the center of the sample tray, slide the sample tray under the detector and depress the “COUNT” button to obtain a source count.

7.4.8 Upon completion of the measurement, calculate and record the total counts and count rate in the columns labeled “Total Counts” and “CPM” respectively, under ‘Source’ information on the Daily Calibration Check form. The count rate (CPM) can be calculated as listed in Step 7.4.6.

7.4.9 Calculate Net Source CPM, as below, and record on the Daily Calibration Check form under “Net CPM.”

$$Net\ Source\ CPM = CPM - BKG\ CPM$$

Note: Obtain activity (DPM) value from the source certification paperwork. Decay correct activity, if needed.

7.4.10 To determine the Total Efficiency (E_T), the user may use the methodologies prescribed OP-3402, Calculating Alpha and Beta Total Efficiency for Field Instruments.

7.4.11 To calculate the efficiency, for the next source, remove the current source standard and insert a new source standard, then repeat steps 7.4.1 through

7.4.10, as necessary.

7.4.12 Remove calibration standards and place in source holders.

7.4.13 Generate an excel control chart tracking the daily efficiencies (or response source counts/count rates).

7.4.14 During subsequent source response checks (required prior to each daily use at a minimum), take the instrument out-of-service to prevent inadvertent use and contact the AU/RSO for corrective guidance **if** either of the following conditions are met:

- Any two consecutive response check values fall outside of +/- 2 standard deviations of the mean response (efficiency or count rate).
- Any source response check falls outside of +/- 3 standard deviations of the mean response.

8.0 REFERENCES

- 10 CFR § 20, Standards for Protection Against Radiation
- U.S. Department of Energy Standard, DOE-STD-1098-2008, “Radiological Control.”
- 10 NYCRR § 16.5, Responsibility of radiation safety
- 10 NYCRR § 16.10, *Inspections, Surveys, Checks and Tests; Vacating Installations; Securing Radiation Sources.*
- 10 NYCRR § 16.17, *Records* 12 NYCRR § 38.22, Surveys, checks and tests
- DOE Order 458.1, *Radiation Protection of the Public and the Environment*
- NUREG-1575, Supp. 1, *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME)*
- OP-3401*, HP Instrument General Quality Control Procedure*
- OP-3402*, Calculating Alpha and Beta Total Efficiency for Field Instruments*
- Ludlum Measurements; Ludlum Model 2929/3030 – Dual Channel Scaler Instruction Manual.

9.0 REQUIRED RECORDS

- Daily Instrument QC sheets (written or electronic)
- Chi-Square Data Sheet (when applicable)
- Daily Calibration Check
- Calibration records

10.0 ATTACHMENTS

Attachment A – Chi-Square Data Sheet

Attachment B – Daily Calibration Check

Attachment A

Chi-Square Data Sheet

Chi-Square Data Sheet

Date:_____Instrument:_____Serial Number:_____ X^2_____

Alpha Source No./Activity:_____Beta Source No./Activity:_____

Count Number	X_i	(X_i-X_m)	$(X_i-X_m)^2$
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
Sum			
X_m			

Prepared By: _____ Date: _____
Print/Sign

Reviewed By: _____ Date: _____
Print/Sign

Attachment B

Daily Calibration Check

Make	Model	S/N	Probe	S/N	Cal Date
Bkg Count Time	**Source #1 Count Time**	**Source #2 Count Time**	**Source #1 ID**	**Source #2 ID**	**Cal Due Date**

Date(s)										
Intial QC's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Init.**
Bkgd											
Source #1											
Source #2											

Daily QC's

Date	Bkgd	Source #1 ( ) α/β/γ	Source #2 ( ) α/β/γ	Battery OK?	Comments	Init.
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		

CABRERA SERVICES

RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

Radiation Safety Procedure

For

Operation of Micro-R Meters

OP-023

Revision 0

Reviewed By: _____ Date: 1/24/00

David Watters, Radiological Safety Engineer

Approved By: _____ Date: 1/24/00

Steven Masciulli CHP, CSP, Radiation Safety Officer

Approved By: _____ Date: 1/24/00

Henry Siegrist CHP, P.E., Corporate Health Physicist

1.0 PURPOSE

The purpose of this procedure is to provide instruction for the operation of the micro-R meter for gamma radiation surveys. Adherence to this procedure will provide reasonable assurance that the radiological surveys performed have reproducible results.

2.0 APPLICABILITY

This procedure will be used by Cabrera Services, Inc. (CABRERA) personnel operating the micro-R meter during gamma radiation surveys. The micro-R meter is used to determine gamma radiation levels from facility surfaces, equipment, waste and source packages, etc., containing gamma emitting radioactive materials.

3.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

3.1 Precautions

3.1.1 Individuals performing work with the micro-R meter shall be familiar with the requirements set forth in the current and approved version of this procedure.

3.1.2 If any instrument inconsistencies are observed (e.g., unusually high or low background readings, source checks outside the acceptable range, etc.), remove the instrument from use, label it "OUT OF SERVICE" and report the condition to the Radiation Safety Officer (RSO) or duly authorized representative.

3.2 Limitations

None

3.3 Requirements

3.3.1 Calibration sources shall be traceable to the National Institutes of Science and Technology (NIST).

3.3.2 A battery check, general observation of instrument condition and source check shall be performed each day before instrument use and daily following work activities as a final verification.

3.3.3 Survey instrument calibrations shall be performed by an NRC or Agreement State licensed calibration facility.

4.0 REFERENCES

- RSP Radiation Safety Program
- ALARA ALARA Program
- AP-001 Record Retention
- OP-001 Radiological Surveys
- OP-009 Use and Control of Radioactive Check Sources
- OP-020 Operation of Contamination Survey Meters
- NUREG-1556 Consolidated Guidance About Material Licenses (Vol.11)

5.0 DEFINITIONS AND ABBREVIATIONS

5.1 Restricted Area – An area to which access is controlled to protect individuals against undue risks from exposure to radiation and radioactive materials.

5.2 Gamma Radiation Survey – A survey technique to determine gamma radiation levels from radioactive material(s) in facilities, materials, landmasses, etc.

5.3 Acceptance Range – A range of values that describe an acceptable daily instrument source check result.

6.0 EQUIPMENT

Ludlum Model 19 or equivalent

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – the PM is responsible for ensuring that personnel assigned the task of operating a micro-R meter is familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

7.2 Radiation safety Officer (RSO) – The RSO is responsible for verifying that personnel comply with this procedure and are trained in the operation of a micro-R meter described in this procedure.

7.3 Radiological Field Supervisor (RFS) – During field assignments, the RFS is responsible for ensuring that this procedure is implemented. When the RSO is not on site, the RFS will act as the RSO's duly authorized representative for radiological issues.

7.4 Health Physics Technicians (HPT) – The HPT operating the micro-R meter are responsible for knowing and complying with this procedure.

8.0 OPERATION

8.1 Instrument Inspection

8.1.1 Before each use, perform the following checks:

8.1.1.1 Verify the instrument has a current calibration label.

8.1.1.2 Visually inspect the instrument for physical damage or defects.

8.1.1.3 Position the meter switch to "BAT". Check to see that the needle falls within the "Bat Test" checkband.

- If the needle falls below the "Bat Test" checkband, install new battery(s).
- If the needle still falls outside the "Bat Test" checkband after the installation of new battery(s), tag the instrument "Out of Service" and notify the RSO or duly authorized representative.

8.1.2 Remove and tag the instrument "Out of Service" if it fails any of the criteria in Step 8.1.1.1 through 8.1.1.3 and notify the RSO or duly authorized representative.

NOTE: Any defects, damages or other physical abnormalities require that the instrument be removed from service and the RSO or duly authorized representative be notified.

8.2 Pre-operation of instrument

8.2.1 Position the meter fast/slow ("F/S") switch to "S".

8.2.2 Position the meter switch to the appropriate range scale.

8.2.3 If a Quality Control (Q.C.) acceptance range has not already been calculated, then follow the instructions below, other wise proceed to step 8.2.5.

8.2.3.1 Ensure the source and detector are in documented reproducible positions, which will be used each time this check is performed. Document this position on appropriate form.

8.2.4 Place the QC check source and detector in the documented position on appropriate form.

8.2.5 Allow the instrument reading to stabilize (approximately 30 seconds). Compare the reading to the response check criteria. If the response reading falls outside of the acceptance range, tag the instrument "Out of Service," and notify the RSO or duly authorized representative.

8.3 Operation of the instrument

8.3.1 Grid Surveys

8.3.1.1 Turn the audio switch to the “On” position.

8.3.1.2 Verify the instrument selector switch is on the lowest scale (usually the μR position). Turn the instrument selector switch to the next higher scale only if meter indication is off scale.

8.3.1.3 For a stationary grid reading in a facility or land mass, position the instrument one meter above the surface to be surveyed and allow meter to stabilize. With the instrument toggle switch set in the "SLOW" position, the meter reaches 90% of its final reading in 22 seconds. Record the average meter indication in μR/hr on appropriate form(s).

Note: Two survey methods (step 8.3.1.4 or 8.3.1.5) can be used to obtain contact readings in the survey grids. The survey method used will be specified in the site specific work plan.

8.3.1.4 For a scan survey, make sure the meter response is set to fast and suspend the instrument from a strap which locates the detector at surface or ground level. Move the instrument slowly over the surface while walking in an "S" pattern unless otherwise instructed by the RSO or duly authorized representative. Areas, which could concentrate radioactive materials such as drainage ditches, floor cracks, and wall/floor joints, should be surveyed. Observe meter indication and listen for increases in audible clicks from the speaker. If elevated readings above background are observed, a stationary survey shall be performed (at one-meter height and at the surface) at the point of elevated activity. Record area meter indications above background in μR/hr on appropriate form.

8.3.1.5 As an alternate to the "S" pattern survey used in step 8.3.1.4, the survey grid can be divided into subgrids and readings taken as directed by the site work plan. Elevated measurements should be performed in the same manner as above (i.e., at one meter and at the surface). The readings from each measurement are recorded on appropriate form.

8.3.2 Waste Container Surveys

8.3.2.1 Set the instrument scale to accommodate the highest expected radiation level. If radiation levels may approach 5000 μR/hr (5 mR/hr) obtain an instrument with appropriate range before performing any radiation surveillance.

8.3.2.2 Slowly scan the total surface of the package and record the maximum contact reading obtained on appropriate forms.

8.3.2.3 Obtain instrument readings at one meter from all sides of the package and record the maximum reading obtained on appropriate form.

8.3.3 Final Verification

Upon completion of work activities, repeat steps 8.1.1.1 through 8.2.2 and 8.2.4 through 8.2.5, as a final verification that the instrument is working properly

8.3.4 Additional Information

8.3.4.1 In a uniform background radiation field (without interfering sources of radiation), methods such as selectively shielding the detector, soil sample analysis, etc., can be used to differentiate between extraneous radioactive sources (e.g., skyshine or radioactive waste shipment containers), naturally occurring radioactive material and/or radioactive contamination.

8.3.4.2 Note the location of installed devices, which contain radioactive material and could cause elevated background radiation levels in localized areas.

8.3.4.3 Land mass surveys might contain areas with naturally occurring radioactive materials, which will elevate background radiation levels.

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

9.1.1 The health physics technician performing the survey shall ensure that this procedure is current.

9.2 Records

9.2.1 Documented information shall be legibly written in ink.

9.2.2 Data shall not be obliterated by erasing, using white-out, or by any other means. Incorrect entries shall be corrected by striking a single line across the entry. The correction shall be entered, initialed, and dated.

9.2.3 The health physics technician performing the survey shall review appropriate forms and any other applicable forms for accuracy and completeness.

9.2.4 Entries must be dated and initialed by the health physics technician performing the survey to be valid.

9.2.5 The RSO or duly authorized representative shall review any applicable completed forms. The review shall be for accuracy and completeness.

10.0 ATTACHMENTS

None

OPERATING PROCEDURE

FOR

GLOBAL POSITIONING SYSTEMS (GPS)

OP-3502

(FORMERLY OP-341)

Revision 4.0
January 2021

Level of Use:
Reference Use

APPROVALS	
Technical Lead	*S. Owe*
Quality Assurance	*S. Liddy, CSP*
This procedure is the property of Cabrera Services Inc. and is considered approved and effective for the duration it is posted electronically to the Controlled Copy Document Repository.	

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History of Revisions		
Revision	**Month-Year**	**Description**
0	July 2003	OP-051, Global Positioning System (GPS) - Initial issue.
1.0	Undated	General (minor) revision to update overall program elements to latest regulations, guidance, and industry practices. Revised to include Trimble Pro XR XRS equipment protocols.
2.0	Undated	General (minor) revision to update overall program elements to latest regulations, guidance, and industry practices.
3.0	May 2014	Substantial (major) revision to update overall program elements to latest regulations, guidance, and industry practices. Included integration of OP-051A, Trimble GPS Supplemental Manual for TSCE Handset. Numerical change to OP-351 to accommodate 3-digit series.
4.0	January 2021	Substantial (major) revision to update overall program elements to latest regulations, guidance, and industry practices. Includes formatting update and renumbering per OP-2001. Renumbered OP-3502. Removal of Attachment B for equipment specific (Trimble) information.

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1.0 PURPOSE

The purpose of this Operating Procedure (OP) is to provide the instructions for Cabrera Services Inc. (Cabrera) personnel utilizing a Global Positioning System (GPS) device. The process presented will guide Cabrera technical staff in the setup and utilization of GPS devices, while maintaining high standards of data quality and avoiding common errors.

2.0 SCOPE/APPLICABILITY

This procedure applies to all Cabrera personnel utilizing a GPS device.

This procedure may be modified to accommodate site-specific situations; however, modifications must be documented and approved, as outlined in OP-1103, Document Control. In addition, any modifications must not compromise data quality or damage equipment.

3.0 DEFINITIONS

3.1 Global Positioning System (GPS) – Radio navigation system comprised of orbiting satellites and receivers that can provide users with positioning, navigation and timing information anywhere on earth. Although GPS is a United States owned utility, other countries have similar systems and modern GPS devices may be able to use foreign systems to aid in navigation.

3.2 Personal Computer (PC) – A desktop or laptop computer, capable of running software applications associated with the GPS device.

4.0 RESPONSIBILITIES

4.1 Project Manager (PM) and Field Site Manager (FSM) – Responsible for ensuring that the assigned personnel know and understand this procedure and have access to a current copy.

4.2 Field Technician/Personnel – Responsible for operating the GPS device according to this procedure, project-specific work documents, the manufacturers operating manual, or direction from the authorized field representative. The technician is also responsible for informing their supervisor if additional training is necessary to comply with this procedure.

4.3 Geographic Information Systems (GIS) Analyst – May be required to assist field personnel in selecting the appropriate coordinate system for GPS data collection and/or providing field personnel with predetermined coordinates, as discussed in section 7.4.

5.0 PRECAUTIONS, LIMITATIONS AND PREREQUISITES

5.1 Precautions

Cabrera utilizes a variety of GPS devices from various manufacturers. GPS hardware, software and setup can vary slightly depending on the specific model being used. Refer to the manufacturer's operating manual to complete setup.

If using a GPS device in conjunction with an external sensor, including radiological meters; refer to the applicable OP to perform that task (e.g. OP-3605, Gamma Walkover Survey).

Ensure that the GPS Receiver and handheld data logger have been charged prior to use.

5.2 Limitations

When utilizing a GPS device, geospatial positions will only be recorded when the GPS is receiving a signal from the minimum number of required satellites. Continually check the GPS during operation to ensure it is receiving a signal from the appropriate number satellites.

Positional accuracy of a GPS device is affected by line of sight to orbiting satellites. Note that using a GPS device near buildings, tree canopies or any elevated structure; the accuracy of the GPS can be reduced or positioning lost.

5.3 Requirements

Qualified individuals shall utilize GPS devices. Qualification will be determined by the Project Manager (PM), Field Site Manager (FSM), or duly authorized field representative. Qualification considers prior training, experience, and certifications.

All GPS devices must be operated in accordance with this operating procedure and/or the manufacturer's operating manual or applicable work instruction.

6.0 EQUIPMENT

Cabrera utilizes a variety of GPS models. GPS hardware, software and setup can vary depending on the specific make and model, but the following hardware and software is typical of all GPS devices.

- GPS Receiver/ Antenna/ Backpack
- Handheld datalogger, equipped with data acquisition software
- Personal Computer (PC), equipped with software for data transfer from datalogger
- Micro-USB/USB cable, USB drive, or equivalent depending on GPS model (data transfer from datalogger to PC)

7.0 PROCEDURE

7.1 Connecting GPS Hardware

Complete Setup of the GPS device - GPS hardware can vary depending on the specific model being used. If using an external antenna, connect the GPS receiver to the antenna using the appropriate cable.

If necessary, check with manufacturer's operating manual to complete setup.

- Turn on power switch to GPS receiver and GPS handheld datalogger.
- If connection between the GPS receiver/antenna and the GPS handheld datalogger requires Bluetooth, ensure the Bluetooth device is communicating properly.

7.2 GPS and Data Acquisition Software Setup

7.2.1 Coordinate System

Within the data acquisition software program settings, select the appropriate coordinate system. Consult the project plan, or with the authorized field representative or the project Geographic Information Systems (GIS) Analyst to ensure the correct coordinate system is being used. The appropriate coordinate system should be identified prior to field mobilization.

7.2.2 Connect GPS to Satellites

Within the data acquisition software program, connect GPS to satellites to begin acquiring a GPS position. Consult the manufacturers operating manual or appropriate work instruction attachment to complete this step.

The GPS device must have connection to at least four (4) satellites to compute a GPS position. Reference project plans for higher accuracy settings that may require connection to more than four satellites. It is important to note that if the connection to satellites drops below the minimum requirement, GPS position is lost and data will not be recorded. Continually monitor the GPS datalogger to ensure a GPS position is being maintained. If the GPS position is lost, wait for the GPS to reacquire satellites. Move to an open area if necessary.

Position Dilution of Precision (PDOP) is a measurement of the quality of GPS positions, based on the geometry of the satellites used to compute the positions. When satellites are widely spaced relative to each other, the PDOP value is lower and positional accuracy is greater. When satellites are closer together, PDOP is higher and positions may be subject to a greater level of error. PDOP can be monitored on the GPS device. It is important to note that if PDOP is consistently high (greater than 5), it may be advisable to wait for orbiting satellites to change position and PDOP to improve before continuing to collect GPS data. In some situations, high PDOP is unavoidable (operating the GPS in close proximity to elevated structures or tree canopy) and the technician may continue to collect GPS data, but log environmental factors in the field logbook. Consult with the FSM for guidance if PDOP values are consistently high.

7.2.3 Perform Quality Control (QC) Check

Prior to using the GPS device, the operator should perform an initial and daily QC check to ensure the GPS device is operating normally and

settings, such as the coordinate system, have not been modified inadvertently.

- Choose a control point location to perform initial/daily QC check. The point should be a fixed location that will not move, be available for the duration of the project and be located in an open area, free from any overhead obstructions (elevated structures or tree canopies).
- Collect approximately 1-minute of GPS data at the designated control point using the logging feature which collects data points at 1-second intervals (approximately 60 data points will be collected). This should be conducted in the beginning of the project, prior to collecting GPS field data. The GPS antenna should be as close to the control point as possible.
- Download the GPS data from the device and enter the data into the GPS QC Spreadsheet (Attachment A). Statistics are automatically calculated to determine if the initial GPS QC data meets the minimum precision benchmark. Two separate QC spreadsheets are available, depending upon the coordinate system unit of measurement used for a specific project (feet or meters). Ensure that the appropriate QC spreadsheet is being used, which reflects the correct unit of measurement.

- A Pass flag will notify the user if the QC criteria has met the precision benchmark. If a Question flag is displayed, the GPS initial QC data did not meet the required precision benchmark. The user should check to ensure the GPS coordinate system units match the appropriate QC spreadsheet (feet or meters), ensure that the GPS is connecting to a sufficient number of satellites and ensure the QC control point is free from overhead obstructions; then collect new initial GPS QC data.

- The QC precision benchmark is established to determine whether the GPS device is operating normally and within a tolerance of the device's precision capabilities. The precision capabilities of a GPS are based on optimal operating conditions (optimal conditions would be sufficient number of satellites, ideal orientation of satellites and limited overhead obstructions). It may not be possible to achieve optimal operating conditions on a project site. If the QC precision benchmark cannot be met, notify the Field Site Manager. The GPS device may still be used; however, the precision/accuracy limitations will be noted.

7.3 Collect GPS Data

7.3.1 GPS File Naming Convention

Within the GPS data acquisition software, create a unique file name that describes the data you intend to collect and the date of the data collection.

Consult the project work plans or the PM/FSM for specific file name nomenclature.

7.3.2 Select GPS Data Type

Typical GPS devices are capable of collecting three (3) types of data; Point, Line and Area (or Polygon) data. Prior to collecting data, select the data type that best fits the features you intend to collect. Multiple point, line or area data features can be recorded under a single file name.

Point Data

- Data type used to collect single point features. This data type would be used to collect features like sample locations, boring locations, monitoring wells, or any other single point feature.
- The technician operating the GPS device should stand in a still position, with the GPS antenna 'in-line' with the feature being recorded (i.e. soil sample location, monitoring well, etc.) and remain in that position for a period of approximately 10 seconds. The GPS will log positioning information at a rate of one (1) location per second and average those positions to create a single point feature.

Line Data

- Data type used to collect linear features. This data type would be used to collect features like excavation boundaries, fence lines, or any other type of linear feature.
- The technician operating the GPS should walk the path of the linear feature they intend to collect at a constant pace, with the GPS antenna as close to the feature as possible. The GPS will log positioning information at a rate of one (1) location per second to create the linear feature.

Area Data

- Data type used to collect area (polygon) features. This data type would be used to collect features like excavation boundaries, building perimeters, or any other type of area/polygon feature. Note that polygon features are 'closed' features, and data collection should start/end at the same location, by walking the complete area/polygon boundary.
- The technician operating the GPS should walk the path of the area/polygon feature they intend to collect at a constant pace, with the GPS antenna as close to the feature as possible. The GPS will log positioning information at a rate of one (1) location per second to create the polygon feature.

7.4 Locating Predetermined Coordinates

The GPS device can also be used to field locate predetermined coordinates. Predetermined coordinates can be uploaded to the GPS datalogger from a PC, using the applicable software package associated with the GPS device. The user can navigate to each predetermined coordinate by using the **Map** utility on the handheld datalogger. Consult the manufacturer's operating manual or the appropriate work instruction attachment to complete this task.

- After uploading predetermined coordinates to handheld datalogger, the coordinate(s) will appear in the map utility as a point. The user can navigate to a specific coordinate by walking towards the location using the map utility. The user can see their current position change on the map as they walk closer to the desired coordinate.
- Adjust the scale in the map utility as you walk in closer proximity to the coordinate by using the **Zoom** function. As you walk closer to the desired point, Zoom-in to verify your distance from the desired coordinate and fine-tune your position by taking incremental steps toward the desired target.
- Stop when your position coincides with the desired coordinate.

7.5 Transferring GPS Data from Datalogger to PC

7.5.1 Connect GPS Datalogger to PC

- Connect the GPS datalogger to a PC using the micro-USB-to-USB cable, or equivalent. Windows® should automatically recognize the external device (datalogger) and establish connection using the Windows® Mobile Device Center program. If Windows® fails to recognize the external device, contact Cabrera IT to resolve the issue.
- Some GPS models do not use a cable to connect the GPS datalogger to a PC. These models use a USB drive to transfer GPS data from the data logger to a PC. Consult the manufacturer's operating manual or the appropriate work instruction attachment to complete this task.

7.5.2 Transfer Data Files using GPS software program for PC

- The PC software program associated with the GPS device is used to transfer GPS data files from the datalogger to a PC. Consult the manufacturers operating manual or the appropriate work instruction attachment to complete this task.

7.6 Differential Correction

Differential correction is a data post-processing technique that improves the accuracy of collected GPS positions. Differential correction reduces the systemic errors within GPS measurements by using a base station, which is an additional receiver at a fixed location whose position is accurately known. The GPS data collected at the base station is used to calculate and correct the

errors contained in the data collected by GPS receivers, called roving receivers. When possible, differential correction should be conducted on all GPS data collected. Consult the manufacturers operating manual or the applicable work instruction attachment to perform differential correction on GPS data. Differential correction post-processing is not available on all GPS models.

8.0 REFERENCES

- Cabrera OP 1103, Document Control
- Cabrera OP 3605, Gamma Walkover Survey

9.0 REQUIRED RECORDS

- QA/QC Records (logs, notebooks, GPS QC spreadsheet)
- Data files associated with GPS data

10.0 ATTACHMENTS

- Attachment A – GPS QC Spreadsheet

Attachment A

GPS QC Spreadsheet
(Electronic version available in Excel)

OP-3502, GPS

CABRERA SERVICES
CHALLENGE ACCEPTED

INSTRUCTIONS FOR GPS QC SPREADSHEET

1) Enter GPS Receiver Make/Model and Serial Number (SN); and project specific coordinate system
2) Prior to using GPS (beginning of project), collect a minimum 1-minute of GPS positional data at 1-second intervals (min. of 60 measurements)
   - Enter GPS coordinates (N/E) into GREEN cells
   - Pass/Question Cell will alert user if GPS has met QC Precision Benchmark criteria
   - If 'Question', check GPS coordinate system, coordinate units (feet/meters), ensure GPS antenna connection, ensure adequate GPS signal.
   - Collect new GPS QC data. Re-enter new QC data.
3) If GPS QC result indicates 'Question' - Refer to GPS QC Precision Benchmark Criteria Table below for appropriate action.

GPS Initial QC (Meters)

Date	Northing (m)	Easting (m)	Offset (m)
1/1/2021	0.00	0.00	0.834
1/1/2021	0.10	0.10	0.693
1/1/2021	0.20	0.20	0.552
1/1/2021	0.30	0.30	0.410
1/1/2021	0.40	0.40	0.269
1/1/2021	0.50	0.50	0.127
1/1/2021	0.60	0.60	0.014
1/1/2021	0.70	0.70	0.156
1/1/2021	0.80	0.80	0.297
1/1/2021	0.90	0.90	0.438
1/1/2021	1.00	1.00	0.580
1/1/2021	1.10	1.10	0.721
1/1/2021	1.20	1.20	0.863
1/1/2021	1.30	1.30	1.004
1/1/2021	0.00	0.00	0.834
1/1/2021	0.10	0.10	0.693
1/1/2021	0.20	0.20	0.552
1/1/2021	0.30	0.30	0.410
1/1/2021	0.40	0.40	0.269
1/1/2021	0.50	0.50	0.127
1/1/2021	0.60	0.60	0.014
1/1/2021	0.70	0.70	0.156
1/1/2021	0.80	0.80	0.297
1/1/2021	0.90	0.90	0.438
1/1/2021	1.00	1.00	0.580
1/1/2021	1.10	1.10	0.721
1/1/2021	1.20	1.20	0.863
1/1/2021	1.30	1.30	1.004
1/1/2021	0.00	0.00	0.834
1/1/2021	0.10	0.10	0.693
1/1/2021	0.20	0.20	0.552
1/1/2021	0.30	0.30	0.410
1/1/2021	0.40	0.40	0.269
1/1/2021	0.50	0.50	0.127
1/1/2021	0.60	0.60	0.014
1/1/2021	0.70	0.70	0.156
1/1/2021	0.80	0.80	0.297
1/1/2021	0.90	0.90	0.438
1/1/2021	1.00	1.00	0.580
1/1/2021	1.10	1.10	0.721
1/1/2021	1.20	1.20	0.863
1/1/2021	1.30	1.30	1.004
1/1/2021	0.00	0.00	0.834
1/1/2021	0.10	0.10	0.693
1/1/2021	0.20	0.20	0.552
1/1/2021	0.30	0.30	0.410
1/1/2021	0.40	0.40	0.269
1/1/2021	0.50	0.50	0.127
1/1/2021	0.60	0.60	0.014
1/1/2021	0.70	0.70	0.156

Initial GPS Measurement (Meters)

GPS Reciever Make/Model (SN):		
Project Coordinate System:		
GPS QC - Coordinate Statistics		
Parameter	Northing	Easting
Min	0.00	0.00
Max	1.30	1.30
Delta	1.30	1.30
Standard Deviation	0.40	0.40
Mean Center	0.69	0.69
GPS QC Results		
# of GPS Measurements	60	
Max Offset (m)	1.004	
Mean Offset (m)	0.481	
GPS Meas. ≤ 1.0m Offset	56	93.3%
GPS Meas. > 1.0m Offset	4	6.7%
PASS		

GPS QC Precision Benchmark Criteria

% of GPS Measurements < 1.0m Offset	QC Grade	Action
>85%	PASS	GPS is operating normally, No Action.
75 - 85%	PASS	GPS may be subject to less than optimal operating conditions. Precision limitations have been documented, continue to use GPS normally.
< 75%	QUESTION	Check GPS connections and settings to ensure proper setup. Repeat QC procedure. If QC result is less than 75%, GPS may be subject to less than optimal operating conditions. Inform the PM/FSM for appropriate action. Actions may include performing GPS measurements at a later time when the number of satellites available or satellite orientation improves. If limitation is due to the presence of overhead obstructions, GPS limitations can be documented.

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

RADIOLOGICAL SURVEYS

OP-001

Revision 3.0

Reviewed by:

David Wunsch, Quality Assurance Manager — 4/8/13 Date

Approved by:

Henry Siegrist, CHP, PE, Radiation Safety Officer — 4/8/13 Date

1.0 PURPOSE

The purpose of this procedure is to establish the framework and to define the requirements for Cabrera Services Inc., (CABRERA) personnel performing radiological surveys. Adherence to this procedure will provide reasonable assurance that the radiological surveys performed yeild reproducible results. In addition, adherence to this procedure will provide adequate control of radiation exposures As Low As Reasonably Achievable (ALARA).

2.0 APPLICABILITY

2.1 This procedure provides the requirements and general guidelines for identifying, scheduling, and performing routine, radiation, contamination, and airborne surveys by radiation safety personnel. Remediation and facility areas that are radiologically controlled (restricted areas) due to the potential for fixed or transferable contamination are considered for routine survey performance.

2.2 The following types of surveys may be performed using this procedure:

- Surveys for shipping radioactive materials (Department of Transportation [DOT] regulations may require additional consideration).
- Surveys performed to characterize facilities, sites, and/or release items potentially contaminated with radioactive materials from restricted areas.
- Surveys performed to provide information used to guide or direct decontamination and decommissioning of facilities and sites.

2.3 This procedure does not include survey requirements for radiation generating devices and survey requirements specified in radiation work permits (RWPs).

2.4 Approved work plans may require more or fewer surveys and controls to be applied at the site than described in this procedure.

3.0 DEFINITIONS

3.1 Radiological Control/Restricted Area – An area to which access is controlled to protect individuals against undue risks from exposure to radiation and radioactive materials.

3.2 Contamination Survey – A survey technique to determine fixed and removable radioactive contamination on components and facilities.

3.3 Radiation Survey – An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation.

3.4 As Low As Reasonably Achievable (ALARA) – An approach to radiation exposure control to maintain personnel exposures as far below the federal limits as the technical, economical and practical considerations permit.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

4.1.1 Instruments used to perform routine surveys should be operated in accordance with the respective operating procedures or manufacturer's recommendations.

4.1.2 Large area smears (LAS) may be used to augment (but not replace) the one hundred square centimeter (100 $cm^{2)}$ smear survey. LAS may be counted with a Ludlum Model 3 and 44-9 probe or Ludlum Model 2224-1 and 43-93 probe or equivalent. LAS are used to obtain immediate information concerning loose contamination for the purpose of radiological protection and to minimize time spent performing smears on an item easily identified as contaminated.

4.1.3 Personnel performing routine surveys must be logged in on a RWP in accordance with AP-012, *Radiation Work Permits* (if applicable).

4.1.4 Audible response instruments should be used during direct scan surveys.

4.1.5 The instruments used for routine surveys must be within current calibration and must have had a performance test check performed daily, or before use, in accordance with the instrument's operating procedure.

4.2 Limitations

4.2.1 The maximum probe speed during direct scan surveys of surfaces must be 3 centimeters per second (cm/sec).

4.2.2 The probe face must be held within ¼ inch of the surface being surveyed for alpha radiation, and within ½ inch of the surface being surveyed for beta-gamma radiation.

4.2.3 If an instrument used to perform routine surveys fails operational checks, it will be removed from service. Data collected during the period of instrument failure must be evaluated by the Radiation Safety Officer (RSO) or duly authorized representative.

4.2.4 Posting of radiological control areas must be performed in accordance with OP-019, *Radiological Posting*.

4.3 Requirements

4.3.1 Individuals performing surveys will obtain and review any previous surveys performed in the area, or on the object, to determine radiation conditions that may be encountered.

4.3.2 Only qualified individuals will perform surveys. Qualification will be determined on a case-by-case basis by the Project Manager, Radiation Safety Officer or their duly authorized representative. Qualification considers prior training, experience, and certifications such as Radiation Protection Technician or National Registry of Radiation Protection Technologists.

4.3.3 Survey samples must be analyzed in a low-background area, whenever practical, to ensure achieving the required sensitivity of measurements.

4.3.4 At a minimum, dose rate surveys must be performed in locations where workers are exposed to radiation levels that might result in: radiation doses in excess of 10% of the occupational dose limits – or – where an individual is working in a dose rate area of 2.0 millirem per hour (mrem/hr), or more.

4.3.5 Prevent access to unrestricted areas if contamination is found and immediately notify the RSO or duly authorized representative.

5.0 EQUIPMENT

5.1 Radiation and Contamination survey meters will be selected based on job specific requirements and be identified in the Site Work Plans.

5.2 Instruments used to perform routine surveys will be used in accordance with the applicable CABRERA administrative and operational procedures.

5.3 Authorized suppliers of properly calibrated and maintained equipment will supply/calibrate instruments; although equipment counting efficiencies may be determined by qualified CABRERA personnel.

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) - The PM is responsible for ensuring that personnel assigned the task of performing routine surveys are familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

6.2 Radiation Safety Officer (RSO) - The RSO is responsible for monitoring compliance with this procedure and training personnel in performing radiation and contamination surveys. The RSO can also assist in the interpretation of the results obtained during surveys.

6.3 Site Radiation Safety Lead (SRSL) - During field assignments, the SRSL is responsible for ensuring that this procedure is implemented. When the RSO is not on site, the SRSL will act as the RSO's duly authorized representative for radiological issues.

6.4 Radiation Protection Technicians (RPT) - The RPT performing radiation and contamination surveys are responsible for understanding and complying with this procedure.

7.0 PROCEDURE

7.1 Safety Considerations

The safety requirements specified in the job specific Health and Safety Plans (HASPs) and work plans, the Radiation Safety Program (RSP), and other safety documentation must be adhered to when performing surveys.

7.2 Initial Preparations

Obtain and review any previous surveys performed in the area to determine radiation conditions that may be encountered.

7.2.1 Obtain appropriate survey instruments and assure daily quality control (QC) checks have been performed prior to instrument use.

7.2.2 Obtain necessary forms, smears, and protective clothing, which will be used during the survey.

7.2.3 Plan any strategy for performing the survey before entering the area to reduce exposure time within the area.

7.2.4 If smearable contamination is expected to be above allowable limits, set up an entry/exit area which will prevent the spread of contamination.

7.3 Radiation Surveys

7.3.1 If radiation levels are unknown or previous surveys remain in question, first measure general area radiation levels using a Micro-R Meter or equivalent dose rate meter to determine if elevated radiation levels exist in the survey area.

7.3.2 Small Areas/Items/Containers – This survey technique is used to establish exposure rates from small areas, items, or containers that contain radioactive materials.

- Scan the entire surface area of the area, item, or container with a Micro-R or equivalent meter and record locations and readings on the Survey Form, in Attachment B, or an equivalent form.

- Measure the exposure rate at 30 centimeters from all surfaces or sides of the area, item, or container and record the location and readings on the Survey Form, in Attachment B, or an equivalent.
- Large waste containers used for shipment of bulk quantities of soil debris etc., may have a single dose rate measurement per accessible side of the container for ALARA purposes. DOT regulations may require additional dose rate measurements prior to shipping which is not covered by this procedure. Note readings on the Survey Form or an equivalent.

7.3.3 Facility Surveys – This survey technique may be used to release facilities (buildings, etc.) to "unrestricted" status or to determine the status of facilities requiring decontamination and decommissioning. Final release of a facility will be established using the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance.

- Establish a 1 meter by 1 meter grid system [or another work plan-approved grid] for the facility surfaces and use a marking system that assigns a unique number/letter to the center of each grid section. Graphically illustrate the location of the grid system on the Survey Form, in Attachment B, or an equivalent.
- Using a Micro-R Meter or equivalent obtain radiation levels at 1 meter from the grid center point and at contact with the grid center point. Record the reading on the Survey Form, in Attachment B, or an equivalent. If elevated readings are noted, scan the surface of the grid and note the location of any elevated readings with a marker on the form.
- Obtain Micro-R or equivalent readings from locations surrounding the facility, or within the facility, which do not contain activity. This establishes a background level for comparison to the reading taken above.

7.3.4 Area Surveys – This survey technique may be used to release land masses to "unrestricted" status or determine status of areas requiring decontamination before release. Final release of a site area will be established using MARSSIM guidance

- Establish a 10 meter by 10 meter grid system of the area to be surveyed [or another approved grid as provided by the work plan] using surveyor stakes or equivalent, which are numbered with a unique number/letter to identify the center of each grid. List the locations of the "gridded" system on the Survey Form or an equivalent.
- Using a Micro-R meter or equivalent, obtain radiation levels at 1 meter above the ground surface in the center of the grid. Record all readings on the Survey Form or an equivalent.

- Survey the remainder of the grid at the surface using an “S” pattern for the instrument. If elevated readings are noted above or below the grid center point reading, subdivide the grid into additional sub-grids and obtain readings at 1 meter above the ground surface. Record all readings on the Survey Form or an equivalent.

7.4 Contamination Surveys

7.4.1 If removable contamination is suspected or previous surveys are in question, first scan likely contaminated areas with an alpha (α) and/or beta (β) probe and determine if elevated areas of contamination exists. Obtain smear samples from any elevated areas and count smears in sample counter. If smearable contamination above limits set for the job is found, use appropriate protective clothing and entry control techniques to prevent the spread of contamination.

7.4.2 Small Areas/Items/Containers – This survey technique is used to establish total and transferable contamination levels on small areas, items, or containers, which contain radioactive materials.

- If the area, item, or container contains alpha activity, scan the area with an alpha probe at ¼ inch above the surface. Note total (fixed plus transferable) contamination readings on the Survey Form or an equivalent.
- If the area, item, or container contains beta activity, scan the area with a beta probe at approximately ½ inch above the surface to be surveyed and obtain reading following meter stabilization. Record meter reading on the Survey Form or an equivalent. The surface of a container can only be directly surveyed for beta activity if the radiation level from the container does not significantly elevate the beta probe background. Note total (fixed plus transferable) contamination readings on the Survey Form or an equivalent.
- Provide transferable smear contamination survey on the area, item or container by performing 100 cm^2 smears, at routine intervals, on the subject area, item, or container.
- Large waste containers used for shipment of bulk quantities of material will have one or more contact readings taken at routine intervals on the accessible sides of the container. Note total (fixed plus transferable) contamination readings on the Survey Form or an equivalent. **Note:** DOT regulations may require additional survey points.
- For large waste containers used for shipment of bulk quantities of material for disposal (or other large items such as soil moving equipment), determine the transferable surface contamination by taking LAS. Use Masslinn cloth or equivalent material to obtain a

LAS representative of the potentially contaminated area. Count the LAS, in a low background area, using alpha and beta detection equipment. If no transferable contamination above limits is found on the LAS, take several confirmatory 100 cm^2 smears at routine intervals on the object and count smears for alpha and beta activity. Record results on the Survey Form or an equivalent. **Note:** DOT regulations may require additional survey points.

Note: The presence of activity above transferable limits on a LAS signifies potential contamination. Determine actions to be taken with the RSO or SRSL.

7.4.3 Facility Surveys – This survey technique is used to aid in the release of facilities (buildings etc.) to "unrestricted" status or determine status of facilities requiring decontamination and decommissioning. Final release of a facility will be established using MARSSIM guidance.

- The grid system established in Section 7.3.3 will also be utilized for contamination surveys.
- Hold the beta probe at approximately ½ inch above the grid center point and obtain reading following meter stabilization. Record the meter reading on the Survey Form or an equivalent.
- If the readings are at background levels, randomly scan the remainder of the grid, concentrating on cracks, floor/wall joints, top of horizontal surfaces, ventilation ducts and grills, and other areas that might collect radioactive materials. Mark any locations above the release criteria on the Survey Form or an equivalent.
- If readings are at or near the release levels, scan grid surface and identify the portion of the grid that is above the release criteria. Note these areas on the survey form and mark the area of the grid with spray marker (or equivalent) on the Survey Form or an equivalent. Repeat steps 8.3.4 with an alpha probe at ¼ inch above the grid center point. If sufficient documentation of previous history is known about the facility and contamination is known not to be present, the alpha survey may not be required.
- One smear sample from a 100 cm^2 area will be taken in each grid. If the above survey found no elevated readings in the grid, the smear sample will be taken in the center of the grid. If elevated levels readings are identified the smear sample will be taken from the area where the highest reading was obtained.
- Each smear sample will be labeled with the grid location and counted for alpha and beta activity in the sample counter. The smear sample results will be recorded on the Survey Form or an equivalent.

7.4.4 Area Surveys – This survey technique is used to aid release of land masses to "unrestricted" status or determine status of area requiring decontamination before release. Final release of a facility will be established using MARSSIM guidance.

- The grid system established in Section 7.3.4 will be utilized for contamination surveys.
- Hold the beta probe at ½ inch above the grid center point and obtain reading following meter stabilization. Record the meter reading on the Survey Form or an equivalent.
- If readings are at background levels, randomly scan the remainder of the grid. Mark any locations above release criteria on the Survey Form or an equivalent.
- If readings are at or near the release levels scan the grid surface and identify portion of the grid that is above release criteria. Note these areas on the Survey Form or an equivalent.
- Areas contaminated with radioactive materials may require soil sample analysis to determine the activity concentration. The quantity and location of samples will be determined on a case-by-case basis.

7.5 Frequency and Requirements for Routine Surveys

Appropriate routine radiological surveys will be performed at the following frequencies as a minimum:

7.5.1 Radiation Surveys

- Upon initial entry after extended periods of closure,
- Daily, at contamination control points, where the potential exists for personnel to be exposed to dose rates greater than 2 mrem/hr,
- Daily, during continuous operation, and when levels are expected to change,
- Weekly, in routinely occupied areas adjacent to radiological control areas with dose rates greater than 2 mrem/hr,
- Weekly for operating High Efficiency Particulate Air (HEPA)-filtered ventilation units,
- Weekly, for any temporary Radiation Area boundaries to ensure that the Radiation Areas do not extend beyond posted boundaries, and
- Monthly, or upon entry if entries are less than monthly, for Radioactive Material Storage Areas.

7.5.2 Contamination Surveys

- Daily, at contamination control points from areas exhibiting contamination above surface contamination limits for the job site,
- Daily, in office spaces located in the radiological control areas,
- Weekly in lunchrooms or eating areas adjacent to radiological control areas,
- Weekly, in routinely occupied locker rooms or the shower areas adjacent to radiological control areas associated with site radiological work,
- Weekly, or upon entries, if entries are less frequent, in the areas where radioactive materials are handled or stored, and
- Weekly for all project offices on site.

7.5.3 Airborne Surveys

Airborne survey frequency, locations, and methods are determined by the RWPs and by the RSO/SRSL.

7.6 Identifying and Scheduling Routine Radiological Surveys

7.6.1 To assist in assuring surveys are scheduled, the RSO or duly authorized representative will identify and schedule routine surveys, as required by the radiological conditions and work activities.

7.6.2 Routine Survey Schedules or equivalent should be developed using a standard system for designating surveys such as:

Frequency of Survey	
• Daily	D
• Weekly	W
• Monthly	M
• Quarterly	Q
• Semi-Annually	S
• Annually	A
• Upon Entry	U

Type of Survey	
• Radiation	R
• Contamination	C
• Area TLD	T
• Air Sample	A

Example: DRC-1
Where:

D: is the survey frequency (Daily in this example)
R: is the type of survey (Radiation in this example)
C: is a type of survey (Contamination)
1 corresponds to the numerical sequence of the survey

7.6.3 Routine survey schedules should be submitted to, and reviewed by, the RSO or duly authorized representative.

7.6.4 Routine Survey Schedules should be indicated on form in Attachment A or an equivalent. Task Leaders may elect alternate methods of determining the information contained on the Routine Survey Schedule.

7.7 Using ALARA Principles for Scheduling and Performing Surveys

7.7.1 Routine surveys should not be performed in High Radiation Areas unless other work necessitates entry. Boundary verification surveys would be appropriate if an entry is not required.

7.7.2 Routine surveys should be performed in conjunction with other work surveys as much as practicable.

7.8 Performance of Routine Surveys

7.8.1 RPTs and qualified individuals will perform routine surveys in accordance with the applicable operational procedure.

7.8.2 Upon completion of a routine survey, the RPT will initial and date the appropriate Survey Form.

7.9 Periodic Evaluation of Routine Surveys

7.9.1 Routine Survey Schedules should be reviewed and updated periodically to ensure that all areas within the project boundaries are receiving the appropriate routine survey coverage.

7.9.2 Changes of conditions within the project area will be reported to the RSO or duly authorized representative and may require a modification of the routine radiological survey schedule.

7.10 Management Notification

The RSO should be notified, by the PM or duly authorized representative, of failure to complete a routine survey, as scheduled. The missed survey will be completed within 24 hours (or next working day) of discovering the inconsistency.

8.0 REFERENCES

- Title 10, Code of Federal Regulations, Part 20, Standards for Protection Against Radiation, Subpart E,*Radiological Criteria for License Termination*
- Title 10, Code of Federal Regulations, Part 20, Standards for Protection Against Radiation, Subpart F,*Surveys and Monitoring*
- Title 10, Code of Federal Regulations, Part 20.2103, *Records of Surveys*
- Radiation Safety Program, Cabrera Services Inc., Manual
- OP-187, *Records Management*, Cabrera Services Inc., Operating Procedure
- AP-010, *Personnel Protective Equipment Used Within Radiological Controlled Areas*, Cabrera Services Inc., Operating Procedure
- AP-012, *Radiation Work Permits*, Cabrera Services Inc., Operating Procedure
- OP-019, *Radiological Posting*, Cabrera Services Inc., Operating Procedure
- OP-020, *Operation of Contamination Survey Meters*, Cabrera Services Inc., Operating Procedure
- OP-021, *Alpha-Beta Counting Instrumentation*, Cabrera Services Inc., Operating Procedure
- OP-022, *Operation of Ionization Chambers* , Cabrera Services Inc., Operating Procedure
- OP-023, *Operation of Micro-R Meters*, Cabrera Services Inc., Operating Procedure

9.0 REQUIRED RECORDS

9.1 Survey records should include the following, at a minimum:

- A diagram of the area surveyed, if applicable.
- A list of items and equipment surveyed.
- Specific locations on the survey diagram where wipe test were taken.
- Background radiation levels with appropriate units.
- Contamination levels with appropriate units.
- Make, model number, and serial number of instruments used.
- Name of the person making the evaluation and recording the results and date.

9.2 Routine Survey Schedule

9.3 Survey Form

10.0 ATTACHMENTS

- Attachment A – Routine Survey Schedule
- Attachment B – Survey Form

Attachment A

Routine Survey Schedule

Routine Survey Schedule

Survey Designation	Location of Survey

Prepared By: _____ Date: _____

Reviewed By: _____ Date: _____

Attachment B

Survey Form

Survey Form

Location: Site:	RWP#	Survey #	Survey Type:	pg. 1 of __

Smear (CPM/100 cm^2)						circle one
Direct Count (CPM/Direct Frisk)						
No.	α	β	No.	α	β	
1			26			
2			27			
3			28			
4			29			
5			30			
6			31			
7			32			
8			33			
9			34			
10			35			
11			36			
12			37			
13			38			
14			39			
15			40			
16			41			
17			42			
18			43			
19			44			
20			45			
21			46			
22			47			
23			48			
24			49			
25			50			

Comments	Surveyed By:	Date:	Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	γ Bkg	Cal. Due		Key	
												■	A/S Location
												-	Boundary
												○	Smear
												□	Dose Rate _____ /hr
	Reviewed By:	Date:										*	Direct Reading CPM/direct frisk
												△	Grab Sample

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

GAMMA WALKOVER SURVEY

OP-387

Revision 0

Prepared/Reviewed by:

Stephan Owe, Scientist — March 7, 2014 (Date)

Approved by:

Michael Winters, CHP, HP Group Manager — March 7, 2014 (Date)

1.0 PURPOSE

This Operating Procedure (OP) provides the instructions for Cabrera Services Inc. (Cabrera) personnel conducting a Gamma Walkover Survey (GWS); correlated with global positioning system (GPS) coordinates. The process presented will guide Cabrera technical staff in conducting surveys, while maintaining high standards of quality and avoiding common errors.

2.0 APPLICABILITY

This procedure applies to all Cabrera personnel conducting a geospatially correlated GWS for the detection of radiological contamination/ radioactivity and contains a complete description of GWS operations.

This procedure may be modified to accommodate site-specific situations; however, modifications must be documented and approved, as outlined in OP-181, Document Control. In addition, any modifications must not compromise data quality or damage equipment.

3.0 DEFINITIONS

3.1 Gamma Walkover Survey (GWS) – Geospatially correlated radiological scanning survey, which typically uses a sodium iodide scintillation probe to detect gamma emitting radionuclides by holding the detector in close proximity to the ground and moving it in a serpentine pattern as the surveyor walks transects over a given area.

3.2 Global Positioning System (GPS) – Radio navigation system comprised of orbiting satellites and receivers that can provide users with positioning, navigation and timing information anywhere on earth. Although GPS is a United States owned utility, other countries have similar systems and modern GPS devices may be able to use foreign systems to aid in navigation.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

- The GPS and radiological survey instruments should be operated in accordance with Cabrera operating procedures and manufacturers recommendations, and shall be in current calibration. Refer to OP 020, Operation of Contamination Survey Meters and OP 058, Health Physics Instrument General Quality Control Procedure and OP 051, Global Positioning Systems for guidance.

- Multiple detectors can be used for conducting GWS. The appropriate detector depends on factors such as potential nuclide present, investigation level, and/or other site conditions. Consult the work plan

or the project technical lead for the project specific detector that should be used to conduct the GWS.

- GWS scan rates can be adjusted depending on the expected detector response and the desired investigation level. A standard scan rate is presented in this procedure; however, consult the work plan or the project technical lead for the project specific scan rate that should be implemented.

- Covering or 'sleeving' the detector and probe in plastic is recommended to protect the instrumentation from cross-contamination or water during inclement weather, wet, dirty or muddy environments.

4.2 Limitations

- When conducting a GWS, radiological readings can only be correlated with a geospatial position when the GPS is receiving a satellite signal. Continually check the GPS during the GWS to ensure it is receiving a satellite signal.

- The preferred method of coupling the Ludlum 2221 to the GPS handheld is through a 9-pin serial cable, due to its durability. Some model 2221s are not equipped with this port, in which a RG-174 coaxial cable must be used.

- Positional accuracy during a GWS is affected by line of sight to orbiting satellites. Note that when conducting a GWS near buildings, trees or any elevated structure; the accuracy of the GPS can be reduced or positioning lost.

4.3 Requirements

- Qualified individuals shall perform surveys. Qualification will be determined by the PM, FSM, SRSL or duly authorized field representative. Qualification considers prior training, experience, and certifications.

- All radiological survey Instruments and the GPS Device used during a GWS must be operated in accordance with applicable operating procedures. Instruments used to perform GWS should be performance checked prior to and at the end of each day's use. Refer to OP 020, Operation of Contamination Survey Meters, OP 058, Health Physics Instrument General Quality Control Procedure and OP 051, Global Positioning Systems Device for guidance.

5.0 EQUIPMENT

GWS requires the use of both radiological instrumentation and a GPS device in order to combine radiological data with a highly accurate geospatial position.

5.1 Radiological Instrumentation

- Appropriate portable Scaler-Ratemeter (typically a Ludlum Model 2221) with RS-232 communications port (RG-174 coaxial port or a 9-pin serial port for some models) for linking to the GPS datalogger.
- Appropriate radiation detector, as specified by the Project HP or in established work plans.

5.2 GPS Equipment

Various GPS models exist that are compatible with the radiological survey instruments described above. Typical models used by Cabrera include the Trimble® Pathfinder® Pro XRT GPS receiver mated with a Trimble® Nomad® handheld data logger, or equivalent. GPS hardware and setup can vary slightly depending on the specific model, but the following hardware is typical of all GPS models. OP 051, Global Positioning Systems for guidance.

- Trimble® GPS Receiver/ Antenna/ Backpack
- Trimble® Handheld Datalogger with Terrasync™ software
- RG-174 coaxial cable to 9-pin serial cable (female) or
- 9-pin serial cable (male/female connection), depending on 2221 specifications
- PC with Trimble® Pathfinder® software for data transfer
- Micro-USB/USB cable (data transfer from datalogger to PC)

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) – Responsible for ensuring that the assigned personnel know and understand this procedure and have access to a current copy.

6.2 Site Radiation Safety Lead (SRSL) - During field assignments, the SRSL is responsible for ensuring that this procedure is properly implemented. The SRSL is responsible for ensuring only properly trained operators use the GPS and GWS instrumentation, reviewing daily operational checks to ensure the unit is operating properly, backing up survey data and transmitting data to the Cabrera server, and communicating any issues to the SRSL. When the RSO

is not on site, the SRSL will act as the RSO's duly authorized representative for all radiological matters. These responsibilities may be delegated to HP support staff with approval of the Corporate RSO.

6.3 Radiation Protection Technician (RPT) – Conduct GWS according to this procedure, project-specific work documents or, direction from the assigned Sr. HP assigned to a Project.

7.0 PROCEDURE

7.1 Connecting Hardware (Ludlum 2221 and GPS Unit)

- Complete Setup of the GPS Unit - GPS hardware can vary depending on the specific model being used. If using an external antenna, connect the GPS receiver to the antenna using the appropriate cable.

  If necessary, check with manufacturers operating manual to complete setup.

- Turn on power switch to GPS receiver and GPS handheld datalogger.

- If connection between the GPS receiver/antenna and the GPS handheld datalogger requires Bluetooth, ensure the Bluetooth device is communicating properly. If necessary, check with manufacturers operating manual to complete setup.

- Connect the Ludlum Model 2221 to the Trimble® handheld datalogger using the RG-174 coaxial cable or a 9-pin serial cable. The 9-pin serial cable is preferred due to the durability, however not all Ludlum Model 2221 are equipped with this port. The RG-174 coaxial port is located below the handle in the center of the meter. If available, the 9-pin serial port is located on the side or front of the meter.

- Connect the 9-pin side of the coaxial cable to the serial port located on the GPS datalogger. If using a serial cable, connect the other end of the serial cable to the GPS datalogger serial port.

- Turn on power switch to the Ludlum Model 2221 and set to the following settings:

  - RESPONSE = F (Fast)

  - DIGITAL CONTROL = Dig. Rate

  - WIN = Out

  - Adjust the Volume dial to an audible level

7.2 GPS and Data Acquisition Software Setup (Terrasync™)

7.2.1 Coordinate System

- Within the Terrasync™ program settings, select the appropriate coordinate system. Consult with the GIS analyst assigned to the project to ensure the correct coordinate system is being used.

- Coordinate system settings can be modified by accessing the drop-down tab and selecting ‘Setup’, then ‘Coordinate System’ option.

7.2.2 Data Logging Settings

- Within the Terrasync™ program settings set the data logging interval setting to one (1) second for all data types (Point_generic, Line_generic, Area_generic). This will ensure that radiological measurements are recorded at a rate of one measurement per second.

- Data logging interval settings can be modified by accessing the drop-down tab and selecting ‘Setup’, then selecting ‘Options’ in the secondary drop-down, then selecting the ‘Logging Settings’ option.

7.2.3 External Sensor

- Within the Terrasync™ program settings ensure that the external sensor is activated and the appropriate settings have been entered.

- External Sensor settings can be modified by accessing the drop-down tab and selecting ‘Setup’, then selecting ‘Options’ in the secondary drop-down, then selecting the ‘External Sensors’ option. The external sensor can be activated by selecting the ‘check box’ next the sensor heading.

- The external sensor settings should already be entered, however for verification, the settings should be as follows:

    - Baud rate = 9600

    - No parity

    - 1 stop bit

    - 8 data bits

7.2.4 Connect GPS to Satellites

- Connect GPS to satellites by accessing the drop-down tab and selecting ‘Setup’, then selecting ‘Options’ in the secondary drop-down, then selecting the ‘GNSS’ button, which will begin the connection process to the GPS receiver.

- When connection is made, the status icon in the top portion of the screen will display an image of a satellite with a number, representing the number of satellites connected.

- It is important to note that if the number of satellites available drops below ‘5’, GPS signal connection is lost and data will not be recorded. The ‘satellite’ icon will also disappear. Continually monitor the ‘satellite’ icon to ensure GPS connection. If the GPS signal is lost, wait for the GPS to regain connection. Move to an open area if necessary.

7.2.5 Create Data File

- Create data file by accessing the drop-down tab and selecting ‘Data’, then selecting ‘New’ in the secondary drop-down.

- Type a unique file name in the ‘File Name:’ dialog box that describes the survey you are about to conduct and the date of the survey. Consult the project work plan or SRSL for specific file name nomenclature.

- After you have entered the file name, select ‘Create’. The program will prompt you to select a data type, select the ‘Line_generic’ for conducting GWS. Data will start to record immediately, the user can pause data collection by selecting the ‘pause’ button.

- To stop collecting data, select the ‘Ok’ button. Data is automatically saved.

- To begin a new survey, create a new data file as described above.

7.2.6 Check connection with Radiological Meter

- It is only possible to verify that the GPS system is receiving radiological count data from the Ludlum 2221 during data collection. After the user has created and begun logging in a file, as described above; access the drop-down tab and select ‘Status’, then select ‘Sensor’ from the secondary drop-down.

- If the GPS system is receiving radiological count data from the Ludlum 2221, the sensor data field will continually change value in accordance to the cpm digital count display located on the Ludlum 2221 meter.

- If the GPS system is registering the correct count values at a rate of one (1) value per second, the system is operating correctly and is ready to conduct the GWS.

7.3 Conduct GWS

7.3.1 Documenting the Survey Area

Before beginning the GWS, the following details about the survey area should be documented in the field log.

- Survey area size, shape and general elevation changes/ sloping

- Terrain cover (vegetation, grass, brush, soil, gravel, etc.)

- Obstructions that prevent survey coverage

- Debris (surface, buried or partially buried)

- Disturbances in terrain (mounding of soil, lack of vegetation growth, soil staining, etc.)

7.3.2 Perform GWS

- Perform Terrasync™ program setup and create data file as described in Section 7.2.

- Technicians should walk the survey area in parallel transects, one meter apart; while moving the detector in a serpentine (S-shaped) pattern with the detector held close to the ground surface (approximately 6 cm or 2.5 in., unless otherwise directed by a project-specific work plan or the Project Health Physicist)

- A scan rate of approximately 0.5 meters per second and a one second interval recording rate ensure that two (2) radiological measurements are collected per square meter. However, scan rates can be adjusted depending on the expected detector response and the desired investigation level. Consult the work plan or the SRSL for the project specific scan rate that should be used.

- Survey coverage should be conducted in accordance with the work plan. Consult the work plan, Sr. HP, or SRSL to determine the survey coverage when conducting a GWS. Absent specific work plan requirements or technical guidance from the Sr. HP assigned to the Project, the following guidelines should be utilized when conducting a GWS to ensure adequate survey coverage throughout the survey area.
    - 100% GWS Coverage – Transects should be 1 meter apart.
    - 50% GWS Coverage – Transects should be 2 meters apart.
    - 25% GWS Coverage – Transects should be 4 meters apart.
- To ensure adequate coverage when surveying large areas, markers should be used to delineate survey lanes. Pin-flags, cones, or similar items should be used as a visual guide to aid in walking straight, parallel transects. Background map files should also be loaded onto the datalogger for use as a guide if available. Background files could consist of property boundaries, survey boundaries, and roads (etc.); and be loaded to the datalogger using Trimble® Pathfinder® Office program. Consult with the GIS technician assigned to the project to create background files.

7.4 Transferring GWS Data from Datalogger to PC

7.4.1 Connect GPS Datalogger to PC

- Connect the GPS datalogger to a PC using the micro-USB-to-USB cable.
- Windows should automatically recognize the external device and establish connection using the ‘Windows Mobile Device Center’ program.

7.4.2 Transfer Data Files using Trimble® Pathfinder® Office

- Open the ‘Trimble® Pathfinder® Office’ program on a PC.
- The program will prompt you to select an existing ‘Project’ or to create a new ‘Project’. Pathfinder® ‘Projects’ allow the user to organize GPS data files into site specific folders. A Pathfinder® ‘Project’ should be created for each field site.

- Open the ‘Data Transfer’ utility by selecting the ‘Utilities’ drop-down, located on the horizontal task bar at the top of the screen. Or by selecting the ‘Data Transfer’ icon on the left side of the screen.

- The ‘Data Transfer’ utility should automatically connect to the GPS handheld. The connection icon will alert you when connection to the GPS datalogger is complete.

- Ensure that the ‘Receive’ tab is selected (the ‘Send’ tab is used for sending data to the GPS datalogger).

- On the right side of the screen, select the ‘Add’ drop-down tab, then select ‘Data File’.

- A dialog box will appear that contains all GPS data files stored on the GPS datalogger. Select those files in which you want to transfer.

- Select the ‘Transfer All’ button. A message will alert you if the data transfer was successful.

- GPS Data files are stored as ‘.SSF’ and will be located on your PC in the designated project folder.

7.4.3 GIS Process & Mapping

Refer to OP 388, GWS, GIS Process & Mapping for guidance.

8.0 REFERENCES

- Cabrera OP 181, Document Control
- Cabrera Procedure OP-020, Operation of Contamination Survey Meters
- Cabrera Procedure OP-051, Global Positioning Systems
- Cabrera Procedure OP-058, Health Physics Instrument General Quality Control Procedure
- Cabrera OP 388, Gamma Walkover Surveys, GIS Procedures
- MARSSIM, NUREG-1575

9.0 REQUIRED RECORDS

- Annual Calibration Records for Radiological Instrument

- QA/QC Records (logs, notebooks, instrument background and source response check files)
- '.SSF' Data files associated with GWS data

10.0 ATTACHMENTS

None

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

GAMMA WALKOVER SURVEY – GIS PROCESSING AND MAPPING

OP-388

Revision 0

Prepared by:

Kathleen Wheatley, GIS Analyst — 10/23/2013 Date

Approved by:

Alan Solow, CHP/CEO — 10/21/2013 Date

1.0 PURPOSE

This procedure establishes the process for the data processing and mapping gamma walkover survey data within the geographic information system (GIS) software program.

2.0 APPLICABILITY

This procedure specifically applies to all Cabrera employees who will be processing gamma walkover survey data using the Pathfinder Office GIS software program. All project staff should be familiar, with this procedure, to enhance their understanding of how project data is processed and mapped.

3.0 DEFINITIONS

3.1 Pathfinder Office – software program used to export the collected survey data into a .CSV file format.

3.2 Excel – software program used to convert the .CSV file format into an Excel workbook, where it will be formatted for use within the GIS software program.

3.3 ArcMap Version 10.1 – GIS software program used to map the formatted data from Excel

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

There are no special precautions, limitations or requirements associated with this procedure.

5.0 EQUIPMENT

There is no special equipment associated with this procedure.

6.0 RESPONSIBILITIES

6.1 Geographic Information System (GIS) Analyst – Processing and mapping all gamma walkover survey data, as instructed, for applicable projects.

6.2 Project Manager (PM) – Using this operating procedure as a reference when proposing accurate project budgets in which gamma walkover survey data will be collected, processed and mapped. Ensuring that field staff understand the procedure and that their GIS analyst has been properly trained in its use.

6.3 Field Staff – Using this operating procedure to enhance their understanding of how the data they are collecting is processed and mapped after a walkover survey is complete.

7.0 PROCEDURE

The step-by-step instructions, and their associated screen shots, involved in the processing of field data and mapping of the results, from a gamma walkover survey, are found in Attachment A. The main sections (step numbers) are listed below:

- Export process from Pathfinder Office (Steps 1-20)
- Formatting the exported .CSV file in Excel (Steps 21-27)
- Creating the Gamma Walkover Survey map in ArcMap (Steps 28-116)

8.0 REFERENCES

- ESRI Software, ArcGIS 10.1, 2012 Edition (for ArcMap)
- Trimble Navigation Limited, TerraSync™ Software Manual, Version 5.40, Revision B, May 2013 (for Pathfinder)
- Cabrera Procedure OP-387, *Gamma Walkover Survey – Field Operations*

9.0 REQUIRED RECORDS

- Original field file in .SSF format
- Exported .CSV file from Pathfinder Office
- Formatted Excel file
- Shapefile (.SHP) created in ArcMap
- Final PDF map of Gamma Walkover Survey

10.0 ATTACHMENTS

Attachment A – Step-by-Step Instructions for GIS Processing and Mapping

Attachment A

Step-by-Step Instructions for GIS Processing and Mapping

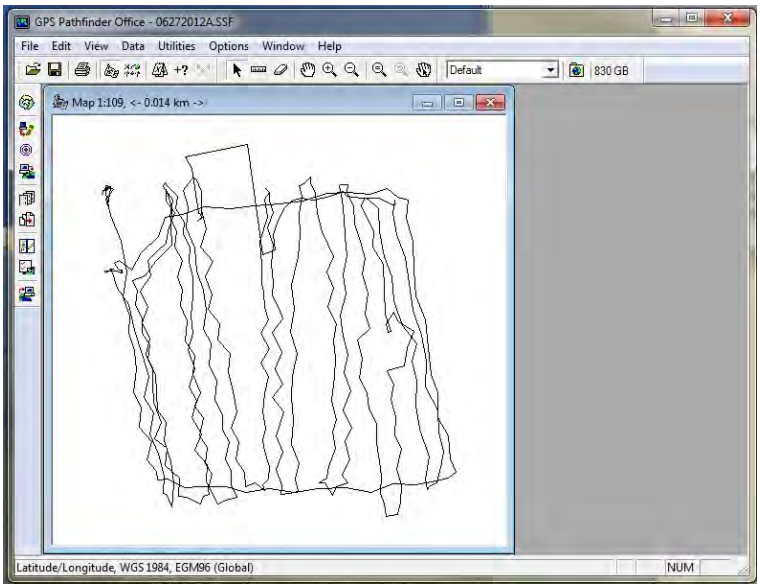
Gamma Walkover Survey – GIS Processing and Mapping Instructions

All the files from the field, for GIS processing, should be in .SSF format and should be saved in a project-specific folder using the following naming convention:

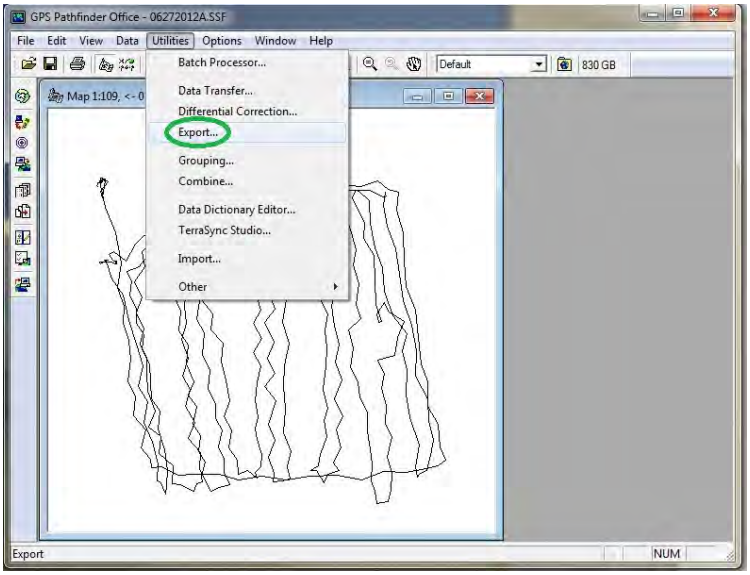
Project Name/GIS Data/Field Data/Date of Survey

A. The Export Process from Pathfinder Office

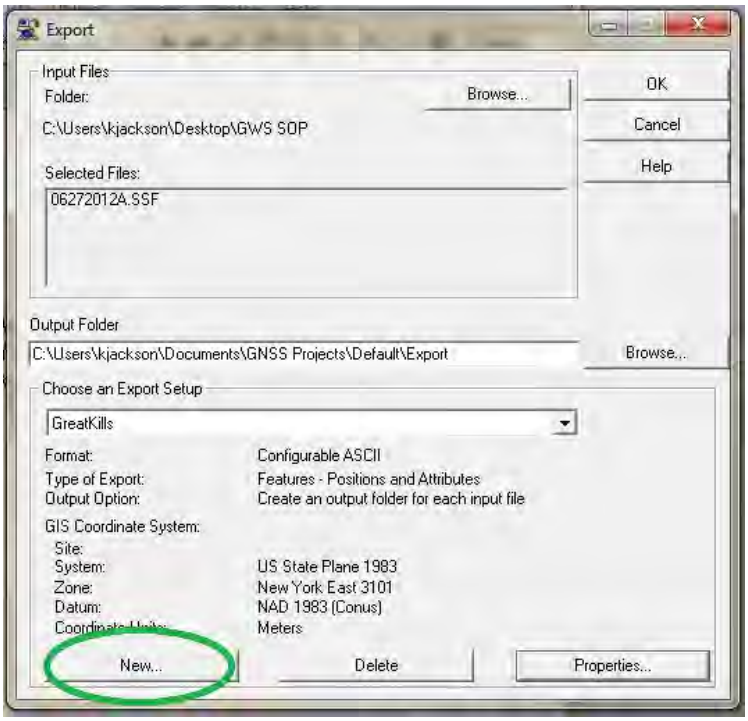
1. Open the .SSF file in Pathfinder Office



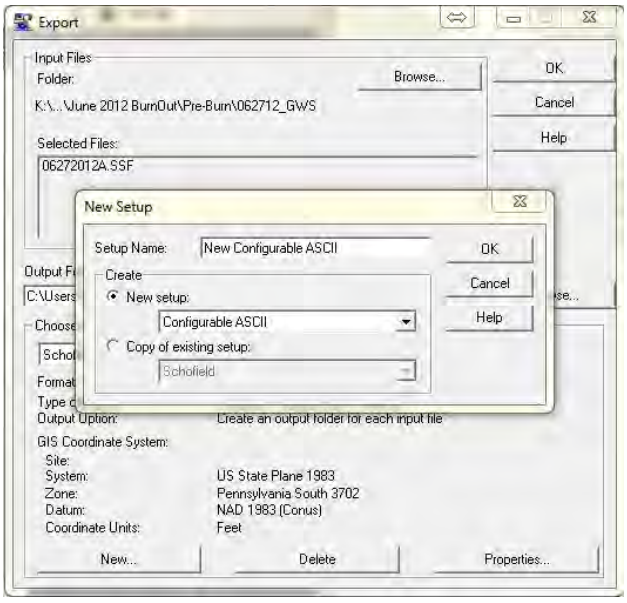
2. Open **Utilities** and choose **Export**



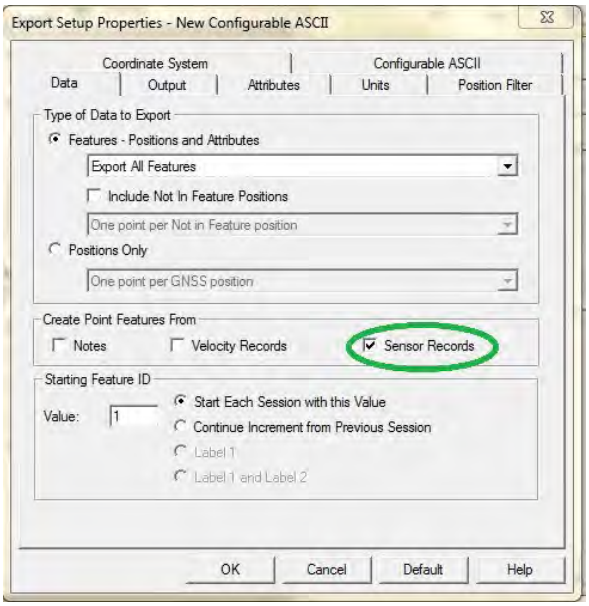
3. Under **Choose an Export Setup** – Click **New**



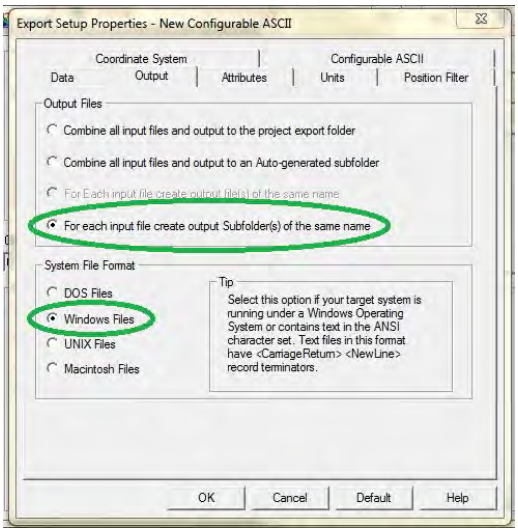
4. Setup Name: Project Name (in this example, Schofield)
   - Create: **New Setup**
   - Click OK



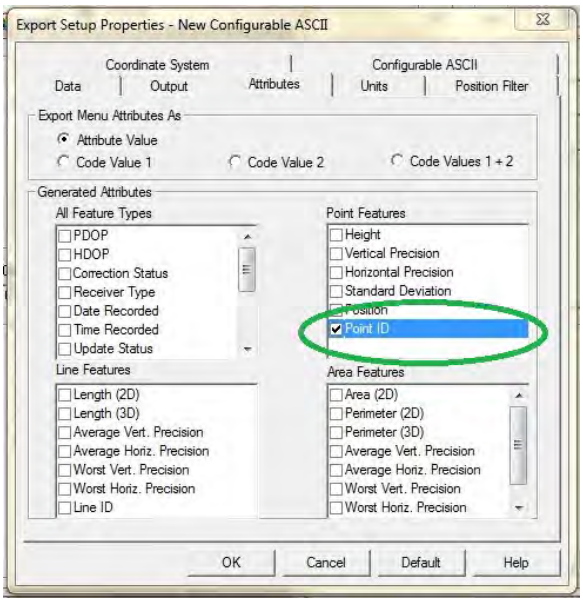
5. Under the **Data** tab
   - Check **Sensor Records**
   - Leave the rest, as is.



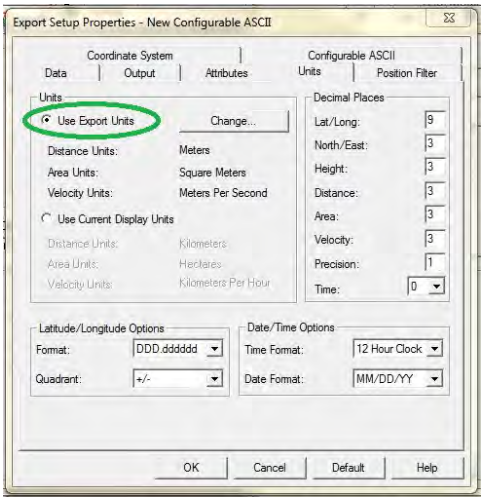
6. Under the **Output** tab
   - Change Output Files to: **For each input file create output Subfolder(s) of same name**
   - Change System File Format to: **Windows Files**



7. Under the **Attributes** tab
   - Within **Point Features** – check of **Point ID**
   - Leave the rest, as is.

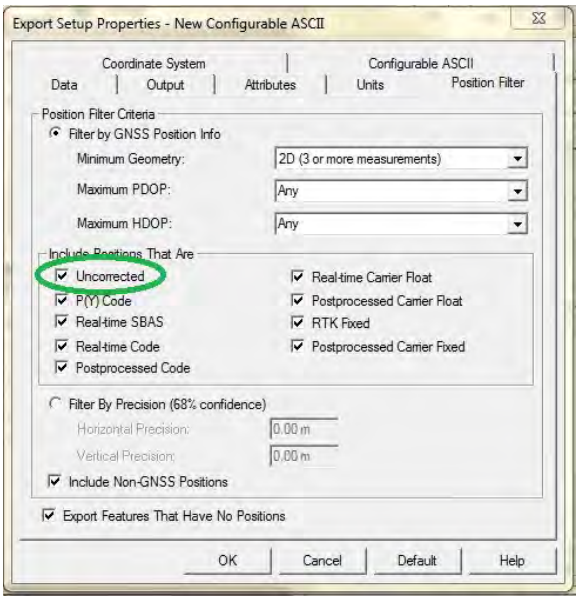


8. Under the **Units** tab
   - Check **Use Export Units** under **Units** window
   - Leave the rest, as is.



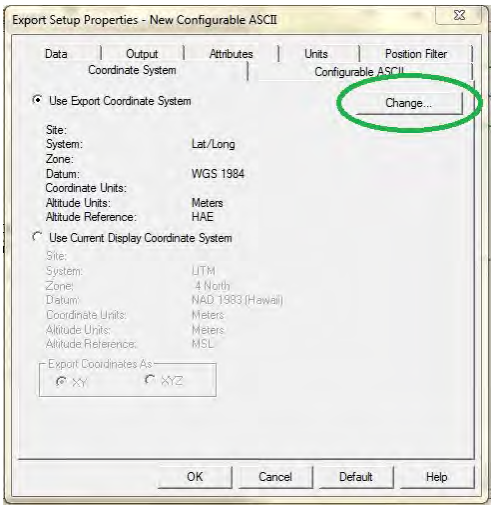
9. Under the **Position Filter** Tab

- Under **Include Positions that Are** window – check **Uncorrected**
- Leave the rest, as is.



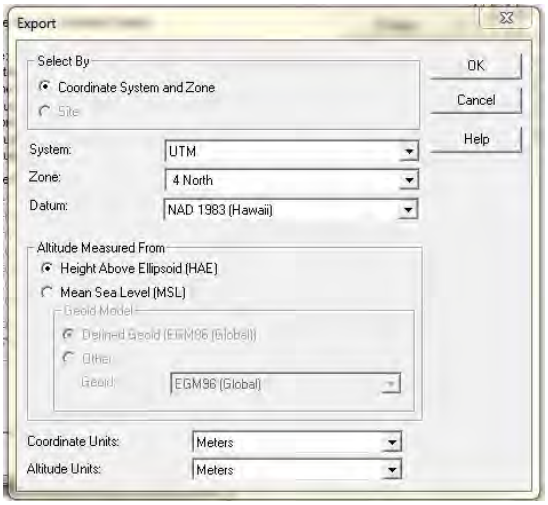
10. Under the **Coordinate System** tab

- Change to project coordinate system – in this example, Schofield: NAD 1983 UTM Zone 4
- Click **Use Export Coordinate System – Change**

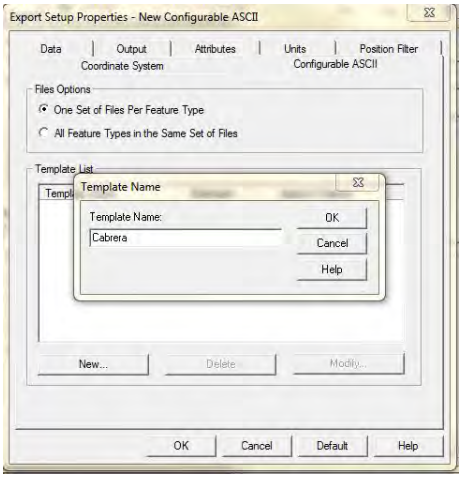


11. In new **Export** window:
    - Change **System** to UTM
    - Change **Zone** to 4 North
    - Change **Datum** to NAD 1983 (Hawaii)
    - Leave the rest, as is.

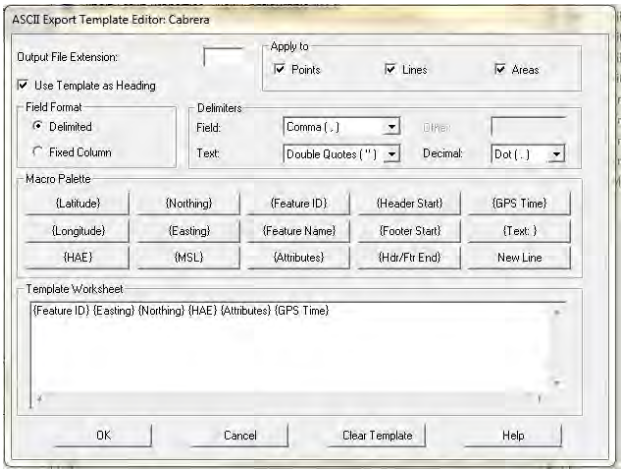
NOTE: THIS IS PROJECT DEPENDENT



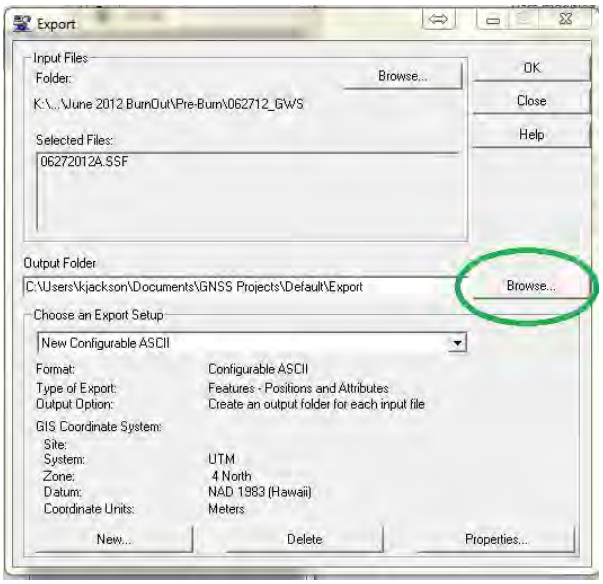
12. In **Configurable ASCII** tab
    - Under **Template List**, click **New**
    - **Template Name**: Cabrera



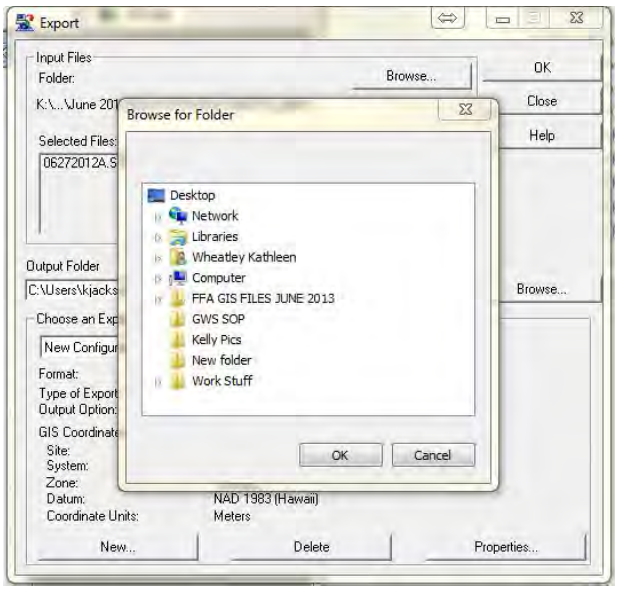
13. In **ASCII Export Template Editor** Window
    - **Output File Extension**: csv
    - Check **Use Template as Heading**
    - In **Template Worksheet** add: {Feature ID} {Easting} {Northing} {HAE} {Attributes} {GPS Time}
    - Leave the rest, as is.



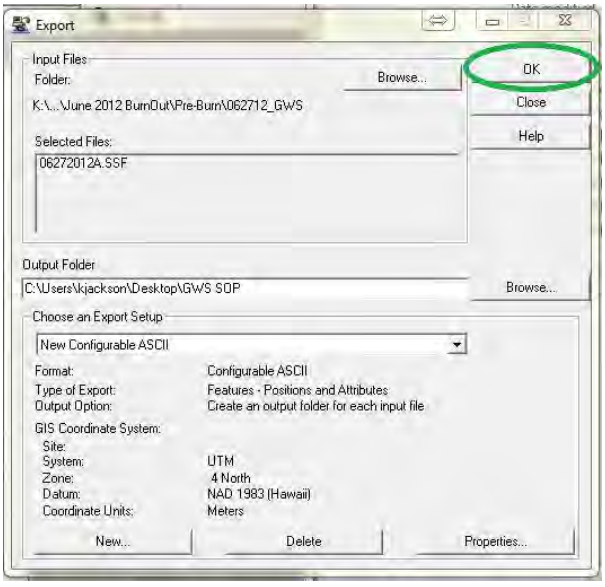
14. Click **OK** to save settings
15. The .SSF file can now be exported for use in GIS
16. Under **Output Folder**, click **Browse**



17. Navigate to Project Folder/GIS Data/Field Data/Date of Survey. (In this example, it is being saved to my desktop)



18. Click **OK**



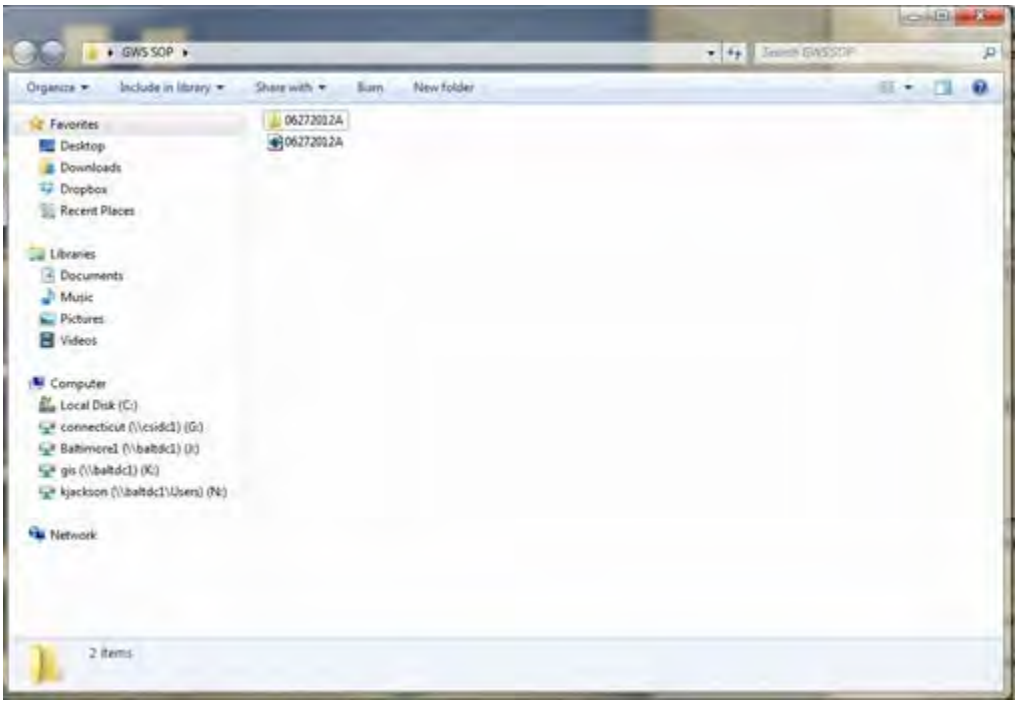
19. A window will pop up to confirm the export is complete

20. Close Pathfinder

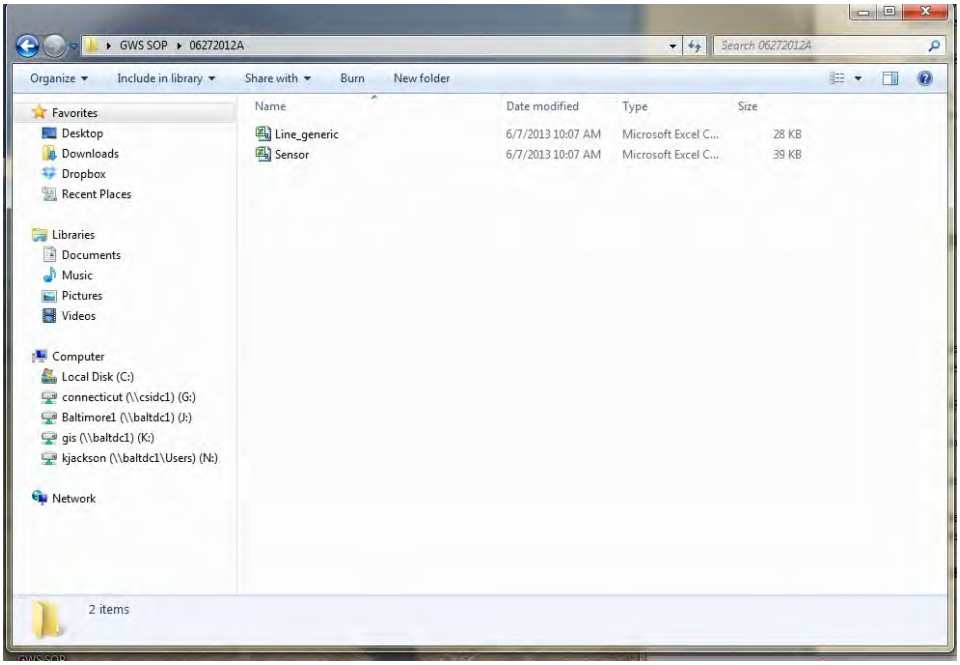
B. Formatting the Exported .CSV File in Excel

21. Navigate to the Project Name/GIS Data/Field Data/Date of Survey folder where you saved the exported .CSV file.

22. Once there, you will see a new folder with the same name as the .SSF file.



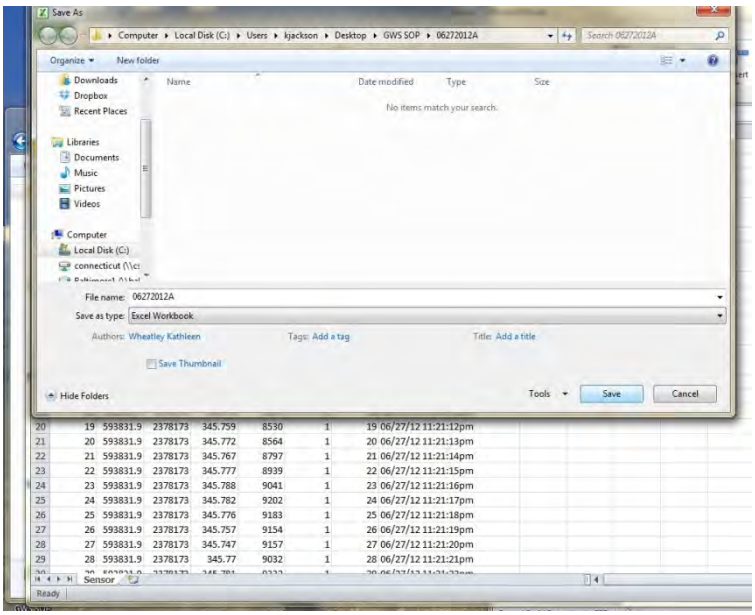
23. Within that folder, there will be a few different .CSV files – in this case, there are two: **Line_generic** and **Sensor**.



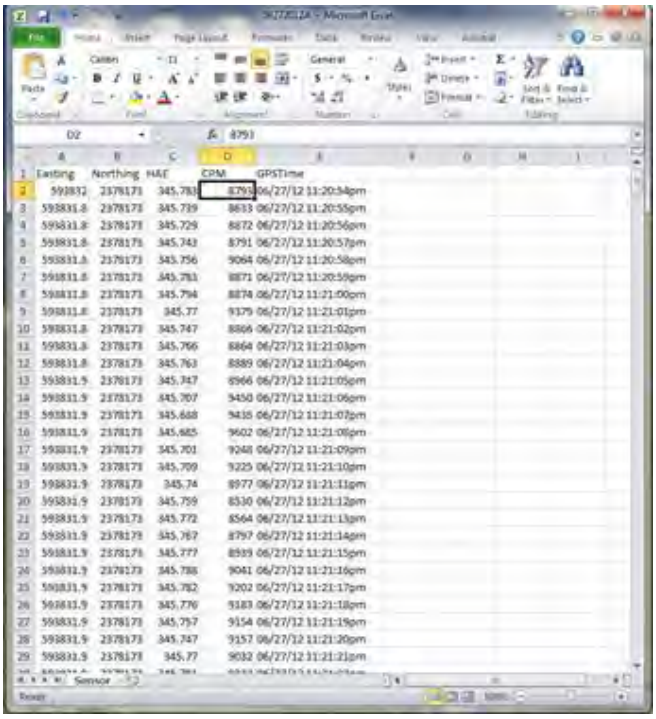
24. In other cases, **Area_generic** may also be exported.

25. Open the **Sensor** file

26. Save it as an Excel file, named with the same name as .SSF file, within the new subfolder.

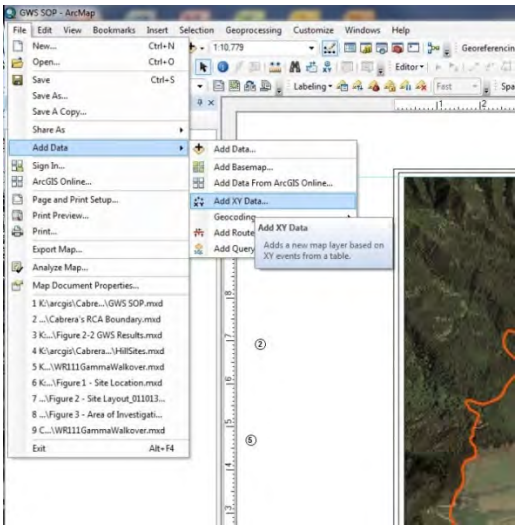


27. Delete Columns: **ID, Channel** and **Point_ID**
    - Change the **Text** header to **CPM.**
    - Save the Excel file.

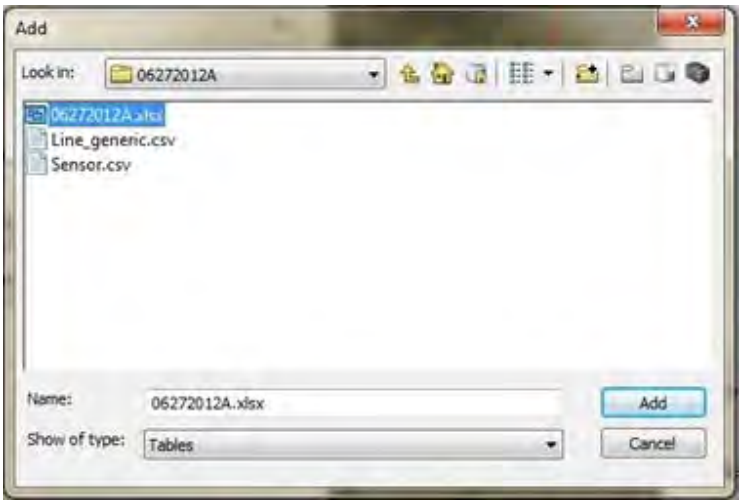


C. Creating the GWS Map in GIS (ArcMap)

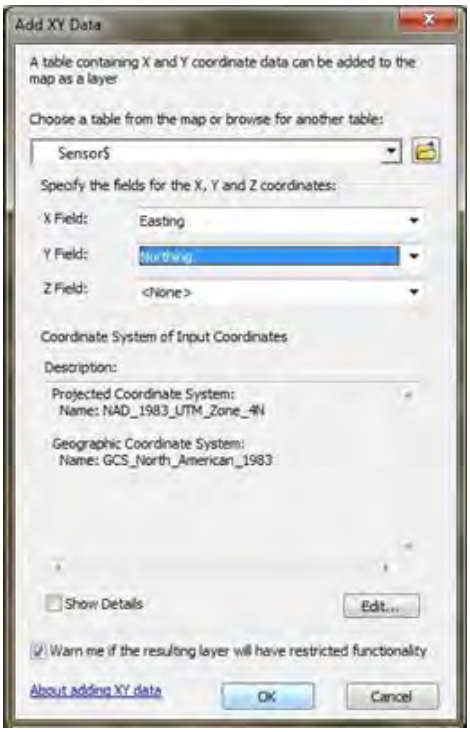
28. Open the ArcMap file in which the GWS Data will be mapped.
29. Navigate to **File** – **Add Data** – **Add XY Data**



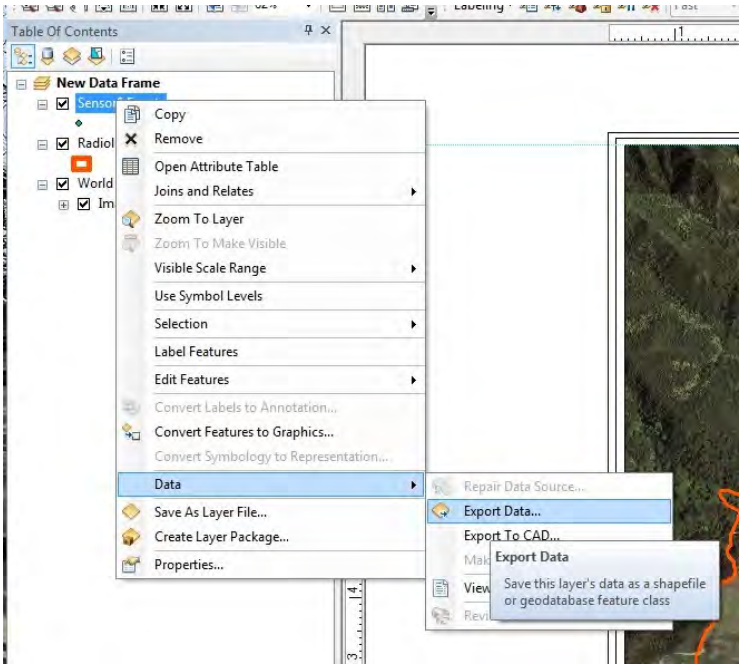
30. Navigate to the saved Excel file – Click the **Sensor** sheet



31. Fill out the necessary fields, as follows:
    - **X Field**: Easting
    - **Y Field**: Northing
    - **Z Field**: <None>
    - **Projected Coordinate System**: NAD_1983_UTM_Zone_4N



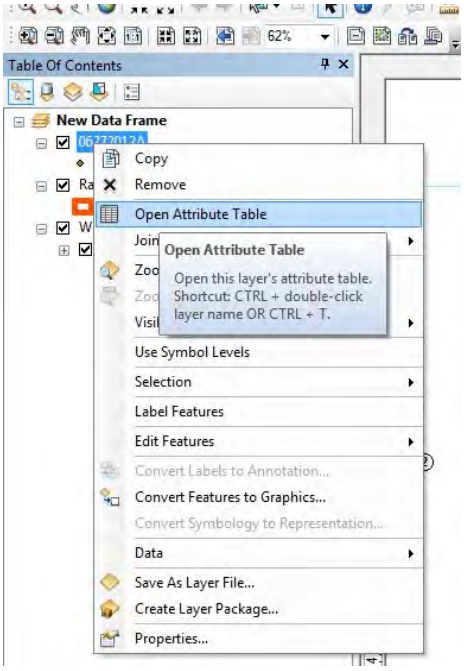
32. Click **OK**
33. A **Sensor$ Events** file will be created
34. Right click the **Sensor$ Events, Data – Export Data**



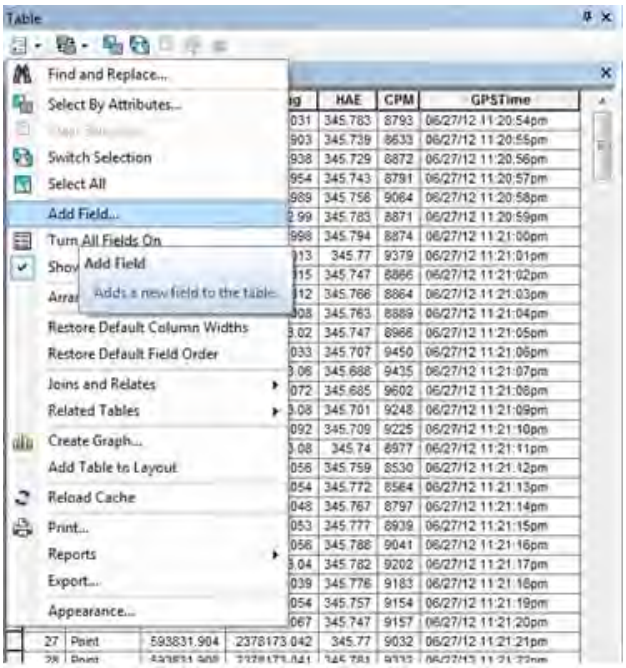
35. Save the export file to Project Name/GIS Data
36. Name is the same as the .SSF file (in this example 06272012A)
37. Make sure the file format is **Shapefile.**

38. Click **Save**
39. Make sure '**this layer's source data'** is highlighted
40. Click **OK**

41. Yes, you want to add the exported data to the map as a layer
42. The newly created **Shapefile** will now be within the Table of Contents
43. Remove the **Sensor$ Events** file
44. Right Click **06272012A** Shapefile
45. **Open Attribute Table**



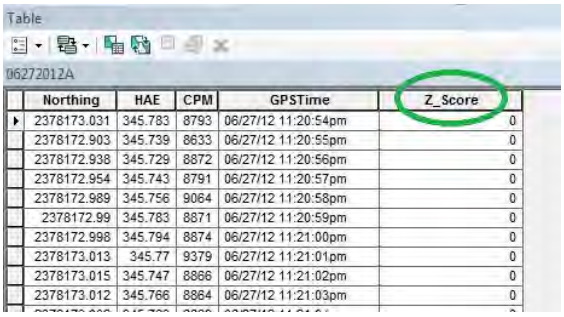
46. You will now see the same Excel table, as before.
47. Create a new field: Click first dropdown option under **Table – Add Field**



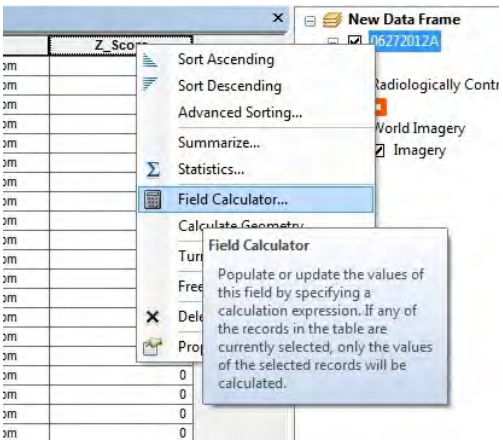
48. File out the fields as followed:
    - **Name**: Z_Score
    - **Type**: Double
    - **Precision**: 15
    - **Scale**: 5

49. Click **OK**

50. The new field will now show up in the Attribute table

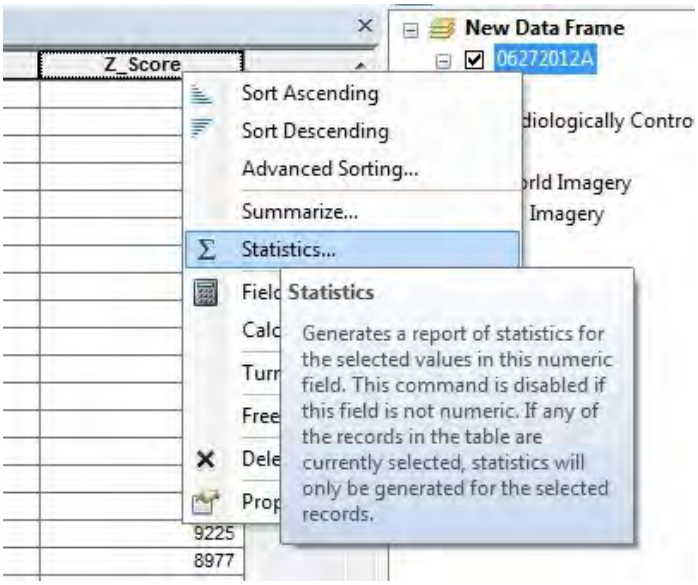


51. Right Click the **Z_Score** Field – **Field Calculator**

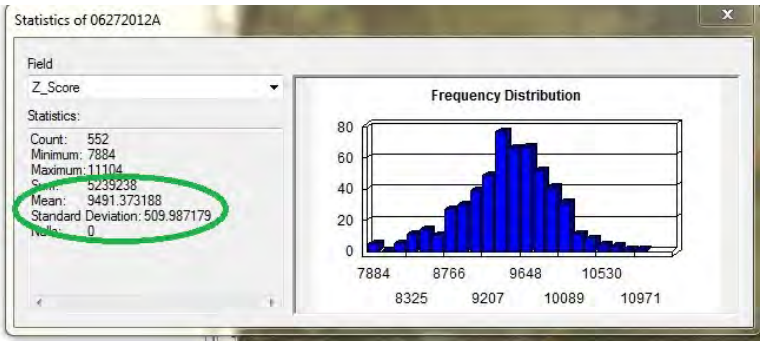


52. Within the **Z_Score = window**, add **CPM** from the **Fields** window above

53. Click **OK**
54. The CPM values have now been copied to the **Z_Score** column
55. Right Click the **Z_Score field – Statistics**

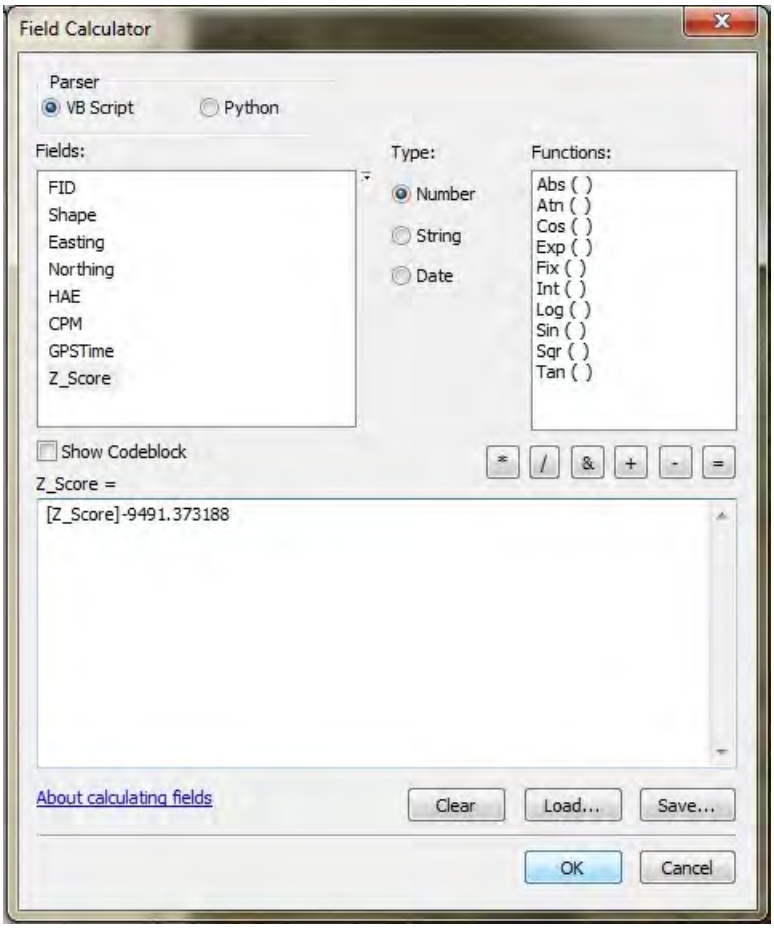


56. A pop up with show the Z_Score statistics including Min, Max, Sum, Mean and Standard Deviation. A graph showing the frequency distribution will also be shown.



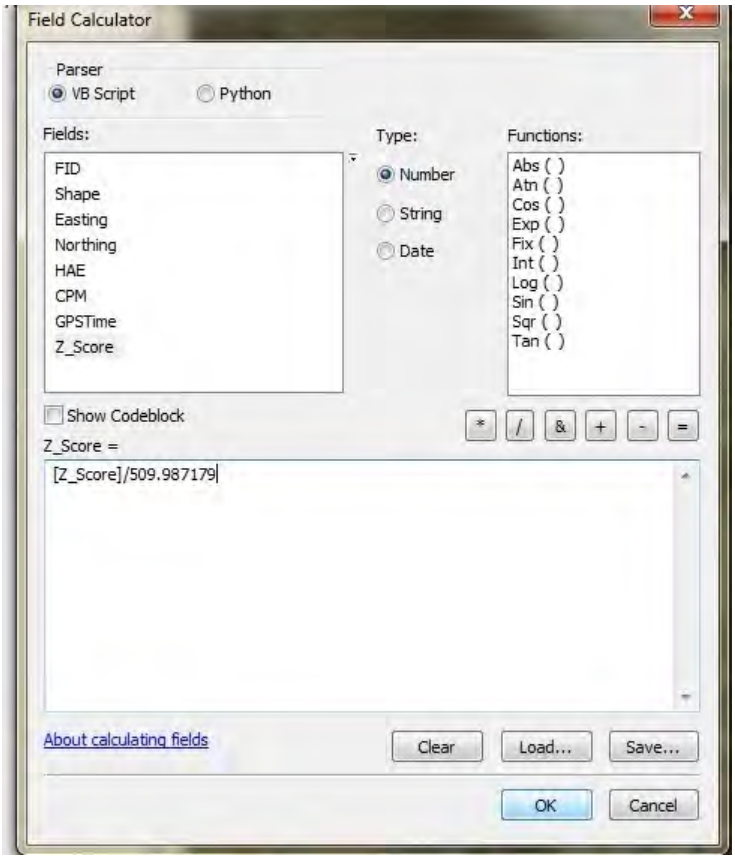
57. Write down the **Mean** and **Standard Deviation**
58. In this example: Mean is 9491.373188 and Standard Deviation is 509.987179
59. Right Click the Z_**Score field – Field Calculator**
60. Remove CPM from the **Z_Score = window**

61. Add Z_Score from the Fields window then “- 9491.373188” (you are subtracting the Mean value from the Z_Score value)



62. Click **OK**
63. Right Click the **Z_Score Field – Field Calculator**
64. Remove the **Z_Score – Mean** value from the **Z_Score = window**

65. Add **Z_Score** from the **Fields** window then "/509.987179" (you are dividing the Standard Deviation from the new values in the Z_Score field)



66. Click **OK**

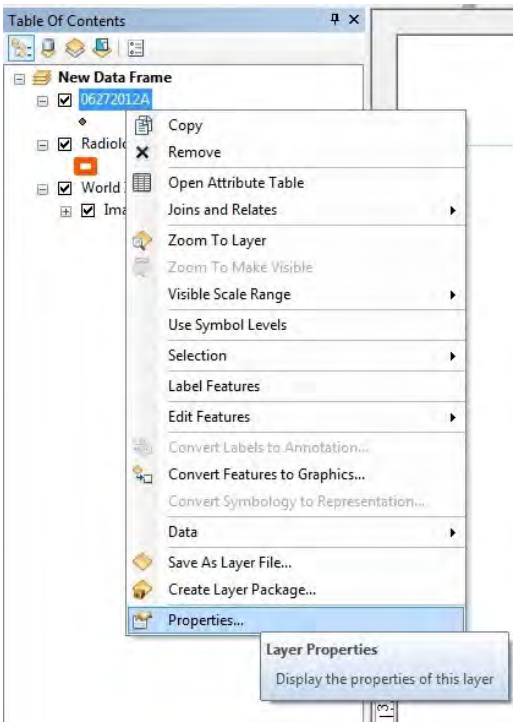
67. You have now found the Z-Score values of the surveyed data

06272012A

Northing	HAE	CPM	GPSTime	Z_Score
2378173.031	345.783	8793	06/27/12 11:20:54pm	-1.36939
2378172.903	345.739	8633	06/27/12 11:20:55pm	-1.68313
2378172.938	345.729	8872	06/27/12 11:20:56pm	-1.21449
2378172.954	345.743	8791	06/27/12 11:20:57pm	-1.37332
2378172.989	345.756	9064	06/27/12 11:20:58pm	-0.83801
2378172.99	345.783	8871	06/27/12 11:20:59pm	-1.21645
2378172.998	345.794	8874	06/27/12 11:21:00pm	-1.21057
2378173.013	345.77	9379	06/27/12 11:21:01pm	-0.22035
2378173.015	345.747	8866	06/27/12 11:21:02pm	-1.22625
2378173.012	345.766	8864	06/27/12 11:21:03pm	-1.23017
2378173.008	345.763	8889	06/27/12 11:21:04pm	-1.18115
2378173.02	345.747	8966	06/27/12 11:21:05pm	-1.03017
2378173.033	345.707	9450	06/27/12 11:21:06pm	-0.08113
2378173.06	345.688	9435	06/27/12 11:21:07pm	-0.11054
2378173.072	345.685	9602	06/27/12 11:21:08pm	0.21692

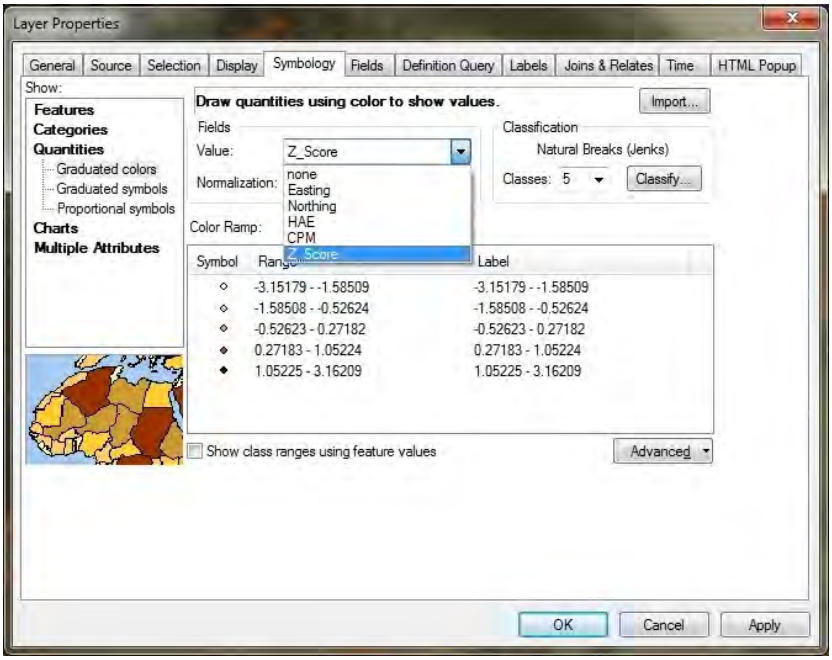
68. Close the **Attribute** table

69. Right Click the **06272012A Shapefile – Properties**

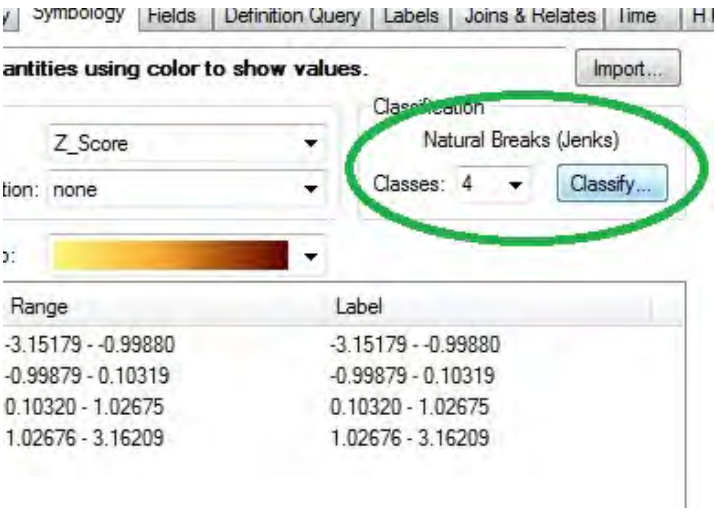


70. Click the **Symbology** tab – **Quantities**

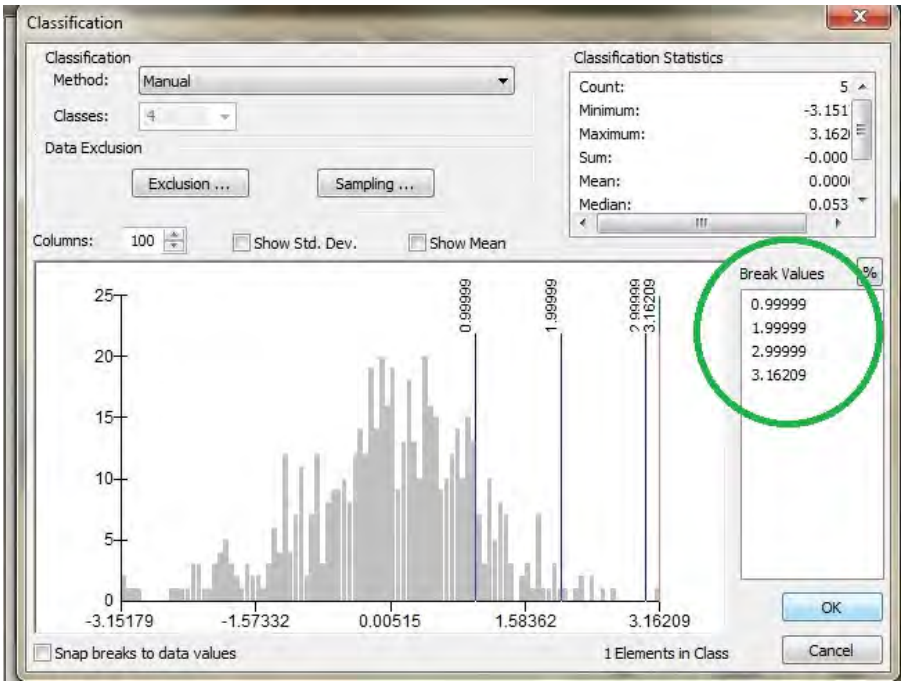
71. Change the **Value** field to be **Z_Score**



72. Change **Classes** to 4
    - Click **Classify**

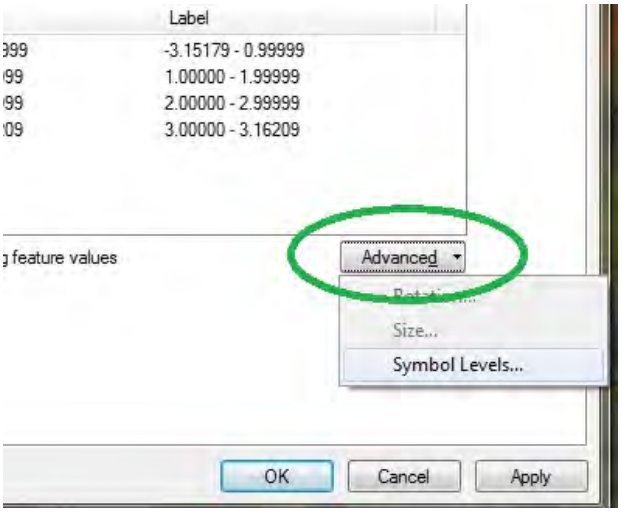


73. Under **Break Values** – change the values to
    - .99999
    - 1.99999
    - 2.99999
    - Leave last value as is (to show anything greater than 3)



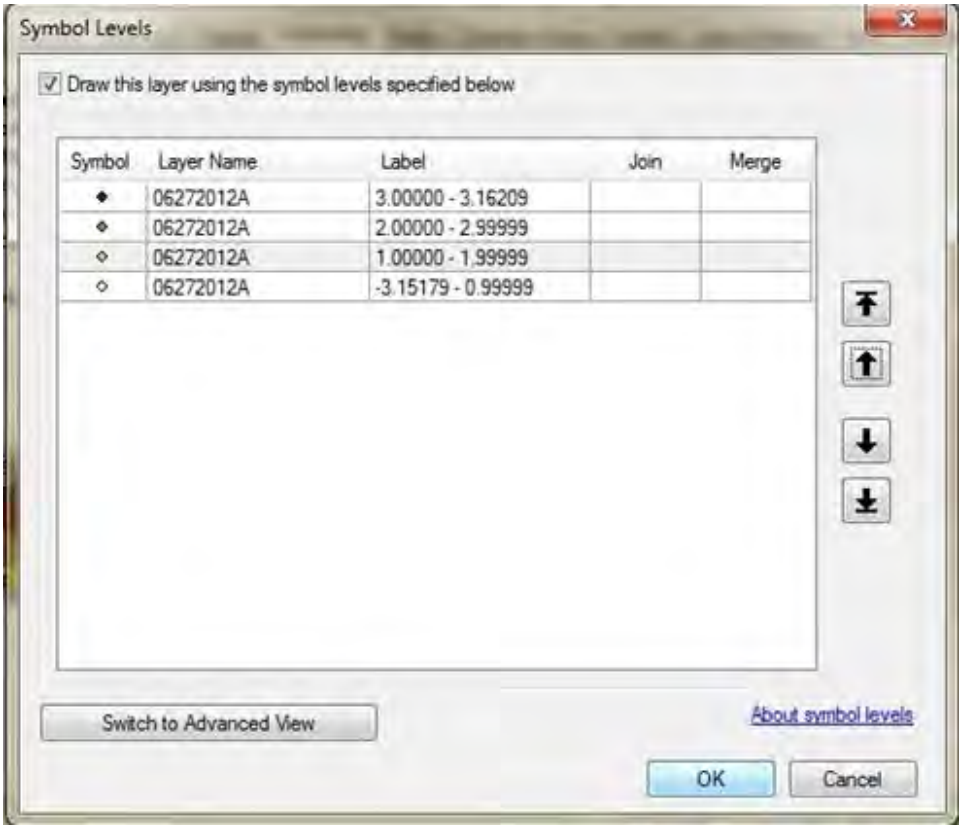
74. Click **OK**

75. Click **Advanced – Symbol Levels…**

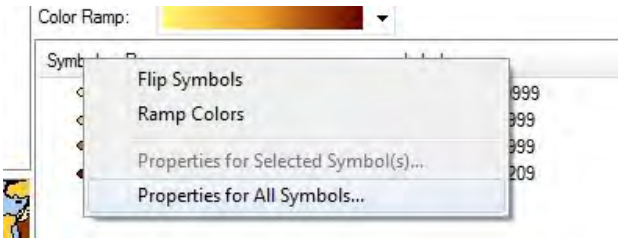


76. Check '**Draw this layer using the symbol levels specified below'**

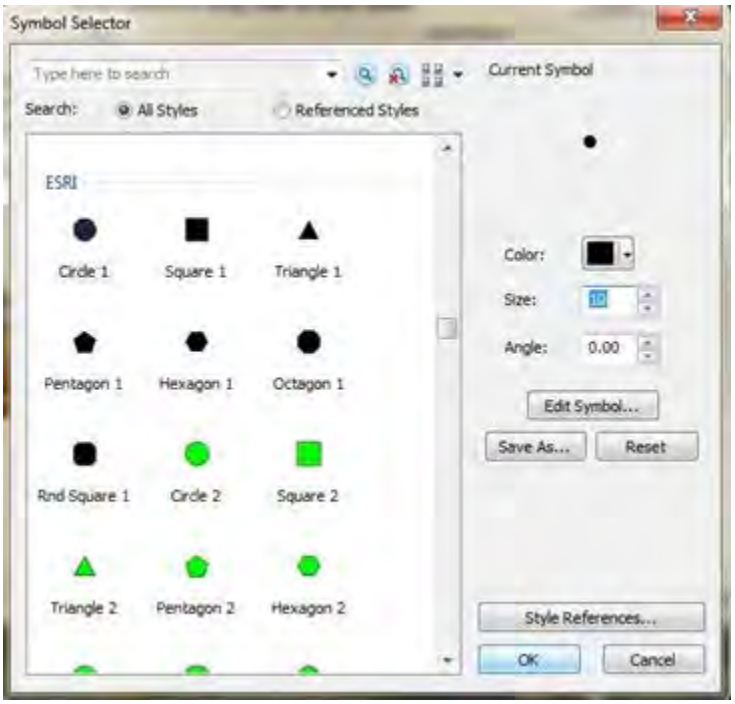
77. Arrange the order so that the symbol representing 3.00 and up is on top, then 2.00-2.99, then 1.00-1.99 with the lowest range on the bottom.



78. Click **OK**
79. Click **Symbol – Properties for all Symbols…**

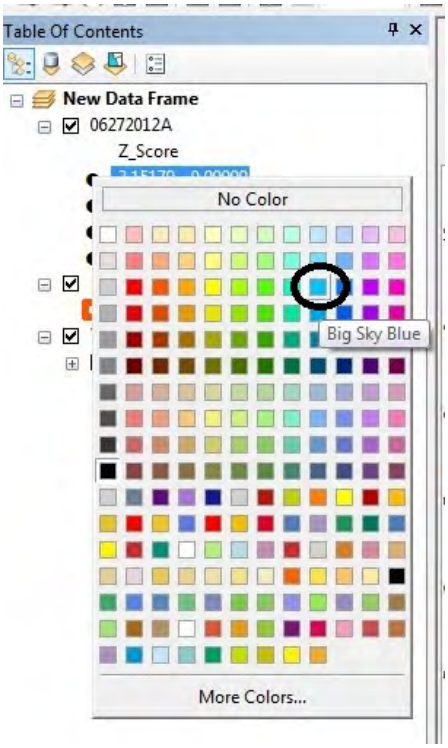


80. Navigate to **ESRI** symbols
    - Click **Circle 1**
    - Change **Size** to 10



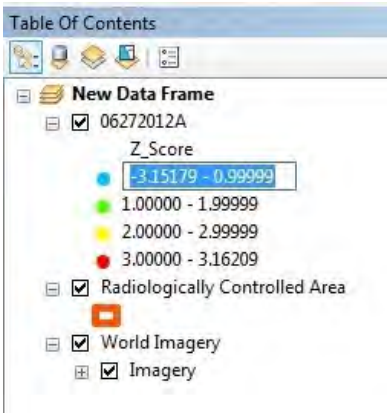
81. Click **OK**
82. Click **OK** to save the settings within Layer Properties
83. The Table of Contents is updated to show the changes

84. Right Click the top black circle to bring up a color option window



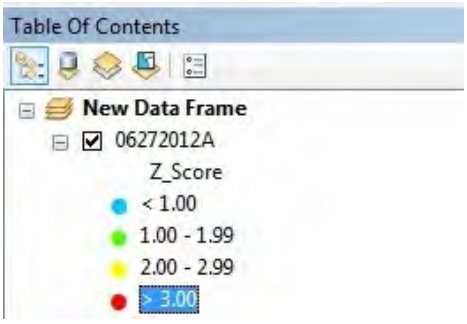
85. Colors are as listed:
    - Less than .99999: Big Sky Blue
    - 1 – 1.99999: Medium Apple
    - 2 – 2.99999: Solar Yellow
    - Greater than 3: Mars Red

86. Click the **Z_Score** range so it allows you to edit the labels

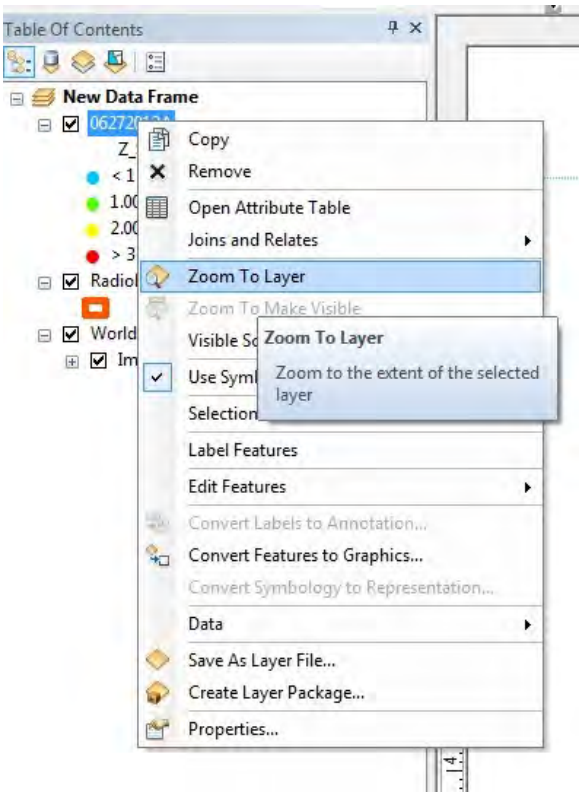


87. Change label range to:

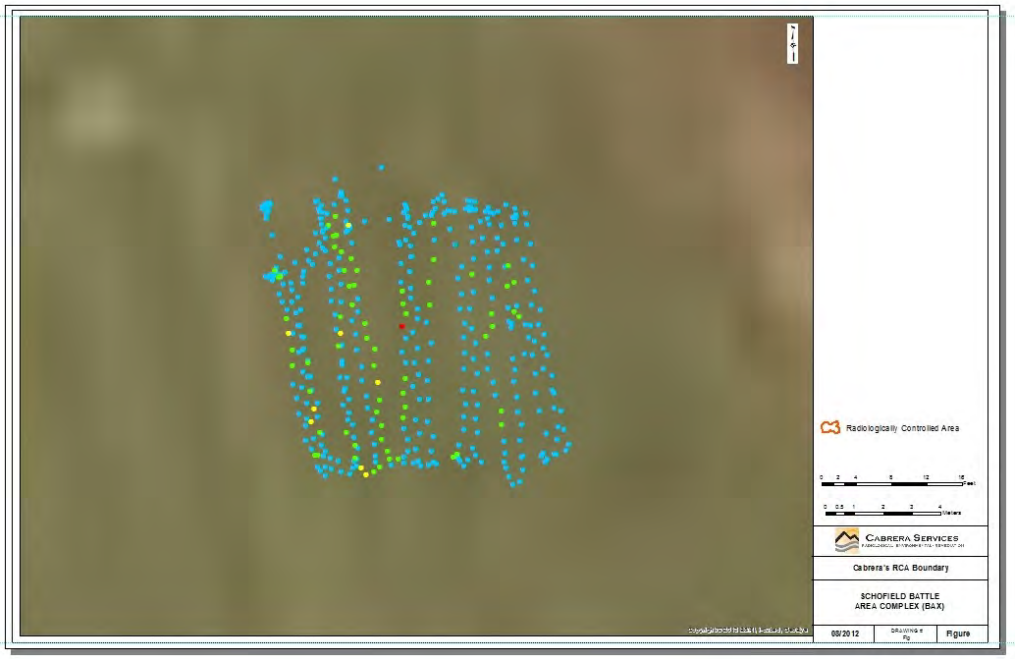
- <1.00
- 1.00– 1.99
- 2.00 – 2.99
- 3.00



88. Right Click the **06272012A file – Zoom to Layer**

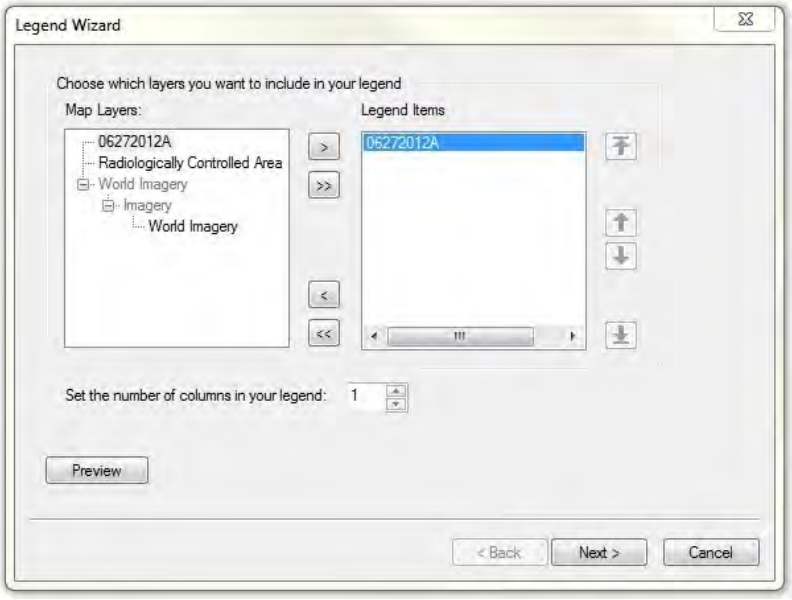


89. This shows the surveyed data set.

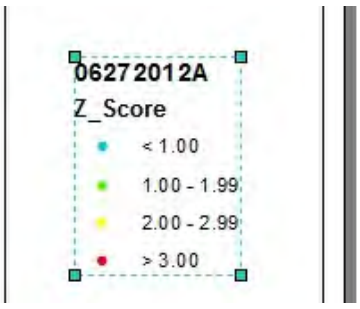


90. In this example, I zoomed to a 1:80 zoom ratio
91. I turned off the **Aerial** photo
92. Update the Figure Title: in this example I changed it to 06272012A GWS Data
93. To the Z_Score legend: Click **Insert – Legend**

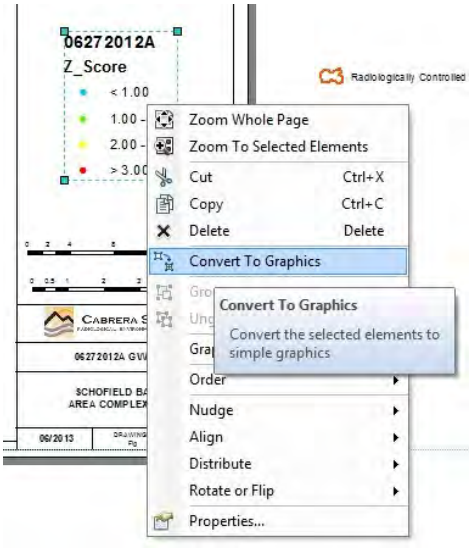
94. Add 06272012A to **Legend Items**



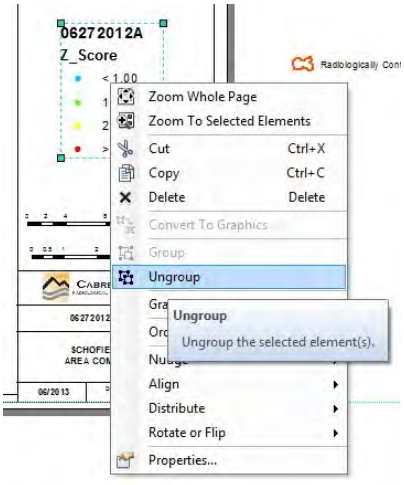
95. Click **Next**
96. Removed “Legend” from Legend Title Box
97. Click **Next**
98. Change nothing to Legend Frame options
99. Click **Next**
100. Change nothing to shape/size of legend items
101. Click **Next**
102. Change nothing to spacing amounts
103. Click **Finish**
104. The **Legend** will now be on the map (it shows up in the middle of the view)
105. Move it to the legend space along the right side of the map



106. Right Click the legend and click **Convert to Graphics**

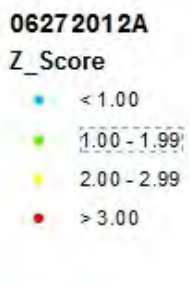


107. Right Click the legend and click **Ungroup**

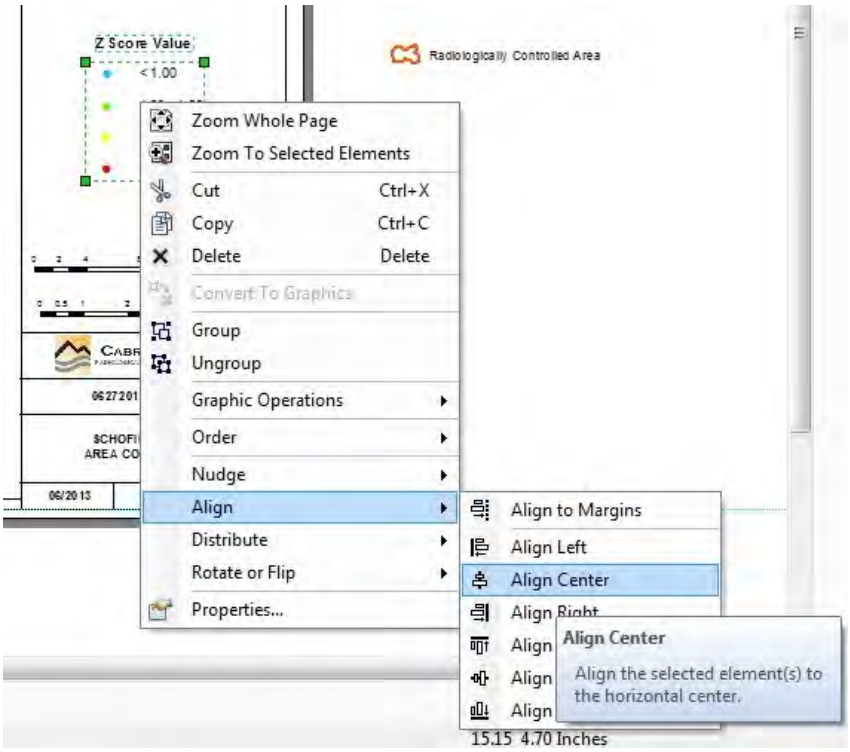


108. Right Click the **legend** and click **Ungroup** again

109. The different pieces of the legend should now be separate from the others



110. Remove the text 06272012A
111. Change **Z_Score** to **Z Score Value** (font size 12)
112. Highlight all symbol range text and change font size to 11
113. Select the colored symbols and range text – right click, **Group**
114. **Center align** the Z Score Value text with the now grouped symbols/range text.



115. Save the map.
116. Export the map to PDF – save as 06272012A GWS Data (as a daily map).

Further steps will be needed if the project requires combining individual daily surveys into an overall map/data file.

OPERATING PROCEDURE

FOR

DECONTAMINATION OF RESIDUAL SURFACE RADIOACTIVITY

OP-3805

(Formerly OP-018)

Revision 2.0
January 2021

Level of Use:
Information Use

APPROVALS	
President	*R. Flowers, PMP, CHMM*
Quality Assurance	*S. Liddy, CSP*
Health Physics	*M. Winters, CHP*
This procedure is the property of Cabrera Services Inc. and is considered approved and effective for the duration it is posted electronically to the Controlled Copy Document Repository.	

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History of Revisions		
Revision	**Month-Year**	**Description**
0	January 2000	OP-018, Decontamination of Equipment & Tools. Initial issue. Initial issue.
1.0	April 2013	General (major) revision to update overall program elements to latest regulations, guidance, and industry practices. Renamed OP-018, Decontamination of Radioactivity from Equipment and Tools.
2.0	January 2021	General (major) revision to update overall program elements to latest regulations, guidance, and industry practices. Formatting and renumbering to OP-3805 per OP-2001. Subject Matter Expert for this revision was Mike Plonski and Bryan Gaudette.

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1.0 PURPOSE

This procedure establishes the methods for decontamination of areas, materials, and equipment that are suspected/confirmed to have residual surface radioactivity from use in radiologically controlled/restricted areas or in proximity to unsealed radioactive materials.

2.0 SCOPE/APPLICABILITY

This document applies to all personnel involved in the decontamination of equipment and tools unless specifically directed otherwise by the RSO or AU. Each decontamination operation is unique; thus, this procedure provides general, effective decontamination techniques and guidelines to be used by field personnel in consultation with Radiation Safety Staff. Elements of this procedure may be used to decontaminate actual surfaces in radiologically controlled/restricted areas with residual surface radioactivity provided sufficient controls are established to prevent cross-contamination into uncontrolled areas.

3.0 DEFINITIONS

3.1 Decontamination – The processes where contamination can be safely and effectively removed from equipment and materials.

3.2 Herculite – Herculite is a brand name plastic or polyethylene floor covering and containment material used for decontamination operations.

3.3 Radiological Work Permit (RWP) - The document that identifies radiological conditions, establishes worker protection and monitoring requirements, and contains specific approvals for radiological work activities. The RWP serves as an administrative process for planning and controlling radiological work and informing the worker of the radiological conditions.

3.4 Safety Data Sheet (SDS) – Sheets providing information and limitations about chemicals and products that is issued by the manufacturer.

4.0 RESPONSIBILITIES

4.1 Radiation Safety Officer (RSO) - Performs periodic assessment of procedure implementation as an element of periodic program reviews. Provides technical interpretations of program requirements/guidance.

4.2 Authorized User (AU) - Responsible for performing the requirements established in this procedure at assigned project sites or corporate office. When the RSO is not on site, AU will act on the RSO's behalf for radiation safety issues related to decontamination of equipment, materials, and tools.

4.3 Radiation Safety Support Staff (RSSS) – Responsible for performing surveys of decontaminated items and ensuring that radioactive material is not released to the public or the environment.

5.0 PRECAUTIONS, LIMITATIONS, AND PREREQUISITES

5.1 Precautions

5.1.1 Decontamination of contaminated tools or equipment will be performed under the direction of a site AU or RSO. The RSSS will provide direction in accordance with this procedure, and the RWP.

5.1.2 Controls to contain the spread of loose contamination, during decontamination evolution, will be planned and established prior to the decontamination of equipment, material, and tools.

5.1.3 Surface destructive decontamination using abrasive means (e.g., cutting, grinding, blasting, torching, etc.) can produce airborne radioactivity resulting in unexpected internal doses to workers; planned decon methods and associated controls for worker protection should attempt to minimize generation of airborne radioactivity to the extent ALARA.

5.1.4 When wet decon techniques are used, radiological controls must consider breakthrough potential for selected protective clothing; select waterproof/resistant layers, as needed to prevent wet permeation to unprotected personnel clothing or skin.

5.2 Limitations

5.2.1 This procedure is not appropriate for the decontamination of personnel which requires specific RSO consultation.

5.2.2 This procedure may **NOT** be applicable or readily applied to decontaminating surfaces composed of porous materials such as wood or concrete. It is therefore not the preferred operating procedure for decontaminating building surfaces.

5.2.3 Protective clothing worn, by the personnel involved in decontamination activities, will be determined in accordance with the RWP.

5.2.4 Decontamination cleaning solvent/solutions will only be used in accordance with the directions and limitations listed on the manufacturer supplied SDS.

5.2.5 Respiratory protection devices, required by the RWP for decontamination operations, will be selected and used in accordance with the provisions of OP-5502, *Respiratory Protection*.

5.3 Prerequisites

5.3.1 Decontamination activities will be performed within a radiologically controlled/restricted area. Additional postings should be placed based on known/expected/observed conditions prior to or during decontamination. Refer to OP-3806, *Radiological Postings* for additional guidance.

5.3.2 Radiation and contamination surveys will be performed in accordance with OP-3601, *Radiological Surveys*.

5.3.3 Release of equipment, materials, and tools from the decontamination work area will be performed in accordance with of OP-3802, *Unconditional Release of Materials and Equipment from Radiological Controls*.

6.0 EQUIPMENT

Appropriate Personal Protective Equipment (Refer to OP-5501, PPE) and decontamination equipment as specified in the Site-Specific Safety & Health Plan (SSHP), Activity Hazard Analysis (AHA) and/or Radiation Work Permit (RWP). Decontamination equipment may include, but is not limited to:

- Thick poly (e.g., Herculite) floors and walls, or other acceptable barrier that minimizes potential for cross-contamination into surrounding areas during decon efforts.
- Decontamination solutions and cleaning material (e.g., wipes, rags, brushes)
- Waste collection container(s)

7.0 INSTRUCTIONS/PROCEDURE

7.1 Pre-Decontamination Preparation

The AU will initiate decontamination work instructions.

A radiological survey will be performed by an RSSS on any item or object that is to be removed from a controlled area.

If radiological survey results indicate that an RWP is required for decontamination, the RSO or AU will write an RWP to in accordance with OP-3809, *Radiation Work Permit*. For activities with low dose consequences (i.e., no reasonable potential to exceed an individual dose monitoring threshold) and direct Rad Safety oversight, controls and work instructions may be communicated by the RSSS without a formal RWP being generated.

If a survey indicates that decontamination is required, the item should be bagged, wrapped, or contained under the direction of RSSS. The RSSS will label the item with all pertinent information.

The AU will approve or disapprove the decontamination operation based on conditions of the RWP and the cost effectiveness of the operation versus disposal costs.

7.2 Establishment of the Decontamination Work Area

The RSO and/or the AU will determine a location for the decontamination area.

Once a location has been established, the decontamination area will be set-up, by the RSSS, under the direction of the AU.

The decontamination area should consist of the following:

- Covered (or equivalent) floor surfaces. A double layer of Herculite (or equivalent) may be laid on the floor at the direction of RSSS.
- Covered (Herculite or equivalent) wall surfaces, if applicable.

- Engineering controls (HEPA ventilation, vacuum cleaners, containment tent walls glove bags, etc.), if applicable.
- Engineering controls will be determined on the basis of the ALARA consideration section of the RWP.

  NOTE: All possible engineering controls will be utilized when feasible to minimize the need for respiratory protection equipment.

- Use of safe, sturdy workstations with contamination resistant surfaces and tables that will support decontamination attempts on heavy pieces of equipment.
- Large pieces of equipment (earth moving equipment, vehicles, cranes etc.) that require decontamination may need a designated pad for decontamination. The pad should be developed/designed to capture sediment and liquid wastewater as appropriate for each project. The requirements for each pad will be documented in the project work plans.
- Adequate supply of overhead light, adequate electrical/compressed air supply for the operation of electrical/pneumatic driven decontamination equipment.
- Adequate supply of project approved cleaning solutions and solvents along with an adequate supply of decontamination equipment, such as:
  - Light duty decontamination equipment such as paper wipes, paper towels, masslinn towels, etc.
  - Medium to heavy-duty decontamination equipment such as pressure washers, scrub pads, wire brushes steel wool, files, sandpaper, etc.
  - Fully stocked dedicated hand tool kit for disassembly of contaminated equipment.
  - Radioactive material storage bags, stickers, etc.
  - Buckets, barrels, or drums for the storage of contaminated liquids, sludges, or slurries, if applicable.
  - Blotter paper or sorbent, if applicable.
  - Approved absorbent material such as oil dry, if applicable.
- Storage drums/bags for the storage of contaminated protective clothing under direction of the RSSS staff.
- Proper surveillance instruments (air monitor/sampler, contamination monitor, friskers, dose rate meter, etc.) in accordance with the RWP.
- Adequate supply of personal protective clothing, gloves, respiratory equipment, etc.
- Area egress location, in accordance with the provision of the RWP.
- A designated area, within the decontamination area, for the segregation of radioactive waste.

Once the decontamination area has been established and stocked for operation, the bagged and/or wrapped contaminated or controlled equipment should be placed in the decontamination work area. Contaminated or controlled items should always be escorted, under the direction of the RSSS, to the decontamination area.

7.3 Decontamination

After the decontamination area has been posted, and area access controls established, all requirements of the RWP will be observed.

7.3.1 The preparation for decontamination of a particular tool, material, or piece of equipment will be performed, as follows:

a. Position the wrapped item so that the written information on the label/wrapping is visible.

CAUTION: Survey instruments to be used in a known or suspected contaminated area should be protected (wrapped in plastic, poly, etc.) against possible contamination before use.

b. The RSSS's will direct the removal of the item from the wrapping in such a manner (rolling plastic, poly, etc.) to control the spread of contamination.
c. An item that is highly contaminated with loose contamination should be misted with an approved liquid such that contamination cannot easily be transferred to the air or other surfaces.
d. Once the item has been removed from the wrapping and has been properly positioned, carefully discard the wrapping as radioactive waste.

7.3.2 The following decontamination techniques should be considered for the decontamination of equipment, materials, and tools:

- Any equipment with inaccessible areas will be dismantled so that all surfaces are accessible for decontamination and survey.
- Decontamination will be performed in a safe, effective manner.
- The RSSS will be notified immediately if the job conditions change (e.g. suspected asbestos found, presence of mercury in a switch or a light bulb, a fluid leak, or any other special circumstances).
- The decontamination area will remain organized and free of debris with the RSSS enforcing the "clean-as-you-go" policy, whenever necessary.
- A HEPA vacuum cleaner may be used during the decontamination operation.

7.3.3 Removal of Loose Surface Contamination

When the item is properly positioned for decontamination and the pre-survey has been completed, perform the following:

a. Moisten the surface of the item with a project approved liquid or detergent (e.g. demineralized water).
b. Fold a paper or cloth wipe into sections, using one surface of the wipe gently wipe contamination off in one direction away from the user's body. This should reduce the possibility of personnel contamination.
c. Re-fold the paper or cloth wipe so that a clean surface is available (this should prevent cross-contamination) and continue until item is ready for survey.

d. For some materials, duct tape will effectively remove smearable contamination. Wrap the duct tape loosely around the gloved hand with the adhesive side out. Roll the tape over the contaminated area and re-survey.

7.3.4 Removal of Fixed Contamination

There are many techniques that can be used to remove fixed contamination. The general idea is to remove the material, which is fixing the activity to the surface, or remove a very thin layer of the surface material. The techniques selected for a particular decontamination operation is at the discretion of the RSO/AU and the RSSS. The techniques can be divided into the following categories:

- Light hand decontamination
- Abrasive hand decontamination
- Power tool decontamination
- Machine decontamination (use of abrasive bead blasters, grit blasters, high pressure water wash systems, etc.).
- Cleaning solutions/solvents (use of ultrasonic cleaners, acid baths, electropolishing, etc.).

NOTE: The specific implementation of these techniques is not included within the scope of this procedure. The selection of methods should first consider safety impacts first, then ALARA considerations to minimize worker exposures, followed by productivity & cost considerations.

7.3.5 Light hand decontamination consists of using many of the same techniques as Step 7.3.4 of this procedure.

7.3.6 Abrasive Hand Decontamination

This will be performed carefully to minimize particulate generation in the worker breathing zone and, in the following manner:

a. Remove as much smearable contamination as possible.
b. Moisten the surface of the item(s) to contain contamination.

CAUTION: Abrasive measure should only be applied to surfaces that are not critical for operation of devices, which must be restored to working condition. Abrasion of machined surfaces should be minimized if the device is intended to provide its designed operation.

c. Use an abrasive cleaning tool (e.g. sandpaper, steel wool, steel brush, hand grinder, etc.) to loosen fixed contamination. Clean in one direction only and clean Away from the body to prevent personnel contamination.
d. Continue to moisten the surface of the item(s) to contain contamination.
e. Remove as much smearable contamination as possible.
f. Re-survey.

7.3.7 Power tool decontamination

This will be performed in the following manner only as a last resort decontamination effort. The use of engineering controls must be considered to maintain dose potential ALARA; consult with the RSO/AU for guidance. Consult with the RSO if the use of effective engineering controls is restricted.

NOTE: When using power tools, always consider the potential of injury due to the hazards involved. Power tools will be used cautiously and in accordance with the manufacturer's recommendations.

Some of the electric power tools that can be used in decontamination operations are:

a. Drills to drill out contaminated areas, to disassemble contaminated components and when used with grinding wheels or disks, may be used as an abrasive tool.
b. Saws to separate contaminated pieces from clean pieces.
c. Grinders to grind fixed contamination from surfaces.
d. Electric screwdrivers used in the disassembly of component parts.

7.3.8 Power tool decontamination will be performed in the following manner:

a. Using a spray bottle, moisten the surface of the item lightly to contain contamination.

CAUTION: Do not use electric power tools on a wet working surface. Keep liquids away from electric power tools.

b. Whenever feasible a containment device (e.g. glove box or bag etc.) should be used to contain the spread of contamination when using power tools for decontamination operations.
c. Use the power tool to remove fixed contamination. Clean in one direction only and clean away from the body to prevent personnel contamination.
d. Re-survey.
e. If the item remains contaminated, attempt a second decontamination.
f. If the item continues to be contaminated, attempt a third decontamination only at the direction of the RSO or AU.

7.4 Post-Decontamination

If the decontamination was successful, the technician will notify the RSSS, who will perform a release survey in accordance with OP-3802, *Unconditional Release of Materials and Equipment from Radiological Controls*.

If the item satisfies the criteria for release, as stated in OP-3802, remove the item and document results. Items may also be released to lower levels of radiological controls to complete more complex surveys (i.e., from Contamination Area to RMA) when removable contamination levels meet posting criteria and any subsequent decon will not potentially spread contamination to an uncontrolled/unrestricted area.

If an item cannot be effectively or economically decontaminated, RSO or AU may direct the work crew to volume-reduce (reduce to component parts) the equipment, material, or tools as much as possible. If the item is expendable, the individual parts may be surveyed and released in accordance with Step 7.3.

If an item is volume-reduced to its component parts and decontamination is not feasible, and the item is not needed, the item parts will be considered radioactive waste. Radioactive waste is to be segregated into similar material for shipment purposes at the direction of the Project Manager.

After all decontamination operations have been completed, an RSSS will perform a survey of the decontamination area prior to down posting or relaxing temporary radiological controls established to support decon. Note that more formal area surveys may be required to support final decommissioning objectives, consult with the PHP/RSO for guidance, as needed.

8.0 REFERENCES

- OP-3601, *Radiological Surveys*
- OP-3802, *Unconditional Release of Materials and Equipment from Radiological Controls*
- OP-3806, *Radiological Posting*
- OP-3809, *Radiation Work Permit*
- OP-5501, *Personal Protective Equipment*
- OP-5502, *Respiratory Protection*

9.0 REQUIRED RECORDS

The records generated using this procedure are documented in accordance with the provisions of referenced procedures. No new records are created.

10.0 ATTACHMENTS

None.

CABRERA SERVICES

RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

Radiation Safety Procedure

For

Radiological Posting

OP-019

Revision 0

Reviewed By: _____ Date: 1/24/00

David Watters, Radiological Safety Engineer

Approved By: _____ Date: 1/24/00

Steven Mascinlli CHP CSP, Radiation Safety Officer

Approved By: _____ Date: 1/24/00

Henry Siegrist CHP, P.E., Corporate Health Physicist

1.0 PURPOSE

This procedure provides the methods Cabrera Services, Inc. (CABRERA) uses to control radioactive materials. Adherence to this procedure will provide reasonable assurance that personnel will remain free of contamination, contamination will not spread beyond the designated contamination area, and personnel exposures will be maintained As Low As Reasonably Achievable (ALARA).

2.0 APPLICABILITY

This procedure will be used by CABRERA personnel to control and contain radioactive materials. The following are types of controls methods that will be employed:

- Posting requirements for radioactive materials.
- Establishing and posting radiation areas.
- Establishing and posting contaminated areas.
- Establishing and posting airborne radioactivity areas.

3.0 PRECAUTIONS, LIMITATION, AND REQUIREMENTS

3.1 Precautions

3.1.1 If a HPT is unable to perform this procedure due to errors, extenuating circumstances, or for any reason, the HPT shall immediately stop and notify the RSO.

3.2 Limitation

None

3.3 Requirements

None

4.0 REFERENCES

- 10 CFR 20, Subpart F Surveys and Monitoring
- 10 CFR 20.2103 Records of Surveys
- RSP Radiation Safety Program
- AP-001 Record Retention
- AP-010 Personal Protective Equipment
- AP-015 Radioactive Materials Brokering

- OP-020 Operation of Contamination Survey Instrument
- OP-021 Alpha-Beta Sample Counting Instrument
- OP-022 Operation of Ionization Chambers
- OP-023 Operation of Micro-R Survey Meters

5.0 DEFINITIONS AND ABBREVIATIONS

5.1 Restricted Area – An area to which access is controlled to protect individuals against undue risks from exposure to radiation and radioactive materials.

5.2 Contamination Survey – A survey technique to determine fixed and removable radioactive contamination on components and facilities.

5.3 Radiation Survey – is defined as an evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation.

5.4 ALARA – (acronym for “as low as is reasonably achievable”) An approach to radiation exposure control to maintain personnel radiation exposures as far below the federal limit as technical, economical and practical considerations permit.

5.5 Radioactive Materials – Materials containing or capable of emitting alpha particles, beta particles, gamma rays, X-rays, neutrons and/or other ionizing radiations.

5.6 Airborne Radioactivity Area – A room, enclosure or area in which radioactive material is dispersed in the form of dusts, fumes, mists, vapors, or gases and the concentration of the of the dispersed radioactive materials in excess of:

5.6.1 The derived air concentrations (DAC’s) specified in Table 1, Column 3 of Appendix B, Title 10 Part 20 of the Code of Federal Regulations.

5.6.2 Concentrations such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

6.0 EQUIPMENT

None Required

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – the PM is responsible for ensuring that personnel assigned the task of establishing and posting restricted areas are familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

7.2 Radiation safety Officer (RSO) – The RSO is responsible for monitoring compliance with this procedure and training personnel in establishing and posting restricted areas. The RSO can also assist in the interpretation of the results obtained during surveys.

7.3 Radiological Field Supervisor (RFS) – During field assignments, the RFS is responsible for ensuring that this procedure is implemented. When the RSO is not on site, the RFS will act as the RSO's duly authorized representative for radiological issues.

7.4 Health Physics Technicians (HPT) – The HPT establishing and posting restricted areas are responsible for knowing and complying with this procedure.

8.0 INSTRUCTIONS

8.1 Posting Requirements for Radioactive Materials

8.1.1 Any area or room in which there is used or stored an amount of licensed material exceeding 10 times of the quantity of such material specified in Appendix C, Title 10 Part 20 of the Code of Federal Regulations shall be posted with a sign or signs "Caution Radioactive Materials Area" or "Danger, Radioactive Materials".

8.1.2 When posting a room as required in step one, a sign should be placed on each entrance door to the room. If the area to be posted is not a room, the area containing the license material shall be bounded by a yellow and magenta/black rope or ribbon securely fastened to stanchions, posts or other durable devices and signs shall be displayed in all accessible directions.

8.1.3 Any container, which contains licensed material in quantities equal to or greater that the quantities listed in Appendix C, Title 10 Part 20 of the Code of Federal Regulation shall be posted with a sign or label bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIALS" OR "DANGER, RADIOACTIVE MATERIALS".

8.1.4 When posting a container as required by step three, the label should also state the radionuclide present in the container, the activity in the container, the date at which the activity was determined, the radiation levels emanating from the unshielded radioactive source, and the levels from the container holding the radioactive source. The label shall also state the mass enrichment if different from natural enrichment and the kind of material (encapsulated source, liquid, powder. etc.).

8.1.5 Posting of containers is not required if the containers are in transport and packages and labeled in accordance with the regulations of the Department of Transportation. (Title 49 Parts 172 and 173 of the Code of Federal Regulations). Containers, which are awaiting shipment at a facility, are subject to posting requirements as specified in 8.1.1

8.2 Establishing and Posting Radiation Areas

8.2.1 Any area accessible to personnel in which there exists ionizing radiation at dose rate levels such that an individual could receive a deep dose equivalent in excess of 5 mrem in 1 hour at 30 cm from the source of from any surface that the radiation penetrates shall be identified and posted with a sign “CAUTION RADIATION AREA”.

8.2.2 A Micro-R Meter or other calibrated dose rate meter is used to identify the boundary location of the 5 mrem/hr dose rate.

8.2.3 If an entire room or most of the room is at or above the 5 mrem/hr level, a sign should be placed on each entrance door to the room. If the area to be posted is not a room, the area at or above the 5 mrem/hr level shall be bounded by a yellow and magenta/black rope or ribbon securely fastened to stanchions, posts or other durable device and signs shall be displayed in all accessible directions.

8.2.4 An exemption to this posting requirement is allowed in areas or rooms containing radioactive materials for periods less than 8 hours, if each of the conditions is met:

8.2.4.1 The materials are constantly attended to during these periods by an individual who takes the precautions necessary to prevent the exposure to radiation or radioactive materials in excess of the limits specified in the RSP; and

8.2.4.2 The area or room subject to the licensee’s control. For example, the area around the truck loading radioactive waste does not require posting if the above conditions are met.

8.2.5 If the dose rates above 100 mrem/hr are encountered, control access to the area and contact the RSO or duly authorized representative for posting instructions.

8.3 Establishing and Posting Contaminated Areas

8.3.1 A restricted area that has fixed and removable radioactive materials in the form of dusts, particulates or sorbed contaminants which are above the limits specified in the RSP shall be identified and posted with a “CONTAMINATED AREA” sign.

8.3.2 Contamination levels are determined using procedure OP-001 (Radiological Surveys) and the results of the survey measurements compared to the contamination limits specified in the RSP.

8.3.3 If an entire room or most of the room is above the contamination criteria, a sign should be placed on the entrance door to the room. If the area to be posted is not a room, the above area contamination criteria shall be bounded by a yellow and magenta/black rope or ribbon securely fastened to stanchions, posts or other durable device and signs displayed in all accessible directions.

8.3.3.1 A single entry point shall be established to access the contaminated area. A step-off pad is placed at the entry point, which provides a defined boundary between contaminated and restricted areas.

8.3.3.2 Receptacles for protective clothing and waste materials shall be placed just inside the entry point to collect protective clothing from personnel exiting the area.

8.3.3.3 If work activities in the work areas are likely to generate significant dusts containing radioactive materials, the area should be enclosed within a containment to prevent the spread of contamination beyond the identified contaminated area.

8.4 Establishing and Posting Airborne Radioactivity Areas

8.4.1 CABRERA’s policy is to minimize (and protect, if practical) the amount of radioactive materials taken into a workers body. In order to accomplish this, Airborne Radioactivity Areas are posted at 10% DAC, as specified in Table 1, Column 3 of Appendix B of 10 CFR 20. Maintaining the airborne activity below these limits will eliminate any posting requirements.

8.4.2 To verify that these limits are not exceeded, an air sample is taken during each work activity, which could create an airborne radioactivity hazard. The results of these samples are compared with the above limits to verify the limits are not exceeded. If these limits are exceeded, immediately contact the RSO or duly authorized representative.

8.4.3 A room, enclosure or area shall be posted with a “CAUTION, AIRBORNE RADIOACTIVITY AREA” or “DANGER, AIRBORNE RADIOACTIVITY AREA” if radioactive material is dispersed in the form of fumes, dusts, mists, vapors, or gases and the contamination of the dispersed radioactive materials is in excess of:

8.4.3.1 The derived air concentration (DAC) specified n Table 1, Column 3 of Appendix B, Title 10 Part 20 of the Code of Federal Regulations.

8.4.3.2 Concentration such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

8.4.4 If a room, enclosure or area requires posting as specified in 8.4.3, immediately stop work activities and contact the RSO or duly authorized representative for instructions.

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

9.1.1 Instrumentation used in the surveys will be checked with standards daily and verified to have current valid calibration.

9.2 Records

9.2.1 Record any radioactive materials posting made in the project logbook. Include the date, location, and all information posted.

9.2.2 Record the date and the location of any radiation areas established in the project logbook. Include a sketch of the area and radiation area boundary on survey forms.

9.2.3 Record the date and location of any contaminated areas established in the project logbook. Include a sketch of the area and contaminated area boundary on survey forms.

9.2.4 Record the date and location of any airborne radioactivity areas established in the project logbook. Include a sketch of the area on survey forms. Indicate time and date of any notifications required by this procedure.

9.2.5 Radiological survey records, routine survey schedules, and tracking forms are generated during the performance of this procedure.

9.2.6 Documented information shall be legibly written in ink.

9.2.7 Data shall not be obliterated by erasing, using white-out, or by any other means. Incorrect entries shall be corrected by striking a single line across the entry. The correction shall be entered, initialed, and dated.

9.2.8 The HPT performing the posting shall ensure that this procedure is the most current and approved revision.

9.2.9 The HPT performing the posting shall review Forms and any other applicable forms for accuracy and completeness.

9.2.10 Entries on Forms and any other pertinent forms must be dated and initialed by the HPT performing the posting to be valid.

9.2.11 The RSO or duly authorized representative shall review any applicable completed forms. The review shall be for accuracy and completeness.

10.0 ATTACHMENTS

None

ATTACHMENT B

SCAN MINIMUM DETECTABLE CONCENTRATION CALCULATIONS AND MICROSHIELD MODELING RESULTS

Ra-226 Scan MDC Calculation

Index MDC Calculations Ra-226 @4"

$Energy_g$ (keV)	$(u_{en}/r)_{air}$ (cm^2/g)	Fluence Rate to Exposure Rate	$(u_{en}/r)_{NaI}$ (cm^2/g)	Probability of Interaction				Relative Detector Response				Counts per Minute per MicroRoentgen per Hour (cpm per uR/hr)				MicroShield Exposure Rate (uR/hr, with buildup)	Weighted cpm per uR/hr			
				44-10	44-20	G5	RSI 700	44-10	44-20	G5	RSI 700	44-10	44-20	G5	RSI 700		44-10	44-20	G5	RSI 700
15	1.29	0.0517	47.4	1.00	1.00	1.00	1.00	0.052	0.052	0.052	0.052	1,179	3,063	5,619	842	1.11E-09	0	0	0	0
20	0.516	0.0969	22.3	1.00	1.00	1.00	1.00	0.097	0.097	0.097	0.097	2,211	5,743	10,535	1,579	0.00E+00	0	0	0	0
30	0.147	0.2268	7.45	1.00	1.00	0.99	1.00	0.227	0.227	0.224	0.227	5,173	13,440	24,344	3,696	0.00E+00	0	0	0	0
40	0.064	0.3906	19.3	1.00	1.00	1.00	1.00	0.391	0.391	0.391	0.391	8,912	23,152	42,470	6,367	0.00E+00	0	0	0	0
50	0.0384	0.5208	10.7	1.00	1.00	1.00	1.00	0.521	0.521	0.520	0.521	11,883	30,870	56,522	8,490	1.76E-04	4	10	18	3
60	0.0292	0.5708	6.62	1.00	1.00	0.98	1.00	0.571	0.571	0.559	0.571	13,022	33,830	60,786	9,304	0.00E+00	0	0	0	0
80	0.0236	0.5297	3.12	1.00	1.00	0.84	1.00	0.530	0.530	0.445	0.530	12,084	31,393	48,369	8,633	3.14E-03	70	183	282	50
100	0.0231	0.4329	1.72	1.00	1.00	0.64	1.00	0.433	0.433	0.275	0.433	9,876	25,658	29,924	7,056	2.95E-05	1	1	2	0
150	0.0251	0.2656	0.625	1.00	1.00	0.31	1.00	0.266	0.266	0.082	0.266	6,060	15,742	8,871	4,329	0.00E+00	0	0	0	0
200	0.0268	0.1866	0.334	1.00	1.00	0.18	1.00	0.186	0.187	0.033	0.187	4,248	11,057	3,612	3,041	6.75E-03	53	139	45	38
300	0.0288	0.1157	0.167	0.96	0.99	0.09	1.00	0.111	0.115	0.011	0.116	2,525	6,795	1,175	1,883	2.07E-02	97	261	45	72
400	0.0296	0.0845	0.117	0.89	0.96	0.07	0.99	0.075	0.081	0.006	0.083	1,711	4,814	610	1,359	5.20E-02	165	465	59	131
500	0.0297	0.0673	0.0955	0.83	0.93	0.05	0.97	0.056	0.063	0.004	0.065	1,279	3,713	399	1,066	3.04E-03	7	21	2	6
600	0.0296	0.0563	0.0826	0.79	0.90	0.05	0.95	0.044	0.051	0.003	0.054	1,011	3,004	290	876	9.70E-02	182	541	52	158
662	0.0294	0.0514	0.07794	0.77	0.89	0.04	0.95	0.039	0.046	0.002	0.049	900	2,700	250	792					
800	0.0289	0.0433	0.0676	0.72	0.85	0.04	0.92	0.031	0.037	0.002	0.040	708	2,175	183	648	2.47E-02	32	100	8	30
1,000	0.0280	0.0357	0.0586	0.67	0.80	0.03	0.89	0.024	0.029	0.001	0.032	543	1,704	131	517	9.93E-02	100	314	24	95
1,500	0.0255	0.0261	0.0469	0.58	0.73	0.03	0.83	0.015	0.019	0.001	0.022	349	1,131	77	352	8.41E-02	54	177	12	55
2,000	0.0234	0.0214	0.0413	0.54	0.68	0.02	0.79	0.012	0.015	0.001	0.017	262	866	56	274	1.48E-01	72	237	15	75
3,000	0.0205	0.0163	0.0367	0.50	0.64	0.02	0.75	0.008	0.010	0.000	0.012	184	617	38	198					
																5.38E-01	839	2,450	566	714

cpm per uR/hr (@ energy of interest for RSI)	900	2,700	250	792
Fluence Rate to Exposure Rate (@ energy of interest for RSI)	0.0514	0.0514	0.0514	0.0514
Background Exposure Rate (uR/hr)	10	10	10	1
Micoshield Modeled Radius (cm)	28	28	28	28
Micoshield Modeled Area (cm^2)	2,463	2,463	2,463	2,463
Micoshield Modeled Thickness (cm)	15	15	15	15
Micoshield Modeled Volume (cc)	36,945	36,945	36,945	36,945
Micoshield Modeled Mass (g)	59,112	59,112	59,112	59,112
Background (counts per second)	162.5	383.3	75.0	13.2
Scan Speed (cm/sec)	50.0	50.0	50.0	101.9
Observation Interval (seconds)	1.12	1.12	1.12	0.55
Background (counts per observation interval)	182.0	429.3	84.0	7.3
Background Variability Rate (percent)	0.15	0.15	0.15	0.15
Minimum Detectable Count Rate (cpm)	1,850	2,842	1,257	753
Surveyor Efficiency	0.5	0.5	0.5	0.5
MDCRsurveyor (cpm)	2,617	4,019	1,778	1,065
Minimum Detectable Exposure Rate Rate (uR/hr)	2.907	1.488	7.110	1.344
MDERsurveyor (uR/hr)	3.119	1.640	3.142	1.491
Microshield Modeled Concentration (pCi/g)	1	1	1	1
Microshield Modeled Density (g/cc)	1.6	1.6	1.6	1.6
Microshield Modeled Concentration (uCi/cc)	1.6E-06	1.6E-06	1.6E-06	1.6E-06
Micoshield Modeled Activity (uCi)	5.9E-02	5.9E-02	5.9E-02	5.9E-02
Top Surface Area (square centimeters)	2,463	2,463	2,463	2,463
Micoshield Modeled Activity (dpm/100 cm^2)	5,328	5,328	5,328	5,328
Scan MDC (pCi/g)	5.8	3.0	5.8	2.77

Ra-226 Microshield Output

Index

MicroShield

EnergySolutions

Date	Preparer	Reviewer
8/28/2024	Scott Hay	

File Name	Run Date	Run Time	Duration
Ra-226 @ 4 inches	28-Aug-24	3:40:17 PM	0:00:00

Project Info

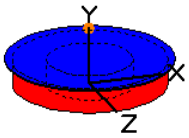
Case Title	Ra-226
Description	10 cm above 0.25 m2 soil
	8 - Cylinder Volume - End Shields

Source Dimensions

Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)

Dose Points

A	X	Y	Z
#1	0.0 cm (0 in)	28.7 cm (11.3 in)	0.0 cm (0 in)



Shield

Shield N	Dimension	Material	Density
Source	3.69e+04 cm³	FGR 12 Soil	1.6
Shield 1	.51 cm	Aluminum	2.7
Shield 2	.318 cm	Carbon	2.25
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons< 0.015: Included
Library: Grove

Nuclide	Ci	Bq	µCi/cm³	Bq/cm³
Bi-210	5.02E-08	1.86E+03	1.36E-06	5.03E-02
Bi-214	5.91E-08	2.19E+03	1.60E-06	5.92E-02
Pb-210	5.02E-08	1.86E+03	1.36E-06	5.03E-02
Pb-214	5.91E-08	2.19E+03	1.60E-06	5.92E-02
Po-210	5.02E-08	1.86E+03	1.36E-06	5.03E-02
Po-214	5.91E-08	2.19E+03	1.60E-06	5.92E-02
Po-218	5.91E-08	2.19E+03	1.60E-06	5.92E-02
Ra-226	5.91E-08	2.19E+03	1.60E-06	5.92E-02
Rn-222	5.91E-08	2.19E+03	1.60E-06	5.92E-02

Buildup: The material reference is Source

Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	7.77E+02	1.17E-11	1.30E-11	1.00E-12	1.11E-12
0.05	9.95E+01	2.48E-05	6.59E-05	6.59E-08	1.76E-07
0.08	5.04E+02	5.08E-04	1.98E-03	8.04E-07	3.14E-06
0.1	2.97E+00	4.68E-06	1.93E-05	7.16E-09	2.95E-08
0.2	2.36E+02	1.10E-03	3.83E-03	1.94E-06	6.75E-06
0.3	4.51E+02	3.76E-03	1.09E-02	7.13E-06	2.07E-05
0.4	8.37E+02	1.05E-02	2.67E-02	2.04E-05	5.20E-05
0.5	3.91E+01	6.68E-04	1.55E-03	1.31E-06	3.04E-06
0.6	1.06E+03	2.33E-02	4.97E-02	4.54E-05	9.70E-05
0.8	2.07E+02	6.80E-03	1.30E-02	1.29E-05	2.47E-05
1	6.85E+02	3.06E-02	5.39E-02	5.65E-05	9.93E-05
1.5	4.16E+02	3.23E-02	5.00E-02	5.44E-05	8.41E-05
2	5.85E+02	6.63E-02	9.54E-02	1.03E-04	1.48E-04
Totals	**5.89E+03**	**1.76E-01**	**3.07E-01**	**3.03E-04**	**5.38E-04**

Cs-137 Scan MDC Calculation

Index MDC Calculations Cs-137 @ 4"

$Energy_g$ (keV)	$(u_{en}/r)_{air}$ (cm^2/g)	Fluence Rate to Exposure Rate	$(u_{en}/r)_{NaI}$ (cm^2/g)	Probability of Interaction				Relative Detector Response				Counts per Minute per MicroRoentgen per Hour (cpm per uR/hr)			
				44-10	44-20	G5	RSI 700	44-10	44-20	G5	RSI 700	44-10	44-20	G5	RSI 700
15	1.29	0.0517	47.4	1.00	1.00	1.00	1.00	0.052	0.052	0.052	0.052	1,179	3,063	5,619	842
20	0.516	0.0969	22.3	1.00	1.00	1.00	1.00	0.097	0.097	0.097	0.097	2,211	5,743	10,535	1,579
30	0.147	0.2268	7.45	1.00	1.00	0.99	1.00	0.227	0.227	0.224	0.227	5,173	13,440	24,344	3,696
40	0.064	0.3906	19.3	1.00	1.00	1.00	1.00	0.391	0.391	0.391	0.391	8,912	23,152	42,470	6,367
50	0.0384	0.5208	10.7	1.00	1.00	1.00	1.00	0.521	0.521	0.520	0.521	11,883	30,870	56,522	8,490
60	0.0292	0.5708	6.62	1.00	1.00	0.98	1.00	0.571	0.571	0.559	0.571	13,022	33,830	60,786	9,304
80	0.0236	0.5297	3.12	1.00	1.00	0.84	1.00	0.530	0.530	0.445	0.530	12,084	31,393	48,369	8,633
100	0.0231	0.4329	1.72	1.00	1.00	0.64	1.00	0.433	0.433	0.275	0.433	9,876	25,658	29,924	7,056
150	0.0251	0.2656	0.625	1.00	1.00	0.31	1.00	0.266	0.266	0.082	0.266	6,060	15,742	8,871	4,329
200	0.0268	0.1866	0.334	1.00	1.00	0.18	1.00	0.186	0.187	0.033	0.187	4,248	11,057	3,612	3,041
300	0.0288	0.1157	0.167	0.96	0.99	0.09	1.00	0.111	0.115	0.011	0.116	2,525	6,795	1,175	1,883
400	0.0296	0.0845	0.117	0.89	0.96	0.07	0.99	0.075	0.081	0.006	0.083	1,711	4,814	610	1,359
500	0.0297	0.0673	0.0955	0.83	0.93	0.05	0.97	0.056	0.063	0.004	0.065	1,279	3,713	399	1,066
600	0.0296	0.0563	0.0826	0.79	0.90	0.05	0.95	0.044	0.051	0.003	0.054	1,011	3,004	290	876
662	0.0294	0.0514	0.07794	0.77	0.89	0.04	0.95	0.039	0.046	0.002	0.049	900	2,700	250	792
800	0.0289	0.0433	0.0676	0.72	0.85	0.04	0.92	0.031	0.037	0.002	0.040	708	2,175	183	648
1,000	0.0280	0.0357	0.0586	0.67	0.80	0.03	0.89	0.024	0.029	0.001	0.032	543	1,704	131	517
1,500	0.0255	0.0261	0.0469	0.58	0.73	0.03	0.83	0.015	0.019	0.001	0.022	349	1,131	77	352
2,000	0.0234	0.0214	0.0413	0.54	0.68	0.02	0.79	0.012	0.015	0.001	0.017	262	866	56	274
3,000	0.0205	0.0163	0.0367	0.50	0.64	0.02	0.75	0.008	0.010	0.000	0.012	184	617	38	198

MicroShield Exposure Rate (uR/hr, with buildup)	Weighted cpm per uR/hr			
	44-10	44-20	G5	RSI 700
3.07E-11	0	0	0	0
0.00E+00	0	0	0	0
2.18E-05	1	2	3	0
2.25E-05	1	3	6	1
0.00E+00	0	0	0	0
0.00E+00	0	0	0	0
0.00E+00	0	0	0	0
0.00E+00	0	0	0	0
0.00E+00	0	0	0	0
0.00E+00	0	0	0	0
0.00E+00	0	0	0	0
0.00E+00	0	0	0	0
0.00E+00	0	0	0	0
0.00E+00	0	0	0	0
1.71E-01	1,011	3,003	290	875
0.00E+00	0	0	0	0
0.00E+00	0	0	0	0
0.00E+00	0	0	0	0
0.00E+00	0	0	0	0
1.71E-01	1,012	3,008	298	877

cpm per uR/hr (@ energy of interest for RSI)	900	2,700	250	792
Fluence Rate to Exposure Rate (@ energy of interest for RSI)	0.0514	0.0514	0.0514	0.0514
Background Exposure Rate (uR/hr)	10	10	10	1
Micoshield Modeled Radius (cm)	28	28	28	28
Micoshield Modeled Area (cm^2)	2,463	2,463	2,463	2,463
Micoshield Modeled Thickness (cm)	15	15	15	15
Micoshield Modeled Volume (cc)	36,945	36,945	36,945	36,945
Micoshield Modeled Mass (g)	59,112	59,112	59,112	59,112
Background (counts per second)	162.5	383.3	75.0	13.2
Scan Speed (cm/sec)	50.0	50.0	50.0	101.9
Observation Interval (seconds)	1.12	1.12	1.12	0.55
Background (counts per observation interval)	182.0	429.3	84.0	7.3
Background Variability Rate (percent)	0.15	0.15	0.15	0.15
Minimum Detectable Count Rate (cpm)	1,850	2,842	1,257	753
Surveyor Efficiency	0.5	0.5	0.5	0.5
MDCRsurveyor (cpm)	2,617	4,019	1,778	1,065
Minimum Detectable Exposure Rate Rate (uR/hr)	2.907	1.488	7.110	1.344
MDERsurveyor (uR/hr)	2.584	1.336	5.956	1.214
Microshield Modeled Concentration (pCi/g)	1	1	1	1
Microshield Modeled Density (g/cc)	1.6	1.6	1.6	1.6
Microshield Modeled Concentration (uCi/cc)	1.6E-06	1.6E-06	1.6E-06	1.6E-06
Micoshield Modeled Activity (uCi)	5.9E-02	5.9E-02	5.9E-02	5.9E-02
Top Surface Area (square centimeters)	2,463	2,463	2,463	2,463
Micoshield Modeled Activity (dpm/100 cm^2)	5,328	5,328	5,328	5,328
Scan MDC (pCi/g)	15.1	7.8	34.8	7.09

Cs-137 Microshield Output

Index

MicroShield

EnergySolutions

Date	Preparer	Reviewer
8/28/2024	Scott Hay	

File Name	Run Date	Run Time	Duration
Cs-137 @ 4 inches	28-Aug-24	3:40:17 PM	0:00:00

Project Info

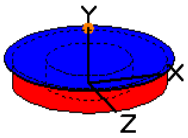
Case Title	Cs-137
Description	10 cm above 0.25 m2 soil
	8 - Cylinder Volume - End Shields

Source Dimensions

Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)

Dose Points

A	X	Y	Z
#1	0.0 cm (0 in)	28.7 cm (11.3 in)	0.0 cm (0 in)



Shield

Shield N	Dimension	Material	Density
Source	3.69e+04 cm³	FGR 12 Soil	1.6
Shield 1	.51 cm	Aluminum	2.7
Shield 2	.318 cm	Carbon	2.25
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons< 0.015: Included
Library: Grove

Nuclide	Ci	Bq	µCi/cm³	Bq/cm³
Ba-137m	5.59E-08	2.07E+03	1.51E-06	5.60E-02
Cs-137	5.91E-08	2.19E+03	1.60E-06	5.92E-02

Buildup: The material reference is Source

Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	2.15E+01	3.23E-13	3.58E-13	2.77E-14	3.07E-14
0.03	1.22E+02	1.44E-06	2.20E-06	1.43E-08	2.18E-08
0.04	2.88E+01	2.52E-06	5.09E-06	1.11E-08	2.25E-08
0.6	1.86E+03	4.11E-02	8.77E-02	8.01E-05	1.71E-04
Totals	**2.03E+03**	**4.11E-02**	**8.77E-02**	**8.02E-05**	**1.71E-04**

Nb-94 Scan MDC Calculation

Index MDC Calculations Nb-94 @ 4"

$Energy_g$ (keV)	$(u_{en}/r)_{air}$ (cm^2/g)	Fluence Rate to Exposure Rate	$(u_{en}/r)_{NaI}$ (cm^2/g)	Probability of Interaction				Relative Detector Response				Counts per Minute per MicroRoentgen per Hour (cpm per uR/hr)				MicroShield Exposure Rate (uR/hr, with buildup)	Weighted cpm per uR/hr			
				44-10	44-20	G5	RSI 700	44-10	44-20	G5	RSI 700	44-10	44-20	G5	RSI 700		44-10	44-20	G5	RSI 700
15	1.29	0.0517	47.4	1.00	1.00	1.00	1.00	0.052	0.052	0.052	0.052	1,179	3,063	5,619	842	3.43E-12	0	0	0	0
20	0.516	0.0969	22.3	1.00	1.00	1.00	1.00	0.097	0.097	0.097	0.097	2,211	5,743	10,535	1,579	9.51E-10	0	0	0	0
30	0.147	0.2268	7.45	1.00	1.00	0.99	1.00	0.227	0.227	0.224	0.227	5,173	13,440	24,344	3,696	0.00E+00	0	0	0	0
40	0.064	0.3906	19.3	1.00	1.00	1.00	1.00	0.391	0.391	0.391	0.391	8,912	23,152	42,470	6,367	0.00E+00	0	0	0	0
50	0.0384	0.5208	10.7	1.00	1.00	1.00	1.00	0.521	0.521	0.520	0.521	11,883	30,870	56,522	8,490	0.00E+00	0	0	0	0
60	0.0292	0.5708	6.62	1.00	1.00	0.98	1.00	0.571	0.571	0.559	0.571	13,022	33,830	60,786	9,304	0.00E+00	0	0	0	0
80	0.0236	0.5297	3.12	1.00	1.00	0.84	1.00	0.530	0.530	0.445	0.530	12,084	31,393	48,369	8,633	0.00E+00	0	0	0	0
100	0.0231	0.4329	1.72	1.00	1.00	0.64	1.00	0.433	0.433	0.275	0.433	9,876	25,658	29,924	7,056	0.00E+00	0	0	0	0
150	0.0251	0.2656	0.625	1.00	1.00	0.31	1.00	0.266	0.266	0.082	0.266	6,060	15,742	8,871	4,329	0.00E+00	0	0	0	0
200	0.0268	0.1866	0.334	1.00	1.00	0.18	1.00	0.186	0.187	0.033	0.187	4,248	11,057	3,612	3,041	0.00E+00	0	0	0	0
300	0.0288	0.1157	0.167	0.96	0.99	0.09	1.00	0.111	0.115	0.011	0.116	2,525	6,795	1,175	1,883	0.00E+00	0	0	0	0
400	0.0296	0.0845	0.117	0.89	0.96	0.07	0.99	0.075	0.081	0.006	0.083	1,711	4,814	610	1,359	0.00E+00	0	0	0	0
500	0.0297	0.0673	0.0955	0.83	0.93	0.05	0.97	0.056	0.063	0.004	0.065	1,279	3,713	399	1,066	0.00E+00	0	0	0	0
600	0.0296	0.0563	0.0826	0.79	0.90	0.05	0.95	0.044	0.051	0.003	0.054	1,011	3,004	290	876	0.00E+00	0	0	0	0
662	0.0294	0.0514	0.07794	0.77	0.89	0.04	0.95	0.039	0.046	0.002	0.049	900	2,700	250	792					
800	0.0289	0.0433	0.0676	0.72	0.85	0.04	0.92	0.031	0.037	0.002	0.040	708	2,175	183	648	5.23E-01	708	2,175	183	648
1,000	0.0280	0.0357	0.0586	0.67	0.80	0.03	0.89	0.024	0.029	0.001	0.032	543	1,704	131	517	0.00E+00	0	0	0	0
1,500	0.0255	0.0261	0.0469	0.58	0.73	0.03	0.83	0.015	0.019	0.001	0.022	349	1,131	77	352	0.00E+00	0	0	0	0
2,000	0.0234	0.0214	0.0413	0.54	0.68	0.02	0.79	0.012	0.015	0.001	0.017	262	866	56	274	0.00E+00	0	0	0	0
3,000	0.0205	0.0163	0.0367	0.50	0.64	0.02	0.75	0.008	0.010	0.000	0.012	184	617	38	198					
																5.23E-01	708	2,175	183	648

cpm per uR/hr (@ energy of interest for RSI)	900	2,700	250	792
Fluence Rate to Exposure Rate (@ energy of interest for RSI)	0.0514	0.0514	0.0514	0.0514
Background Exposure Rate (uR/hr)	10	10	10	1
Micoshield Modeled Radius (cm)	28	28	28	28
Micoshield Modeled Area (cm^2)	2,463	2,463	2,463	2,463
Micoshield Modeled Thickness (cm)	15	15	15	15
Micoshield Modeled Volume (cc)	36,945	36,945	36,945	36,945
Micoshield Modeled Mass (g)	59,112	59,112	59,112	59,112
Background (counts per second)	162.5	383.3	75.0	13.2
Scan Speed (cm/sec)	50.0	50.0	50.0	101.9
Observation Interval (seconds)	1.12	1.12	1.12	0.55
Background (counts per observation interval)	182.0	429.3	84.0	7.3
Background Variability Rate (percent)	0.15	0.15	0.15	0.15
Minimum Detectable Count Rate (cpm)	1,850	2,842	1,257	753
Surveyor Efficiency	0.5	0.5	0.5	0.5
MDCRsurveyor (cpm)	2,617	4,019	1,778	1,065
Minimum Detectable Exposure Rate Rate (uR/hr)	2.907	1.488	7.110	1.344
MDERsurveyor (uR/hr)	3.694	1.848	9.713	1.642
Microshield Modeled Concentration (pCi/g)	1	1	1	1
Microshield Modeled Density (g/cc)	1.6	1.6	1.6	1.6
Microshield Modeled Concentration (uCi/cc)	1.6E-06	1.6E-06	1.6E-06	1.6E-06
Micoshield Modeled Activity (uCi)	5.9E-02	5.9E-02	5.9E-02	5.9E-02
Top Surface Area (square centimeters)	2,463	2,463	2,463	2,463
Micoshield Modeled Activity (dpm/100 cm^2)	5,328	5,328	5,328	5,328
Scan MDC (pCi/g)	7.1	3.5	18.6	3.14

Nb-94 Microshield Output

Index

MicroShield

EnergySolutions

Date	Preparer	Reviewer
8/28/2024	Scott Hay	

File Name	Run Date	Run Time	Duration
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Project Info

Case Title	Nb-94
Description	10 cm above 0.25 m2 soil
	8 - Cylinder Volume - End Shields

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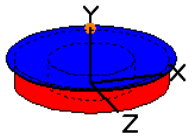

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Source Input: Grouping Method - Standard Indices
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Nb-94	5.91E-08	2.19E+03	1.60E-06	5.92E-02

Buildup: The material reference is Source

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Circumferential	10
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Results

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0.015	2.40E+00	3.60E-14	4.00E-14	3.09E-15	3.43E-15
0.02	4.35E-01	2.26E-11	2.75E-11	7.84E-13	9.51E-13
0.8	4.37E+03	1.44E-01	2.75E-01	2.74E-04	5.23E-04
Total	**4.38E+03**	**1.44E-01**	**2.75E-01**	**2.74E-04**	**5.23E-04**