DRAFT

BUTTERFIELD TRAILS MUNITIONS RESPONSE ACTION

Integrated Corrective Action Plan

June 2021

Prepared for:

ACJ Partnership and Alpert Corporation

TETRA TECH

3801 Automation Way Suite 100
Fort Collins, CO 80525

Review Signature:______________________________ Date: 06/04/2021

Eugene Mikell, Tetra Tech, Inc
Director of Quality

Review Signature:______________________________ Date: 06/04/2021

Anthony Joiner, Tetra Tech, Inc
Project Manager

Property Owner Certification

I certify I am authorized, or authorized by, the property owner of (legal description below) to submit the attached Corrective Action Plan Permit application pursuant to Section 100.26 of the Colorado Hazardous Waste Regulations, specifying the process by which the site in question will be fully investigated.

NAME: ACJ Partnership (ACJ)

TITLE: Property Owner

EMAIL: mcooper@coopermgmt.com; leealpert@msn.com; sjcooper@iriscompanies.com

Signature: Phone #: Date:

Signature: Phone #: Date:

Signature: Phone #: Date:

NAME: Alpert Corporation (Alpert)

TITLE: Property Owner

EMAIL: leealpert@msn.com

Signature: Phone #: Date:

Facility Operator Certification

I certify I am authorized by the operator who conducts business at (legal description below) to submit the attached Corrective Action Plan Permit application pursuant to Section 100.26 of the Colorado Hazardous Waste Regulations, specifying the process by which the site in question will be fully investigated.

NAME: Marc Cooper

TITLE: Facility Operator

EMAIL: mcooper@coopermgmt.com

Signature: Phone #: Date:

Legal Description

All of Section 34, Township 5 South, Range 65 West of the 6th Principal Meridian, Except the North 264.63 acres of said Section 34 and except the South 30 feet of said Section 34 for roadway purposes, County of Arapahoe, State of Colorado, more particularly described as follows:

Commencing at the Southwest corner of said Section 34; thence North 00 degrees 29 minutes 34 seconds East along the West line of the Southwest one-quarter of said Section 34 a distance of 30.00 feet to the True Point of Beginning; thence continuing North 00 degrees 29 minutes 34 seconds East along said West line a distance of 2,610.70 feet to the West one-quarter corner of said Section 34; thence North 00 degrees 29 minutes 53 seconds East along the West line of the Northwest one-quarter of said Section 34 a distance of 460.68 feet to the Southwest corner of said North 264.63 acres, whence the Northwest corner of said Section 34 bears 00 degrees 29 minutes 53 seconds East a distance of 2,179.60 feet; thence South 89 degrees 50 minutes 47 seconds East along the South line of said 264.63 acres, parallel with the North line of said Section 34 a distance of 5,287.39 feet to the Southeast corner of said North 264.63 acres, said corner being a point on the East line of the Northeast one-quarter of said Section 34, whence the Northeast corner of said Section 34 bears North 00 degrees 34 minutes 21 seconds East a distance of 2,179.62 feet; thence South 00 degrees 34 minutes 21 seconds West along said East line a distance of 451.06 feet to the East one-quarter corner of said Section 34; thence South 00 degrees 33 minutes 51 seconds West a distance of 2,599.16 feet to the point on the North Right-of-Way of existing Arapahoe County Road No. 50; thence South 89 degrees 56 minutes 01 seconds West along said Right-of-Way, 30.00 feet North of and parallel with the South line of said Southeast one-quarter a distance of 2,640.49 feet; thence South 89 degrees 54 minutes 51 seconds West along said Right-of-Way, 30.00 feet North of and parallel with the South line of said Southwest one-quarter a distance of 2,643.23 feet to the True Point of Beginning,

County of Arapahoe, State of Colorado.

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ACRONYMS

µs	microseconds
AGGR	Air to Ground Gunnery Range
AHA	Activity Hazard Analysis
AOI	Area of Interest
APP/SSHP	Accident Prevention Plan/Site, Safety and Health Plan
ARAR	Applicable or Relative and Appropriate Requirements
BFT	Butterfield Trails
CA	corrective action
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DDESB	Department of Defense Explosives Safety Board
DESR	Defense Explosives Safety Regulation
DFW	Definable Feature of Work
DGM	Digital Geophysical Mapping
DGPS	Differential Global Positioning System
DMM	discarded military munitions
DoD	Department of Defense
DUA	Data Usability Assessment
ECA	equipment check area
EZ	Exclusion Zone
FCR	Field Change Request
FLBGR	Former Lowry Bombing and Gunnery Range
FS	Feasibility Study
FUDS	Formerly Used Defense Site
GIS	Geographic Information System
GPS	Global Positioning System
GSV	Geophysical System Verification Process
HASP	Health and Safety Plan
HE	high explosives
HMTA	Hazardous Materials Transportation Act
ICAP	Integrated Corrective Action Plan
ID	identification
ISO	Industry Standard Object
IVS	Instrument Verification Strip
MC	munitions constituents
MD	munitions debris
MDAS	material documented as safe
MEC	munitions and explosives of concern
mm	millimeter
MPC	measurement performance criteria
MPPEH	material potentially presenting an explosive hazard
MQO	measurement quality objectives
MR	munitions response
MRS	Munitions Response Site
mV	millivolt

NCR	non-conformance report
NFA	No Further Action
NMRD	non-munitions related debris
NRL	Naval Research Laboratory
PA	preliminary assessment
PLS	Professional Land Surveyor
PM	Project Manager
QC	quality control
QCS	Quality Control Specialist
RA	Remedial Action
RAO	remedial action objective
RCA	root cause analysis
RI	Remedial Investigation
RRD	range-related debris
RTK	real-time kinematic
SMUA	Support and Multi-Use Area
SOP	Standard Operating Procedure
SRA	Saturated Response Areas
SSFR	Site-Specific Final Report
SUXOS	Senior UXO Supervisor
TBC	to be considered
TOI	Target of Interest
TP	Target Practice
USACE	U.S. Army Corps of Engineers
USDOT	U.S. Department of Transportation
USEPA	U.S. Environmental Protection Agency
UXO	unexploded ordnance
UXOQCS	UXO Quality Control Specialist
UXOSO	UXO Safety Officer
VTA	vehicle-towed array
ZIP	Zero Incident Performance

1.0 INTRODUCTION – GENERAL SITE INFORMATION

1.1 Purpose

The purpose of this Integrated Corrective Action Plan (ICAP) is to facilitate a Munitions Response (MR) action at the Butterfields Trails (BFT) site. The MR is necessary to address the potential for explosive-related hazards at the BFT site and to allow for future expected land use at the site. Any changes to the final approved ICAP will be made through the Field Change Request (FCR) process/form.

The BFT site is roughly 373-acres of developable land within the boundaries of the Former Lowry Bombing and Gunnery Range (FLBGR) near the Aurora Reservoir in Aurora, CO. To the west of the BFT is a single-family residential development, and the BFT will also be developed in the near term for residential use. The FLBGR has undergone numerous investigations and clearance activities to address munitions and explosives of concern (MEC) leftover from previous Department of Defense (DoD) use of the area.

1.2 Remedial Action Objectives

The Remedial Action Objective (RAO) for BFT reduces the risk of explosive hazards to human health and minimizes the potential for human interaction with MEC to a state-accepted threshold sufficient to support a no further action letter from the State of Colorado and to allow for the intended future single-family use of the BFT site. Previous investigations and clearance actions performed at the FLBGR have found munitions debris (MD)/small arms ammunition (not considered explosive hazards), 20mm, 37mm, 57mm, and 75mm projectiles. Over 99% of all MD and MEC were found at depths less than two feet below ground surface. Additional data indicates small munitions (20mm, 37mm, 2.25-in. and 2.75-in. rockets) are expected to be located on the surface and in the shallow subsurface, and larger munitions (75mm or larger) are expected to be located entirely in the subsurface.

1.3 Site Information

1.3.1 Property Points of Contact

Marc Cooper
Cooper Management, Inc.
7800 East Union Ave., Ste. 420
Denver, CO 80237

1.3.2 Location of Property

The BFT site is located approximately 15 miles southeast of the city of Aurora, CO, and 12 miles east of the city of Centennial, CO near the Aurora Reservoir on the FLBGR. It is located northeast of the intersection of County Line Rd and Monaghan Rd. Figure 1-1 shows the location of the BFT site within the FLBGR footprint.

1.3.3 EPA Identification Number

Not applicable to this project.

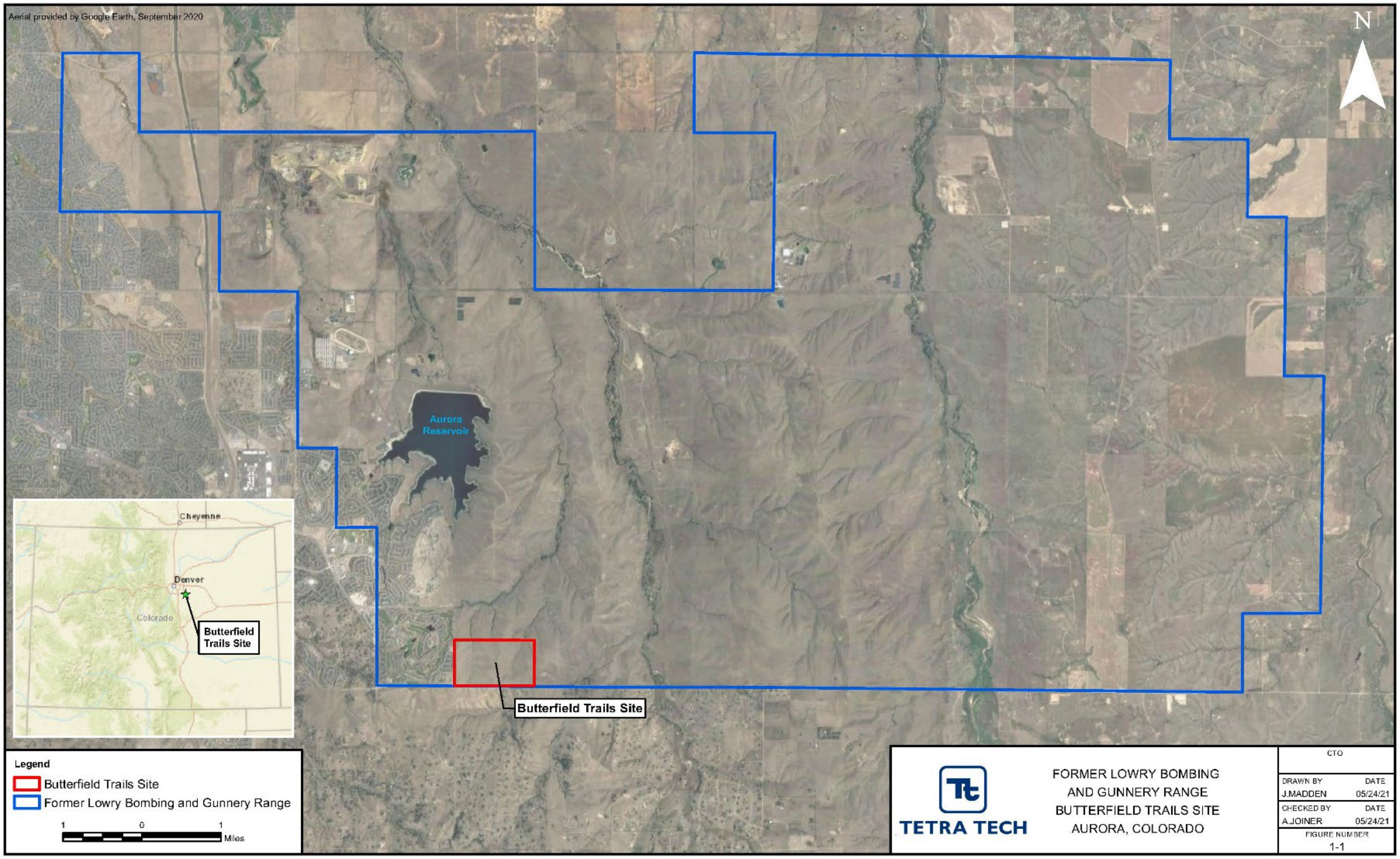

Figure 1-1. Butterfield Trails Site Map for the FLBGR

1.3.4 Current Site Uses of Property

The current site use is zoned residential.

1.3.5 Surrounding Property Uses

Surrounding features include the plains of Colorado with no outstanding surface features and is zoned residential.

1.3.6 Summary of the Type and Source of Contamination at the Site

This work is associated with legacy explosive hazards resulting from the site's prior use as part of the FLBGR.

Figure 1-2 shows the Site for the firing fans and safety buffer zones. BFT falls outside the Air to Ground Gunnery Range (AGGR) Support and Multi-Use Area (SMUA) but within the safety buffer of the Nose and Tail/OQ Gunnery Range (for .50 cal and 20mm projectiles). The OQ is not an acronym, but an Army classification for a "target flying model." The northwest half of the site also falls within the safety buffer of the 20mm Range. Based on previous investigations at the FLBGR, small munitions such as these would be expected to be on the surface with any larger munitions in the shallow subsurface (0 to 2.5ft). MD recovered from SMUA includes remnants of small arms ammunition (.30 cal, .50 cal), projectiles (20mm, 37mm, 57mm, 75mm), rockets (2.25-in, 2.75-in), bombs (3-lb, 100-lb.) and mortars (60mm).

1.4 Site History

The FLBGR range, established in 1938, consists of approximately 100 square miles and was used during World War II as a site for military armament and bombing training, which included practice and high explosive (HE) bombs. Military training continued on portions of the range through 1963. The Colorado Department of Public Health and Environment (CDPHE) and the State Land Board have worked in conjunction with the U.S. Army Corps of Engineers to clean up the former munitions site. The BFT Site is located within an area that was identified by Chicago Bridge & Iron Federal Services during a previous Remedial Investigation (RI), as an area that may warrant further evaluation based on the potential for encountering MEC hazards.

1.4.1 Operational History of the Property

The Nose and Tail/OQ Range fired .50 cal and 20mm projectiles from fixed points at target flying models (OQs) from 1949 to 1954 to simulate ground-air and air-air gunnery. The 20mm Range fired 20mm and other projectile munitions.

Before 1934, the land near Aurora was primarily used for grazing cattle. In 1937, the United States Army established Buckley Field on 65,547 acres of land near Aurora. In 1946, 59,814 acres of this facility were assigned to Lowry Air Force Base as the Lowry Bombing and Gunnery Range. Following the termination of the Air-to-Ground Bombing and Gunnery Mission in 1956, much of the range was leased as grazing land. In 1959, the Lowry Bombing and Gunnery Range was re-designated as the Lowry Air Force Missile Site. Between 1961 and 1965, 12 Titan missiles were maintained in four installations at the site. With declining use for much of the range, approximately 63,600 acres of land were sold or transferred to various State and Federal agencies, as well as to private owners.

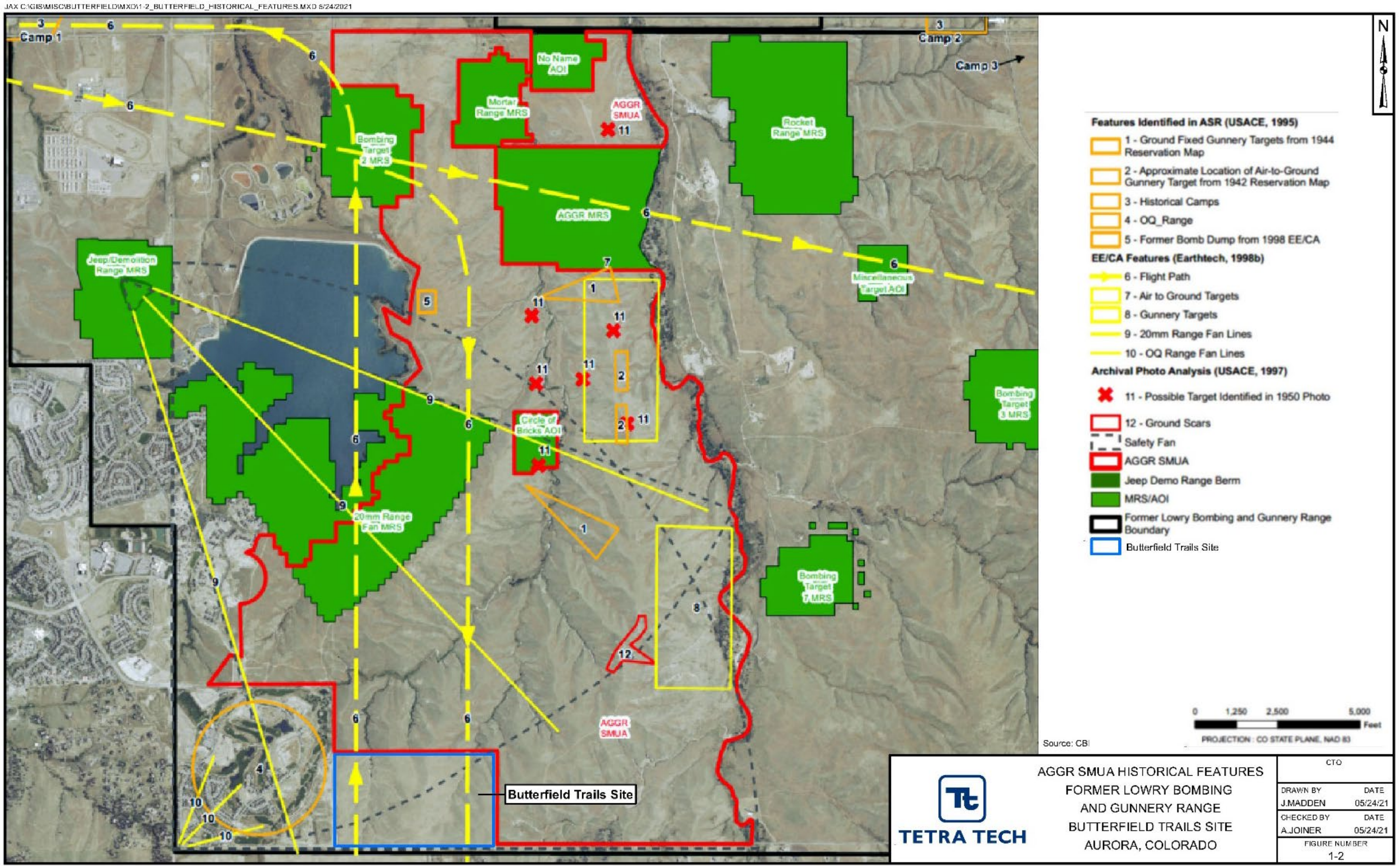

Figure 1-2. Butterfield Trails Site for Range Fans and Safety Buffers

Over the years, numerous commercial and recreational developments have occurred on FLBGR, including a landfill, a horse racing track, and Aurora Reservoir, as well as significant residential, recreational, and commercial development.

The BFT Site currently consists of vacant rangeland. During the 1950s and until the 1960s, the site was located within a portion of the Lowry Air Force Base Bombing and Gunnery range, known as Buckley Field. Buckley Field is now considered a Formerly Used Defense Site (FUDS) within the Omaha District of the U.S. Army Corps of Engineers (USACE). The Army Air Corps used Buckley Field as a technical training school and bombing/gunnery field in support of Lowry Air Force Base. A RI for unexploded ordinances (UXO) dated June 2016 was conducted for the Army Corps of Engineers on approximately 92 square miles of land adjacent to the north and east of the BFT site, comprising the AGGR. The Area of Interest (AOI) that appears to be the closest and most relevant to BFT is the southeast extent of the 20mm Range Fan, an area approximately 0.9 mile to the north, in the vicinity of Aurora Reservoir. This area received 20mm and 50-caliber rounds that originated from the Jeep/Demolition Range during training maneuvers, an AOI approximately three and a half miles to the northwest. The Site has otherwise remained vacant. Development of residential subdivisions in the surrounding are began in the early 2000s.

1.4.2 All business and/or Activities on the Property

Currently, the site is an undeveloped grazing area.

1.4.3 Wastes Generated, Hazardous Substances on the Property and Their Locations On-site

Although it is anticipated material potentially presenting an explosive hazard (MPPEH) could be present, there have been no known incidents recorded for the BFT Site involving emergency responses for military munitions. Additionally, the previous limited site characterization performed by Tetra Tech, Inc. (Tetra Tech) in 2005 for the BFT site did not result in any confirmed MEC during surface clearance activities. 541 subsurface anomalies were identified, but none were investigated.

There have been no reported incidents regarding the spill or release to the environment of petroleum products, solid wastes, or other contaminants at the Site. No record of the production of hazardous wastes can be found for the Site.

1.4.4 History of Releases of Hazardous Substances on the Property and Their Locations On-site

See Section 1.3.3.

1.4.5 Notifications Made Reporting Spills or Accidental Releases

No releases have been identified in the records.

1.4.6 List of all Permits Obtained Related to Activities at the Property

None.

1.4.7 Descriptions of Zoning Restrictions for the Subject Facility

None.

1.4.8 Summary and Submission of Any Prior Environmental Assessment Conducted on the Property

An RI was previously conducted for the nearby AGGR SMUA; a preliminary assessment (PA) was done for all of the FLBGR.

In 1998 a visual surface reconnaissance was conducted by Earth Tech and recovered six 20mm target practice (TP) rounds over 31 acres investigated on the FLBGR. No MEC was recovered.

In 2003 the neighboring property (Blackstone Country Club), containing all firing fans and firing points, was remediated for development. This effort recovered fifteen 20mm HE rounds and approximately 2,000 unfired .50 cal and 20mm rounds in burial pits. Additional MD included .50 cal, 20mm, 2.75-inch rockets, 3-lb and 100-lb bombs, and assorted smoke tanks, signal flares, and small arms ammunition.

In 2020 a munitions response action was performed in the Southshore area, this area is included in the FLBGR and is located to the northwest of BFT. During this cleanup, .50 cal small arms ammunition and 20-mm TP rounds were recovered, no MEC items were recovered during the cleanup.

1.5 Site Characterization

The current landscape could be characterized as rangeland covered in native grassland. Existing housing and recreational developments are located to the North and West. The Blackstone Country Club borders the property to the west.

1.6 Munitions Response Action Alternatives

To meet the RAOs for BFT, Tetra Tech considered several response action alternatives. Using the information and data collected from previous investigations at the FLBGR, the four alternatives considered were:

- Analog geophysics (mag and dig) prior to construction activities – action not selected because although the analog geophysics alternative will allow for hand-held detected subsurface anomalies to be identified/investigated, this option does not provide a digital record of the subsurface condition
- Soil removal and mechanical screening prior to construction activities – action not selected because soil removal/mechanical screening prior to construction activities will reduce the hazard for encountering MPPEH/UXO but it is not a reasonable cost/ground disturbance effort given the efficacy of the selected alternative
- Construction Support (anomaly avoidance) during construction activities – action not selected because construction support does not allow for a digital record of the subsurface with respect to MPPEH/UXO and it does not provide 100% coverage of the site
- Digital Geophysical Mapping (DGM) and intrusive investigation of selected targets prior to construction activities – action selected due to the nature of the site, the likelihood of risk at the site, and potential for encountering MPPEH/UXO during construction activities for future residential housing development. Given these factors, it was determined that this alternative would be the most effective alternative. Of the four alternatives listed, the DGM and intrusive investigation of selected targets alternative allows for 100% coverage of the BFT site,

provides defensibility, provides a digital record of the subsurface condition with respect to MPPEH/UXO and will result in resolution of all identified target of interest (TOIs).

Measurement Performance Criteria (MPC) to meet this alternative for this project is in Table 1-1.

1.7 Evaluating Applicable Standards and Determination of Potential Risk

1.7.1 Standards and Cleanup Levels

This does not apply to this project, as there are no cleanup levels associated with munitions.

1.7.2 Risk-based Assessment

This does not apply to this project for groundwater and surface water usage, vapor migration, or groundwater monitoring.

Potential explosive risks exist to construction workers, visitors, occupants, and future residents, which will be mitigated through this MR action.

1.8 Applicable or Relevant and Appropriate Requirements

U.S. Environmental Protection Agency (USEPA) identifies three basic types of Applicable or Relative and Appropriate Requirements (ARARs). They include the following: chemical-specific, location-specific, and action-specific.

- Chemical-specific ARARs are generally health- or risk-based values which, when applied to site-specific conditions, result in numerical values. These values establish the acceptable concentration of a chemical that may be found in, or discharged to, the ambient environment.
- Location-specific ARARs are restrictions placed upon removal activities of hazardous substances solely because they are occurring in a particular place.
- Action-specific ARARs are generally technology or activity-based requirements on actions taken with respect to hazardous substances. These requirements are triggered by the particular activities selected to accomplish a remedy. Thus, action-specific requirements do not in themselves determine the removal alternative; rather, they indicate how a selected alternative must be achieved.

To Be Considered (TBC) guidance are guidelines or advisories issued by the federal or state government, but which are neither legally binding nor promulgated (USEPA, 1988). However, these guidelines may be used when necessary to ensure protection of public health and the environment, and when they have not been superseded (USEPA, 1988). If no ARARs address a particular circumstance at a CERCLA site, then TBCs can be used to establish remedial guidelines or targets.

A list of potential ARARs and an initial assessment to the actual applicability of these ARARs to the MR response area is provided as Table 1-2. The evaluation of the ARARs is an iterative process to be performed throughout the life of the project.

Table 1-1. Measurement Performance Criteria

Measurement	Data Quality Indicator	Specification	Activity Used to Assess Performance
Site Preparation			
1. Accessibility	Completeness	Right of Entry will be acquired and site access will be arranged with ACJ/Alpert for equipment storage and daily operations. Site access will be restricted to essential personnel while conducting intrusive operations. If required, restricted access signs will be placed on main access points. Intrusive and inaccessible areas will be identified and entered into the project geographic information system (GIS).	Tetra Tech on-site management personnel will visually inspect the survey areas during site preparation activities.
Sampling Design			
2. Detection threshold	Sensitivity	Detection threshold for DGMdata is appropriate for detecting the smallest target of interest relative to observed site-specific noise levels.	1) Review sampling design 2) Initial DGM system validation at Instrument Verification Strip (IVS) 3) Establish an initial target picking threshold based on IVS noise levels. 4) Ongoing evaluation of the appropriateness of target selection threshold during production survey.
Data Acquisition			
3. System Functionality	Accuracy	Detection systems (sensor and positioning system) are demonstrated to function properly.	1) Initial system validation at the IVS 2) Initial sensor function tests 3) Ongoing data validation throughout production survey.
4. Positioning requirement	Accuracy	Positioning system has demonstrated capability of recording measurements within acceptable tolerances.	Geodetic function check during operations involving use of survey-grade positioning system (e.g., RTK GPS).
5. Survey coverage	Completeness	100% of survey area is mapped at the calculated lane spacing and along-line data density.	Data verification for final DGM coverage and along-line sample spacing.
6. Subsurface quality control (QC) seeding	Accuracy/ Completeness	All blind QC seeds are successfully detected and selected as targets for reacquisition and intrusive investigation.	Tetra Tech QC personnel verify QC seed detection and recovery.

Measurement	Data Quality Indicator	Specification	Activity Used to Assess Performance
Anomaly Resolution			
7. Anomaly resolution (Intrusive Investigation)	Accuracy/ Completeness	100% excavation of DGM target locations included on the dig list. Excavation must continue vertically until anomaly source is identified or other obstruction encountered.	UXOQCS, QC Geophysicist or designee verifies the anomaly source was removed or a reasonable explanation for documented residual response above the target selection threshold.
8. Anomaly resolution Saturate Response Areas (SRA)	Accuracy/Completeness	SRA verified to be free of MEC.	UXOQCS shall complete >10% quality control inspection on all SRAs, verifying all anomalies are resolved or a reasonable explanation given for all structures, fences, or construction debris that is left in place.
9. Anomaly resolution (Surface obstruction/fence line)	Accuracy/Completeness	Obstruction/fence line area verified to be free of MEC. .	UXOQCS will place a minimum of 3 blind seeds per acre.
10. MEC/MPPEH Accountability and Material Documented as Safe (MDAS) Management	Accuracy/ Completeness	100% accountability of MEC/MPPEH and MDAS from cradle to grave.	UXOQCS verifies.

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Table 1-2. Identification of Applicable or Relevant and Appropriate Requirements

Type	Standard, Requirement Criteria, or Limitation	Citation	Description of Requirements	Comments	Applicable/Relevant and Appropriate Status
Chemical	Resource Conservation and Recovery Act (RCRA)	42 USC Sect. 6906, 6922-6925, 6937, and 6938	Characterization of solid wastes and management of hazardous wastes.	Waste materials will be characterized upon generation and managed in accordance with requirements. No hazardous waste generation is planned during field work.	Applicable
Chemical	Colorado Hazardous Waste Act	25 C.R.S. 15, Sect. 301-327 6 Code of Colorado Regulations (C.C.R.) 1007, Reg. 3	Characterization of solid wastes and management of hazardous wastes. The State of Colorado is authorized for the management of hazardous wastes in lieu of the USEPA.	Waste materials will be characterized upon generation and managed in accordance with requirements. No hazardous waste generation is planned during field work.	Applicable
Chemical	Generation and Management of Hazardous Wastes	40 CFR Part 261 6 C.C.R. Sect. 1007, Reg. 3, Part 261.	Generator requirements, including waste characterization, pre-transport, storage, and record-keeping requirements.	All recovered UXO or DMM will be accounted for and disposed of on-site.	Applicable if hazardous waste is generated during actions.
Location	Colorado Wildlife Commission Regulations	2 CCR 406, pursuant to CRS §§ 33-2-101 et. seq.	Development and coordination of programs to protect and conserve wildlife and fish	Wildlife may be present within the Remedial Action (RA). However, it is anticipated that most likely the wildlife will move from the general area of human activity during the RA until the activity ceases. There are no water features to provide habitat for fish at the RA Area.	Applicable
Location	Fish and Wildlife Coordination Act	16 USC Sect. 661, et seq.	Development and coordination of programs to protect and conserve wildlife (game and fur-bearing animals) and fish.	Transient wildlife may be present within the RA. However, it is anticipated that most likely the wildlife will move from the general area of human activity during the RA until the activity ceases. Work within the RA Area is limited to removal of UXO, DMM, MD, and metallic debris.	Applicable
Action	Occupational Safety and Health Standards, General Industry	29 USC Sect. 653, 655, 657 29 CFR Part 1910	National standards for occupational health and safety.	Staff awareness program completed, and work conducted in accordance with an approved site plan	Applicable
Action	Occupational Safety and Health Standards, Construction Safety	40 USC Sect. 3701 et seq. and 29 USC Sect. 653, 655,657 29 CFR Part 1926	National standards for occupational health and safety.	Staff awareness program completed, and work conducted in accordance with an approved site plan	Applicable
Action	U.S. Department of Transportation (USDOT) Hazardous Materials Regulations	49 USC Sect. 5101 – 5127 49 CFR Subchapter C, Parts 171-180	Transportation of wastes and materials which are hazardous materials (e.g., Resource Conservation and Recovery Act [RCRA] hazardous wastes, Toxic Substances Control Act wastes, etc.) must be packaged, marked, placarded, and manifested in accordance with the Hazardous Materials Transportation Act (HMTA) regulations.	Materials will be evaluated to determine if hazardous material according to USDOT requirements; packaged and shipped in accordance with requirements.	Characterization is applicable; if hazardous materials, then other requirements also applicable.
Action	Destruction of MEC	Title 10 Colorado Blasters Regulations	Use and storage of explosives	Destruction of MEC will be conducted by trained personnel, following approved procedures.	Applicable

1.9 Community Involvement

The objective of the community involvement program is to include the public in activities and decisions related to the BFT site. Community involvement ensures the members of the public affected by a site undergoing investigation and cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) have input into the process if desired. Specific community involvement activities that will be performed following the CERCLA National Contingency Plan are shown in Table 1-3. Additional community relations activities tailored to the distinctive needs of the site and specific community interests may also be implemented as the process moves forward.

Table 1-3. Community Involvement Activities Projected in Support of the BFT MR Action

Site Status	Action	Projected Completion Date
Community Involvement	Provide supplemental data to established Administrative Record	Spring 2021
	ICAP summary provided for public knowledge	Spring 2021
	Discussions with City of Aurora, and Arapahoe and Douglas Counties about upcoming MR action	Spring 2021
	Post summary of ICAP on City of Aurora development website. Provide summary to Arapahoe and Douglas Counties.	Spring 2021
	Provide ICAP Summary to interested community groups and local paper for 30-day notice and comment.	Spring 2021
	Set up and maintain the community mailing list	Ongoing
	Public meetings held if interest is present	TBD
	Public interviews, if identified as a need	TBD

2.0 FIELD ACTIVITIES

Field activities are divided into two phases. Phase I includes initial mobilization, site preparation, surface sweep and DGM operations. Phase II primarily focuses on the investigation of each target of interest identified during DGM operations and the disposal of all recovered items.

2.1 Phase I - Site Preparation

Using a phased mobilization approach that will allow for immediate productivity, Tetra Tech will mobilize site management consisting of a Senior Unexploded Ordnance Supervisor (SUXOS) and a dual-hatted Unexploded Ordnance Safety Officer/Quality Control Specialists (UXOSO/QCS). Field staff will consist of a site geophysicist, a UXO tech III (team leader), two UXO tech IIs, and four UXO tech Is. This team will perform the duties to prepare the site for data collection and intrusive investigation operations. Site preparation subtasks include but are not limited to the site-specific safety briefing, review of the ICAP and other relevant project-specific documents, munitions response site (MRS) boundary survey, establishment of contiguous grids/exclusion zones (EZ), instrument aided surface sweep operations, and vegetation reduction.

2.1.1 Administration Area

The administration area will be established to support field operations. A mobile office trailer and, generator will be staged at this location. Conex storage containers will be delivered to this location and serve as secure storage for tools, equipment, and material documented as safe (MDAS). This area will be the primary location for the initial receipt and servicing of portable toilets, hand washing stations or other maintenance activities.

2.1.2 Equipment

The team will receive, inspect, and document the condition of all field equipment upon arrival on-site and before use. All equipment will be checked to ensure its completeness and operational readiness. Any equipment found damaged or defective will be returned to the point of origin, and a replacement will be secured.

2.1.3 MRS Boundary Survey

A professional land surveyor (PLS) based out of Denver will establish site-specific control points and delineate the site boundary for use during real-time kinematic (RTK) global positioning system (GPS) operations. Control points will be tied to a high-accuracy reference network or other equivalent networks available in the State of Colorado and will meet third-order accuracy (1:10,000) standards.

The MRS will be sectioned into 200’ x 200’ operational grids for this field effort (Figure 2-1). Each 200’ x 200’ grid will have a unique ID and will constitute a deliverable unit of data, although these may be grouped together for presentation purposes. While the grid corners will not be physically staked, operations and data will be registered to the grid system.

2.1.4 Equipment Check Area

Before surface sweep operations, the UXO Quality Control Specialist (UXOQCS) will establish the equipment check area (ECA) utilizing small Industry Standard Objects (ISOs). The purpose of the ECA is to verify instruments are functioning properly, and instruments in need of repair or replacement are identified, documented, and removed from service before the commencement of daily surface sweep operations.

2.1.5 Vegetation Reduction

Vegetation will be removed to a height to facilitate passage with the DGM systems. Vegetation removal will primarily consist of a tractor and brush hog.

2.1.6 Blind Seeds

Tetra Tech will place blind quality control (QC) seeds within the planned DGM area as part of the geophysical systems verification (GSV) process. The purpose of the seeds is to provide ongoing validation of the VTA throughout the production survey. Seeds will consist of a small ISO80s. Table 2 1 summarizes the items to be emplaced as QC seeds in advance of the DGM operations.

The locations and burial details will remain blind to everyone on the Tetra Tech team except for the UXOQCS, QC Geophysicist, and designees. Designees are considered individuals supporting project quality functions and not involved with production aspects of the DGM survey or intrusive follow-up investigation.

QC seeds will be placed at a rate of approximately two seeds per acre to facilitate each VTA encountering at least one seed per day of production surveying and to allow for an appropriate amount of variability in seed burial depth and orientation.

Tetra Tech will emplace blind seeds at variable depths in the subsurface per Table 2-1. All depth measurements are referenced from the current grade at the time of seeding to the approximate center of mass for each ISO.

Table 2-1. Planned Blind Seed Vertical Distribution

Item	Proportion of Total Seeds	Minimum Depth (inches)	Maximum Depth (inches)
Small ISO80 - Horizontal	80%	3	8
Small ISO80 - Vertical	20%	6	12

The seed positions will be recorded using RTK GPS. The depth and orientation will be documented in the blind seed register, which will be kept firewalled from production personnel through the use of password-protected files. Each seed will be photo documented with the seed exposed in the open hole.

Figure 2-1. Map of Butterfield Trails Site Showing Internal Mapping Grid Structure

2.2 Phase I - Surface Sweep

The purpose of the instrument aided surface sweep is to improve the DGM data quality by minimizing the response from surface metals. The process will remove and document any MPPEH, MD, or non-munitions related debris (NMRD) from the MRS surface before vegetation reduction and DGM collection. UXO Standard operating procedure (SOP) 03 Surface Sweep-Clearance Operations contains the procedures for this task.

The Surface sweep team will be led by a UXO Technician III. The team will systematically traverse the 373-acre MRS removing metallic items greater than 2 inches in any dimension that would potentially interfere with the data collection process. When MPPEH, MD, or NMRD are encountered, the procedures defined in UXO SOP 04 and section 2.4 below will be followed.

2.3 Phase I - Digital Geophysical Mapping Operations

Upon completion of the surface sweep activities and vegetation reduction effort, Tetra Tech will perform the following mapping operations in support of the MR action:

- Perform DGM over the entirety of the 373-acre BFT.
- Process DGM data, derive targets, identify saturated response areas and obstacles, and develop dig lists for intrusive investigation.

Tetra Tech will use two-vehicle towed array (VTA) systems to perform DGM surveys across the accessible portions of the site. If the VTA systems cannot access portions of the site, person portable configurations of the sensors will be employed. All sensor configurations will be validated at the Instrument Verification Strip (IVS) prior to use.

2.3.1 DGM System

Each VTA will consist of a ganged array of three individual Geonics, Ltd. EM61-MK2 sensors coupled to a RTK differential global positioning system (DGPS).

Geonics EM-61 MK2 Vehicle-Towed Array – The EM61-MK2 is a time-domain metal detector that detects both ferrous and non-ferrous metals. The system operates by generating a pulsed primary electromagnetic field in the earth, which induces eddy currents in metallic objects located in the ground. These eddy currents decay over time, producing a secondary electromagnetic field. It is this secondary field that is measured by the receiver coils. The array consists of three 0.5-meter x 1.0-meter coils with the long axis of each coil oriented perpendicular to the array. The coils are separated (center to center) by approximately 2 feet (0.6 meter). The effective swath width of the 3-coil array is approximately 6.5 feet (2 meters). Data are digitally collected at a rate of approximately 10 to 12 hertz, and real-time positioning and navigation are provided by Leica GPS1200 DGPSs. The EM-61 MK2 units configured for the VTA will use four time-gates (216 microseconds [µs], 366 µs, 660 µs, and 1,266 µs). Figure 2-2 depicts the array configuration. Figure 2-3 illustrates the assembled array.

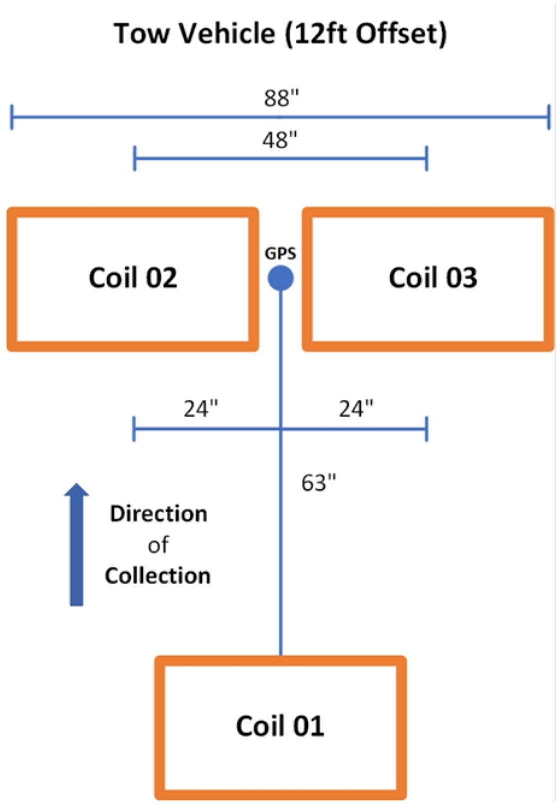

Figure 2-2. VTA 3-sensor Array Configuration

Figure 2-3. Photo of VTA 3-sensor Array and Tow Vehicle

Differential Global Positioning System - The DGPS receives satellite signals with an antenna at a known offset. The use of a separate base station erected on-site provides real-time corrections, which provide sub-centimeter positioning accuracy. The base station will be set up at a temporary control point as established by the PLS prior to the start of DGM operations.

2.3.2 Instrument Verification System

Tetra Tech will construct an IVS in accordance with DGM SOP-03 near the survey area to perform initial validation of the VTA system (EM61-MK2 sensors and positioning system) before the start of DGM operations. The IVS will also be used for twice-daily testing as part of the field QC program for DGM instruments.

Before constructing the IVS, the proposed IVS area will be mapped using EM61-MK2 to assess the area's suitability for an IVS. This pre-seeded survey will assist with a preliminary understanding of the background response at the site and allow for identifying metallic objects of unknown nature to avoid during placement of the IVS seeds.

The IVS will be constructed as shown in Figure 2-4 to include small Schedule 80 industry-standard objects (ISO80s). IVS seeds will be placed nominally 10 to 15 feet from other metallic objects in the subsurface to minimize ambiguity in the responses to each emplaced ISO during the IVS surveys. Tetra Tech UXO personnel will implement subsurface anomaly avoidance measures during the construction of the IVS. The ISOs will be buried at depths corresponding to approximately 3x to 7x their diameter. All ISOs will be emplaced in a horizontal orientation. The position of each seed will be surveyed by Tetra Tech using RTK GPS and the item emplacement depth and orientation documented. Photographs will be acquired of each object before burial and in the open hole. The final IVS construction will also include an area of relatively minimal metal in the subsurface to evaluate changes in background response or sensor noise levels during the twice-daily surveys of the IVS.

The IVS will be surveyed with multiple passes so that each coil within the VTA will traverse all seeds to demonstrate the VTA system is configured properly. Depending on the site logistics, multiple IVS sites may be constructed.

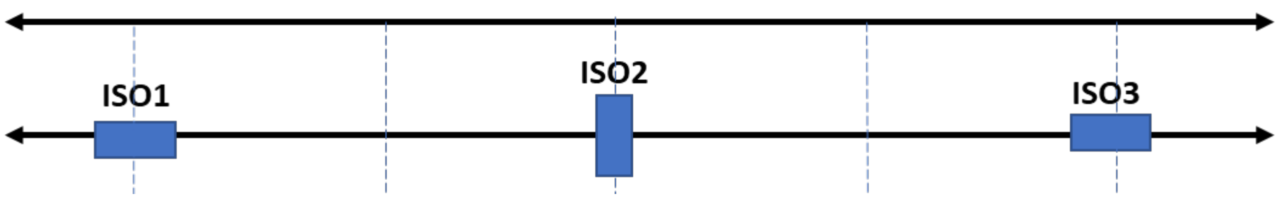

Figure 2-4. Instrument Verification Strip Layout

2.3.3 Data Collection

Geophysical data will be acquired with the VTA to provide effective 100% coverage of the BFT site. The speed of the tow vehicle will be kept to 4 miles per hour (mph) or less. For this survey, Tetra Tech will modify its VTAs to have the bottom of the individual sensors at a ride height of 8-in above the ground surface, similar to the DGM transect survey completed during the RI/Feasibility Study (FS) for the AGGR. This height is approximately half the height of the EM61-MK2 mounted on its standard wheels in person-portable mode. The reduced height is intended to enhance the detection of 20mm projectiles near the maximum reliable detection depth for these items (see Table 2-2). This configuration is intended to facilitate improved signal to noise at depth by decreasing the overall distance between the objects and the sensor.

Table 2-2. Predicted Maximum Reliable Detection Depths for Expected Munitions

Munition Type	Diameter (in)	Diameter (mm)	Predicted CH1 (mV)	Predicted CH2 (mV)	Predicted CH3 (mV)	Sum CH1-CH3 (mV)	Distance from Sensor (in)	Depth BGS (in)
20mm projectile	0.79	20	12.4	7	3.2	22.6	15	7
37mm projectile	1.46	37	13.4	7	3.4	23.8	26	19
57mm projectile[1]	2.24	57	-	-	-	-	-	-
60mm mortar	2.36	60	11.8	7	4	22.8	38	30
75mm projectile	2.95	75	11.6	7	4	22.6	46	38
10-lb practice bomb[2]	4.25	108	11.7	7	4	22.7	59	52
100-lb practice bomb[3]	8.10	206	-	-	-	-	-	-
2.25-in rocket[4]	2.25	57	-	-	-	-	-	-
2.75-in rocket[5]	2.75	70	13.3	7	3.5	23.8	40	32

Notes:
[1]Specific calculations for the 57mm projectile not available in the tool; responses assumed to be similar to the 60mm mortar.
[2]Specific calculations for the 10-lb practice bomb are not available in the tool; responses listed are for the 4.2-inch mortar, which has a diameter of 107mm.
[3]Specific calculations for the 100-lb practice bomb are not available in the tool; it is expected that this item will be detected to reasonable depths to support the project objectives at a threshold of 7mV on Channel 2, given the maximum reliable detection depths of smaller-caliber objects.
[4]Specific calculations for the 2.25-inch rocket are not available in the tool; responses assumed to be similar to the 2.75-inch rocket warhead
[5]Calculations resented are for the 2.75-inch rocket warhead and not a full-up rocket.
Abbreviations and Acronyms:
in – inches
lb – pound
mm – millimeter
mV – millivolt

The onboard navigation system will allow each VTA operator to maintain the survey course and line spacing. Inaccessible areas will be circumnavigated with the arrays and identifiable in the GPS track path and noted in daily field notes. If the resulting area is accessible using a person-portable EM61-MK2 system, Tetra Tech will perform DGM using this system after completion of the VTA survey to minimize the occurrence of data gaps. Any remaining gaps in the overall DGM coverage will result from areas deemed inaccessible by Tetra Tech to the VTA or person-portable EM61-MK2 system. Examples of inaccessible areas include portions of the site that may pose a safety hazard to field personnel or where attempts at digital data collection would compromise the usability of the DGM data. These will be identified and documented as obstacles for clearance with handheld analog instruments.

Raw data files will be downloaded at the end of each day’s operation from the VTA onboard computers and backed up to a separate laptop computer. Raw files will also be uploaded daily to a secure Tetra Tech network server or project Share Point site for data security purposes and retrieval by the data processors. Additional information included in the raw data upload will be daily field logs and notes, QC test data (see next section), RTK GPS measurements, and photos recorded on-site to document observed conditions.

Table 2-2 presents the maximum detection depths with the DGM sensor for the munitions listed in Section 1.2.6. These represent the maximum depth at which a specific target will generate a recognizable response. These depths were modeled using the EM61-MK2 Response Calculator tool developed by the Naval Research Laboratory (NRL) for those munitions and surrogates available within the tool and a 5:1 signal to noise ratio. Tetra Tech used the following assumptions in this process:

- Target selection threshold of 7 millivolt (mV) on Channel 2, consistent with the AGGR SMUA RI/FS DGM surveys.
- EM61-MK2 sensor ride height of 8-in above ground surface, consistent with the AGGR SMUA RI/FS DGM surveys,
- Objects are in their least favorable orientation (i.e., horizontal)

Table 2-2 further demonstrates the 7mV target selection threshold on Channel 2 is consistent with the 20mV threshold cutoff for the Sum of Channels 1 through 3 discussed in the AGGR military munitions response action site-specific final report (HDR, 2014). In this report, the threshold was established at 30mV of the sum of Channels 1 through 3, although a 20mV cutoff was used as an added picking buffer.

2.3.4 Data Processing

Geophysical data processing will be completed shortly after data collection to verify that the survey objectives are met and promptly identify areas for in-fill surveying and potential QC issues.

Preliminary processing of the data includes interpolating positions for each of the EM61-MK2 measurements and formatting the data for further processing using instrument-specific software supplied by Geonics, Ltd.

Pre-processed data are imported into Geosoft Oasis montaj (Geosoft) for further processing, gridding, and target selection. Tetra Tech will use the Geosoft UXO Land suite of tools (Version 9.8 or newer) to process the data and derive target locations. Data processing steps will include latency corrections, sensor drift correction, and additional filtering or leveling as necessary. Tetra Tech's data processors will process daily QC tests (static tests, IVS surveys) to document proper sensor performance. The VTA performance will be tracked in a master Microsoft Access project database and running QC summaries maintained by the DGM data processor. This database will also include the daily RTK GPS geodetic function check. QC outputs for the production data will include assessments of sample separation and footprint coverage.

Data processing culminates in the generation of color mosaics of the survey area. The mosaics depict the EM61-MK2 response amplitude. The derivation of the cutoff between background and targets of interest is discussed in the next section.

Tetra Tech will manage the processed data in regions (sets of adjacent grids). Each region will include a maximum of 4 full grids (but may also include adjacent partial or boundary grids) to facilitate efficient data tracking, completion, and delivery of target lists for follow-up reacquisition promptly. Some regions may contain fewer grids based on the size of the survey area and features of the site. While the survey results will be separated into individual operational grids for presentation and target management, Tetra Tech will deliver data packages by region to CDPHE. Processed data files will be backed up to the secure Tetra Tech server or project Share Point site. Final processed files will be compiled into data delivery packages by region, which will include the following:

- Raw instrument files (by grid)
- Field notes (by date)
- Pre-processed instrument files (by grid)
- RTK GPS QC and feature files (by date)
- Processed databases (Geosoft format) (by grid)
- Data processor notes (by grid)
- Color mosaics for each operational grid (Geosoft and PDF format) (by grid)
- Target selection database for each operational grid (Geosoft and .CSV format) (by grid)
- Updates to the master project Access database (per delivered package)

2.3.5 DGM Target Selection

The attributes of the geophysical anomalies (shape and magnitude) are dependent on the size, shape, wall thickness, orientation, and depth of the subsurface object, along with the physical and chemical properties of the surrounding soils.

Target prioritization is based on a performance objective to remove a 20mm projectile at a depth of 7 inches below the ground surface. Larger ordnance will be detected at greater depths as illustrated in Table 2-2. It includes picked targets with an amplitude of ≥7mV on Channel 2. This is consistent with previous EM61-MK2 surveys at the AGGR and AGGR SMUA. Industry-accepted practices typically include establishing the target threshold at 5x the root mean square noise (or standard deviation). This practice is undertaken in order to refine target selection criteria will be based on the expected munitions-related items of interest and to consider background response and DGM sensor noise levels. At a selection threshold of 7mV, the average RMS noise level would be 1.4mV, which is likely.

Initial assessments of these parameters will be based on the IVS surveys and evaluated from within the production area during the initial data gathering stages. The ongoing appropriateness of this threshold will be further evaluated in initial data collection from within the survey area to assess whether the threshold could be justifiable lowered or should be increased to minimize the number of false positives. The Project Geophysicist will collaboratively discuss adjustments to the target threshold in coordination with DeVoe Law and CDPHE.

Tetra Tech will use the Blakely tool within Geosoft to select targets from the gridded data set for the EM61-MK2 channel used for target selection. Further manual refinement of target locations may be necessary by the data processor near the edges of the survey area and within high-density anomaly areas. The QC Geophysicist will verify that blind seeds are selected as targets above the established threshold.

Assigned target IDs will be unique and will include the grid ID as part of the target ID. The DGM data processor will evaluate each target for its validity for inclusion on the dig list. Invalid targets typically result from suspected noise sources (e.g., uneven terrain causing the sensors to bounce) where the peak anomaly amplitude is above the target threshold, but the geophysical anomaly characteristics are not consistent with a potential munitions-related object. Each target that meets the selection criteria and is considered valid will be added to the target list for reacquisition and intrusive investigation.

Targets submitted to the field for reacquisition will be transferred to the dig sheet developed for each grid. Targets will include a unique ID, location (Easting, Northing), EM61-MK2 amplitude, and relevant data processor comments. Tetra Tech will provide target lists for each completed grid to optimize intrusive follow-up investigation of targets. If the resulting DGM anomaly footprint is larger than a 3.3 feet radius around the target location, the DGM data processor will add a comment to the Geosoft target list indicating the dimension of the expanded radius to be searched to have the UXO intrusive investigation teams adequately inspect the entire geophysical anomaly footprint. These comments will carry over to the dig lists. Inspection of the entire footprint is intended to assess whether additional sources are present within the footprint, masked by a more dominant source. DGM target locations requiring an expanded search radius >2m will be identified as a saturated response area (SRA) and cleared using analog methods. SRA are localized areas where the response from metal in the subsurface is such that it prevents the reliable derivation of discrete targets for reacquisition and digging. SRAs will be presented as polygons and will be identified accordingly on the resulting grid maps. The perimeter of each SRA will be provided to the field team along with the target list for clearance using analog methods.

2.4 Phase II - Reacquisition and Intrusive Investigation Operations

Tetra Tech will perform intrusive investigation operations on DGM TOIs selected by the Project Geophysicist. Each intrusive investigation team will be comprised of a maximum of seven UXO technicians qualified IAW Department of Defense Explosives Safety Board Technical Paper TP-18 (DDESB TP-18).

2.4.1 Reacquisition

TOI reacquisition will be performed in the following sequence:

- All RTK GPS equipment to be utilized during field TOI reacquisition operations will record the location on a known control point before commencing field operations. This daily check will verify RTK GPS positional accuracy requirements defined in the project measurement quality objectives (MQOs).
- Utilizing RTK GPS, all TOI locations will be reacquired and marked with a non-metallic pin flag or other suitable marker containing the unique TOI identification number.
- Flag locations will be electronically recorded. All positions will be downloaded and submitted to the QC Geophysicist for positional location accuracy verification and MQO compliance.

2.4.2 Intrusive Investigation of Selected Targets

- The intrusive investigation team utilizes an analog detector to pinpoint locations of all geophysical anomalies to be investigated within a radius of 3.3 feet of flag locations. Targets where the data processor has indicated a larger search radius will be investigated to that radius.
- Intrusive investigations will be performed to identify and remove all anomalies.

- All anomalies investigated shall undergo an initial assessment to be confirmed and verified by the UXO TIII. Once the assessment is complete, the anomaly source will be characterized as MPPEH, MD, or NMRD. Intrusive investigation results will be entered into a tablet containing the Tetra-forms Intrusive results database.
- Once the anomaly source material has been removed, the area will be checked using an EM61-MK2 in analog search mode to verify that no additional source material remains.
- The TOI is considered resolved when; the post-dig EM61-MK2 amplitude is below the target threshold in a 3.3-foot radius around the flag location, documentation is completed (including recording the post-dig EM61-MK2 amplitude), and the location is marked as complete and ready for QC.

2.4.3 Saturated Response Areas

Conditions identified in the DGM results classified as SRAs will undergo clearance by the UXO intrusive investigation teams using the following analog methods:

- Step 1. Perimeter of the SRA is marked and measured using RTK GPS. A one-foot buffer will be added to the delineated SRA boundary.
- Step 2. Interior area of the SRA will be divided into 3-5-foot-wide lanes (terrain dependent) and delineated with ropes or pin flags to ensure 100% coverage.
- Step 3. Intrusive investigations will be conducted IAW with section 2.4.2 above.
- Step 4. Using an EM61-MK2 in direct read mode to check the SRA, the SRA will pass inspection when there are no more responses above the detection threshold or NMRD left in place has been verified by the UXOQCS.

2.4.4 Inaccessible Areas (Obstacles)

Where field conditions present hazardous or otherwise inaccessible areas for digital data collection with the EM61-MK2 in VTA or person-portable modes, the area will be documented as an obstacle. Obstacles will be cleared using the same techniques as SRAs described above, except that final inspection will be conducted with handheld instruments.

2.4.5 No Contact

If UXO teams are unable to identify a geophysical anomaly within a 3.3-foot radius of a target flag, and the EM61-MK2 cannot reproduce the initial DGM anomaly, the flag location will be recorded as a “No Contact”. No contacts will be reported to and verified by the UXOQCS for verification.

In instances where single point anomalies cannot be defined during EM61-MK2 data processing (SRAs), and analog instruments operators cannot isolate point sources, the UXO Team Leader will assess the specific conditions (e.g., suspected strong geologic response, an abundance of nails, rust flakes, or barbed wire fences, farming equipment, etc.) and whether or not additional intrusive measures are needed to assess the likely presence of MPPEH. The UXO Team Leader will determine the location in conjunction with the SUXOS and UXOQCS. Rationale and final disposition will be clearly captured in the daily field notes.

2.5 MPPEH/MEC Processing and Disposition

- All MPPEH processes will be IAW with DoD 4140.62, EM 385-1-97, and Defense Explosives Safety Regulation (DESR) 6055.09.

- The SUXOS and UXOSO will positively identify all MPPEH/MEC. Before the movement, an acceptable-to-move determination will be made and documented.

- MEC determined acceptable to move will be transported to a pre-determined consolidation point for scheduled disposal operations.

- All MEC located will be guarded or secured until disposal operations have been completed.

Historic findings from nearby sites within FLBGR have shown that both High Explosive filled and TP 20mm projectiles have been recovered. All 20mm projectiles that cannot be positively identified as TP will be vented utilizing explosive or remote cutting operations.

Upon completion of venting operations, all material will be reassessed and undergo the MPPEH inspection process. Tetra Tech will verify all disposal locations and consolidated demolition areas are free of anomalies utilizing an analog detector.

No explosives storage is anticipated for this site. Explosives will be delivered on an as needed basis by Buckley Powder.

2.6 MD Certification and MDAS Containerization

- MPPEH inspections will be IAW with DoDI 4140.62, EM 385-1-97, and DESR 6055.09.

- Munitions Debris will be assessed, and its explosive safety status determined and documented before transfer within the DoD or release from DoD control.

- Only after documenting a 100 percent inspection and an independent 100 percent re-inspection will Munitions debris be reclassified as MDAS.

- DD Form 1348-1A Issue Release/Receipt Document will be used as the certification/verification documentation.

- MDAS will be stored in suitable sealed containers and secured at the project site.

2.6.1 Maintaining the Chain of Custody and Final Disposition

Tetra Tech will arrange for maintaining the chain of custody and final disposition of the certified and verified materials.

MDAS is no longer considered MPPEH as long as the chain of custody remains intact. A legible copy of the inspection, re-inspection, and documentation must accompany the material through final disposition and be maintained for 3 years.

3.0 QUALITY CONTROL

QC measures will be implemented to ensure quality throughout the execution of tasks performed during site activities. These QC measures will also provide added confidence in the usability of the data gathered on-site to ultimately meet the project objectives, as described in Table 1-1 above. Table 3-1 below details the definable features of work (DFW) for the project, including all of the quality inspection points and procedures. MQOs are a list of regularly quantifiable quality metrics that may be part of the quality inspection process and are detailed in Table 3-2.

3.1 DGM Quality Control

QC Geophysicist will implement sufficient mechanisms to ensure data acquisition, processing, interpretation, and target reacquisition practices are monitored at a sufficient level to meet the project objectives.

Functional instrument tests for the geophysical and GPS equipment will be digitally recorded and processed using Geosoft. The results will be compiled and documented in the master project Access database. The twice-daily IVS survey will ensure that the sensor systems are functioning optimally. The Blind QC Seeds will validate the entire processing operation, including data processing, target selection, and intrusive investigation.

The QC Geophysicist will perform a final review of the processed data packages before delivery to CDPHE and is responsible for client-delivered data conforming to the requirements of this ICAP. During data processing, the DGM data processor may identify the need for additional data or clarification from the field team and initiate any requests for follow-up information directly with the DGM field team leader before submitting the data for QC. Data provided to the QC Geophysicist are considered complete and not requiring further action by the field team or the data processor. The QC Geophysicist will evaluate the blind seed performance and update the seed register during the final review of the data package.

3.2 UXO Quality Control

The UXOQCS will perform all QC functions related to the MR actions, including verifying qualifications of individuals, adherence to procedures in work plans, maintenance of records, testing of equipment, and working conditions. A description of the required daily operations and associated QC checks are listed in Table 3-1.

3.3 Quality Control Inspections

3.3.1 Preparatory Phase Inspection

Inspections will be conducted during the life cycle of the project to ensure quality. The UXOQCS/QC Geophysicist will conduct preparatory phase inspections before starting the DFWs. These inspections shall include the following:

- Review the Work Plan and Standard Operating Procedures.
- Ensure that all required procurement forms for supplies and services are approved.
- Ensure that provisions have been made to provide the required QC inspection.
- Ensure all personnel have the required training and certifications needed to perform the work.

- Examine the work area to ensure that all required preliminary work has been completed and comply with the approved ICAP.
- Examine the required materials and equipment physically to ensure that they are properly delivered to the site, conform to specifications, and are properly stored.
- Review the appropriate activity hazard analysis (AHAs) to ensure safety requirements are met.
- Discuss procedures for performing the work, including potential repetitive deficiencies.
- Document workmanship standards for the particular phase of work.

3.3.2 Initial Phase Inspection

An initial phase inspection will be performed at the beginning of a DFW, will be documented on the appropriate form, and will include the following:

- Review the preparatory phase of control deficiencies and ensure they are resolved.
- Check preliminary work to ensure that it complies with contract requirements.
- Affirm the required level of workmanship, testing, and inspection to ensure that work meets minimum acceptable standards.
- Resolve all differences.
- Check safety requirements to include compliance with the Accident Prevention Plan/Site, Safety and Health Plan (APP/SSHP) and AHAs.
- Review and potentially revise the AHAs with project personnel if necessary.

3.3.3 Follow-up Phase Inspection

During a work feature, follow-up inspections will be conducted for each DFW performed, to ensure the fieldwork complies with the requirements of the Work Plan. The UXOQCS will document each follow-up phase inspection and the results on the Daily QC Report.

3.3.4 Completion Inspections

Completion inspections will be conducted and documented before client inspections to ensure the DFW, product, or service meets the contractual requirements and requirements listed in the Work Plan.

3.3.5 Receipt Inspections

Tetra Tech will record the serial number for each EM61-MK2 sensor and RTK GPS in the field logbooks. The UXOQCS will ensure equipment receipt checks will be conducted in accordance with Table 3-2. Any equipment or material(s) that does not meet performance requirements or manufacturer specifications will be rejected and returned to the vendor or warehouse.

Nonconforming material will be segregated and marked accordingly. The UXOQCS will record on the Daily QC Report that a material inspection was performed or will use the quality receipt inspection form.

3.4 Quality Control Training

The UXOQCS will have a working knowledge of QC and how QC influences safety, effectiveness, customer requirements, and company policy. The UXOQCS will also ensure all required training is documented and entered into the project file.

3.5 Records

QC activities shall be documented to provide the required records showing compliance with the project requirements. All records shall be specified, prepared, and maintained to provide documentary evidence of quality. Records will be legible, identifiable, retrievable, and protected against damage, deterioration, or loss. Requirements and responsibilities will be established and documented to ensure control of preparation, maintenance, distribution, retention, and disposition.

- The UXOQCS will record his field activities in the UXOQCS field logbook and the Daily QC Report. The UXOQCS will submit inspection forms, copies of field logbooks, and daily safety sheets to the Tetra Tech Director of Quality representative for review weekly before entry into the project files.
- The UXOQCS may use photography and video recorders as recording devices. The photograph/video records will serve as a part of the historical records.
- The UXOQCS will ensure the Three-Phase Control Process is implemented.

3.6 Corrective Measures

The UXOQCS or QC Geophysicist will document any work not conforming to the MQOs listed in Table 3-2 or contract requirements on a non-conformance report (NCR). The NCR will detail the nonconforming condition, the recommended corrective action (CA), and the disposition of the CA. Where necessary, a root cause analysis (RCA) will be conducted to establish the optimal CA. The recommendation for further action may include but is not limited to re-processing the dataset, adjusting the MQOs, evaluating the intrusive procedures, or recollection of field data.

The NCR will remain open until the nonconforming condition has been satisfactorily resolved and verified by the UXOQCS. Upon receipt of notification of detected nonconformance, NCRs for each item will be completed.

Table 3-1. Quality Inspection Points

DFW	Requirement – Pass/Fail Criteria	Inspector/ Frequency	QC Procedures
Mobilization / Site Setup / Demobilization	**Personnel Qualifications** • Check that all site employees performing MEC clearance activities meet requirements provided in DDESB TP 18. • Ensure all personnel, including subcontractors, receive site-specific training. **Site Setup** • Check equipment from warehouse/vendor • Check that subcontractor activities conform to contract and project requirements • Establish ECA • Emplace QC Seeds	UXOQCS ensures mobilization activities are completed and are documented at the start and end of the project UXOQCS tests all field technicians in the ECA before fieldwork beginning UXOQCS emplaces QC Blind Seeds for DGM controls in coordination with QC Geophysicist.	• Confirm all personnel are qualified and check that all certifications are current • Conduct equipment receipt inspections using operations manuals or purchase orders and document results. Receipt inspection documentation is forwarded to Warehouse Manager for Tetra Tech-owned equipment. • Maintain an equipment log with equipment type, serial number, and operational status (performed by SUXOS). • Conduct testing at the ECA or IVS for each operating system (man and machine) before field operations beginning. • Confirm civil survey accuracy conforms to requirements. • Confirm vegetation removal actions conform to requirements before DGM data collection. • Confirm QC Blind Seeding operations conform to SOP requirements before DGM data collection.
DGM Collection and Processing	**Initial IVS** • Establish IVS • See relevant MQOs for tests and criteria • Document results in IVS Technical Memorandum **DGM Collection** • Ensure daily equipment tests are conducted (geodetic, function test, IVS survey) • See relevant MQOs for tests and criteria **DGM Processing** • Ensure daily data processing tasks are performed and adequately documented	QC Geophysicist inspects all DGM work during preparatory and initial phases of work. No follow-up inspection for Initial IVS is required. UXOQCS inspects DGM collection during follow-up (once per week).	• Confirm suitability of IVS location through background survey results. • Confirm IVS installation conforms to SOP requirements before survey operations. • Confirm Initial IVS survey data meet project MQOs and is documented in the IVS Technical Memorandum. • Confirm DGM system noise levels and target selection threshold are adequate to meet project objectives. • Confirm daily geodetic accuracy tests • Confirm twice daily function tests • Confirm twice daily IVS tests • Confirm adequate line and sample spacing

DFW	Requirement – Pass/Fail Criteria	Inspector/ Frequency	QC Procedures
	• Ensure all targets have been selected according to prescribed methods and no anomalies have been omitted • Ensure all data gaps are adequately explained or filled • See relevant MQOs for tests and criteria	QC Geophysicist inspects DGM processing as follow-up/ completion inspection before intrusive work (once per deliverable unit).	• Verify all target selection and data deliverable packages
MEC and MPPEH Clearance	**Daily Testing** • Perform daily instrument (i.e., Schonstedt, Vallon, or equivalent analog instrument) checks at ECA or IVS, and ensure operator locates all seeds in the test strip. • Test battery strength two times/day and ensure that an audio response is received over ferrous metal object. • Perform daily geodetic test for positioning system used to reacquire target locations. • Use test jig to observe static response to small ISO with EM61-MK2 sensors used in support of intrusive and UXO QC operations **Analog Geophysics** – all intrusive investigation pass/fail criteria apply, in addition to the following: • Ensure sweep lanes are laid out to provide complete coverage. • Ensure handheld detectors are used properly (manufacturer recommended angle and speed). • Excavate and classify all anomaly sources identified during analog operations. • Ensure no MEC or MPPEH on surface (i.e., MPPEH that cannot be verified to be free of explosives) regardless of size, excluding small arms ammunition (0.50 cal and smaller), and no munitions debris or range-related debris equivalent to or greater than 2 in. x 2 in from the surface and shallow subsurface (8-in.) and remove ferrous metal equivalent to or greater than 2.75-in. (70mm) diameter or greater, to a depth of 8-in. below ground surface remain. **Excavation – Target Resolution** • Establish EZs.	UXOQCS inspects during preparatory, initial, and follow-up phases (daily inspections during intrusive operations)	• Verify daily testing of instruments is conducted and documented. • Perform daily spot checks of recovered anomalies to ensure proper classification. • Verify adequate coverage of analog areas using 10% QC check of area. • Verify source of DGM anomaly was removed and post-dig response with the EM61-MK2 within a 3.3-foot radius around each flag location is below the established target threshold. • 100% of No Contact (i.e., false positives) flag locations will undergo inspection by UXOQCS using analog instruments and EM61-MK2 in direct read mode. • Check for acceptable backfill of holes, including site restoration. • Verify/inspect in-progress work. • Verify marking and documentation of all recovered MEC. • Ensure documentation of all acceptable to move determinations before movement. • Verify all MD is removed from grid and stored properly. • Inspect process daily (this procedure is inspecting a process, not a quantity); efficacy of this process is inspected in MPPEH Processing and Disposition phase. • Verify proper handling of MPPEH.

DFW	Requirement – Pass/Fail Criteria	Inspector/ Frequency	QC Procedures
	• Accurately classify recovered source. • Reacquire target locations and record and save measurement of "as-placed" flag location for submittal to UXOQCS and QC Geophysicist. • Pursue source to depth of detection, or until an obstruction is encountered, within a radius of 3.3 feet or as otherwise stipulated on the dig sheets. • Ensure 100% check of source removal at each flag location by the UXO Team Leader using analog metal detector (or a second person on the team) for resolution. • Note post-dig EM61-MK2 amplitude (in mV) for the DGM target picking channel for each flag location • Ensure holes are backfilled. **Documentation** • Document all equipment tests have been conducted. • Record all MEC items found on the MEC Accountability Form. • Record all anomaly information on Intrusive Investigation Data form. • Ensure logbooks are completed and vehicle inspections are recorded. • Ensure the grid tracking log is completed • Ensure vehicle inspections are recorded.		

DFW	Requirement – Pass/Fail Criteria	Inspector/ Frequency	QC Procedures
Management of MEC and MPPEH, and MDAS Certification and Verification	**Performance** **MPPEH Handling** • Identify and clearly mark all MEC. • Inspect, segregate, and reclassify MPPEH, as warranted. • Coordinate MEC/MPPEH demolition with Arapahoe County Bomb Squad. **MDAS Certification and Verification** • Perform 100% inspection by two UXO-qualified technicians. • Ensure a Tech III and a Tech II in the field confirm the identification process. **Documentation** • Complete final inspection/documentation 1348/chain of custody. • Complete logbooks/field inspection/field notes.	UXOQCS inspects during preparatory, initial, and follow-up phases (daily inspections during intrusive operations)	• Verify proper handling of MPPEH, including field team inspections, segregation, and coordination with local law enforcement for disposition of MEC/MPPEH. • Verify marking and documentation of all identified MEC. • Verify all MD is removed from grid and stored properly. • Inspect process daily (this procedure is inspecting a process, not a quantity); efficacy of this process is inspected in MPPEH Processing and Disposition phase. • Verify proper handling of MPPEH. • Verify two 100% inspections of all MD were performed. • Re-inspect 10% of MD to ensure items are safe. • Verify field notes, logbooks, and DD Form 1348-1A documentation are accurate, complete, and consistent.

Table 3-2. Measurement Quality Objectives

Measurement Quality Objective	MPC#	Frequency	Responsible Person/ Reporting Method/ Verified by	Acceptance Criteria	Failure Response
1. Initial instrument function test (EM61)	3	Once following assembly	Project Geophysicist / Daily field log; SOP checklist / DGM Data Processor; QC Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response from theoretical models	Make necessary adjustments and re-verify before use of sensor. If failure is identified after start of DGM operations, then RCA/CA.
2. Initial instrument function test (Analog)	3	Once upon arrival at project site	Instrument operator; UXO Team Leader / UXO team leader daily log; daily quality control report / UXOQCS	Audible response consistent with expected change in tone in the presence of ISO at ECA or IVS	Make necessary adjustments and re-verify before use of instrument. If instrument not operational, then remove from service and repair/ replace. If failure is identified after start of UXO operations with instrument, then RCA/CA.
3. Position accuracy (RTK GPS)	4	Verified for each processed data set collected with RTK GPS	Project Geophysicist / DGM processed database / DGM Data Processor; QC Geophysicist	Measured position of control point within ± 4 inches of known location tied to independently established site control	Make necessary adjustments and re-verify before use of instrument. If failure is identified after start of daily operations, then RCA/CA.
4. Initial dynamic positioning accuracy (EM61 IVS)	4	Once during initial sensor validation at IVS	Project Geophysicist / Running QC Summary / DGM Data Processor; QC Geophysicist	Derived positions of IVS targets are ±10in of the ground truth locations	Make necessary adjustments and re-verify. If failure is identified after start of DGM operations, then RCA/CA.

Measurement Quality Objective	MPC#	Frequency	Responsible Person/ Reporting Method/ Verified by	Acceptance Criteria	Failure Response
5. Ongoing instrument function test during DGM (EM61)	3	Beginning and end of each day, sensors are used; after each battery change.	Project Geophysicist / Running QC Summary / DGM Data Processor; QC Geophysicist	Response (mean static spike minus mean static background) within 20% of initial response	Make necessary adjustments, and re-test. If failure identified after start of DGM operations, then RCA/CA
6. Ongoing instrument function test during intrusive operations (EM61)	3	Beginning and end of each day, sensors are used in direct-read mode; after each battery change.	UXOQCS / Daily QC report; Running QC Summary / UXOQCS; QC Geophysicist	Visual readout of instrument display shows repeatable response within 20% of initial response after instrument null	Make necessary adjustments and re-test before use of instrument. If failure identified after start of UXO operations with instrument, then RCA/CA
7. Ongoing instrument function test (Analog)	3	Beginning and end of each day and after every time the instrument is turned on during the day.	Instrument operator; UXO Team Leader / UXO team leader daily log; daily quality control report / UXOQCS	Audible response consistent with expected change in tone in presence of ISO at ECA or IVS	Make necessary adjustments and re-verify before use of instrument. If instrument not operational, then remove from service and repair/replace. If failure is identified after start of UXO operations with instrument, then RCA/CA.
8. Ongoing dynamic positioning accuracy (EM61 IVS)	4	Beginning and end of each day sensors are to be used for dynamic data collection	Project Geophysicist / Running QC Summary / DGM Data Processor; QC Geophysicist	Derived positions of IVS targets ±10in of the running average positions	RCA/CA

Measurement Quality Objective	MPC#	Frequency	Responsible Person/ Reporting Method/ Verified by	Acceptance Criteria	Failure Response
9. In-line measurement spacing (DGM)	5	Verified for each processed data set using Geosoft purpose-built *Sample Separation* tool	Project Geophysicist / DGM processed database; tool output map / DGM Data Processor; QC Geophysicist	98% ≤ 0.82ft. 100% ≤3.3ft. between successive measurements excluding gaps which are adequately explained and marked for analog investigation (e.g., unsafe terrain, trees)	RCA/CA for gaps with no documented exceptions
10. Survey coverage (DGM)	5	Evaluated in processed data for deliverable unit (grid)	Project Geophysicist / Running QC Summary / QC Geophysicist	≥90% coverage at 2.5 ft; 100% ≤3.3 ft spacing between individual sensor paths. Exceptions include gaps explained by field team (e.g., unsafe terrain) and identified for analog inspection.	RCA/CA for gaps not identified for in-fill data collection or gaps not adequately explained
11. Surface sweep: Documenting recovered surface MEC and debris	8	Daily	UXOQCS / GIS data recorded / Project QC or designee	Metallic objects greater than 2 in. in any dimension is collected, counted, and documented in the project database for the following attributes: designation as UXO, MD, range-related debris (RRD), or other debris; UXO and MD described by type and weight. Photos displaying all MEC and MD recovered (individual MD photos not necessary).	RCA/CA; document questionable information in database; justify safety concerns

Measurement Quality Objective	MPC#	Frequency	Responsible Person/ Reporting Method/ Verified by	Acceptance Criteria	Failure Response
12. Dynamic Positioning – Blind Seeds (DGM)	6	Average one QC blind seed per instrument array per day based on expected productivity. Seeds to be placed throughout expected detection depth range.	QC Geophysicist / Daily QC Reports; QC Seed Registry / Lead Organization QA Geophysicist	All blind QC seeds must be detected and targeted within ±24 inches of ground truth position.	RCA/CA
13. Target Reacquisition	4	Evaluated for each reacquired target location	Project Geophysicist / Running QC Summary / QC Geophysicist	Flag location within ±6 inches of supplied DGM target location. Exceptions include offsets necessary to account for obstructions (e.g., rocks). The offset distance and direction will be noted in daily field notes along with adequate explanation.	RCA/CA if exception is not documented by positioning system operator prior to start of dig operations.
14. Anomaly Resolution (DGM Targets)	7	Per operational grid	UXOQCS / Daily QC Report; QC inspection forms / QC Geophysicist	QC of completed dig locations identifies no MEC and no unexplained post-dig EM61-MK2 response above the established target picking threshold. 100% of blind QC seeds recovered.	RCA/CA Re-inspect flag location;
15. MEC/MPPEH Accountability and MDAS Management	8	Daily/weekly	UXOQCS / Accountability Log / SUXOS	UXOQCS inspects Accountability Log once per week; daily inspections of MDAS seals	RCA/CA

4.0 DATA USABILITY ASSESSMENT

The data usability assessment (DUA) is performed after data collection activities and is considered the data interpretation phase, which involves a qualitative and quantitative evaluation of data. The purpose of the DUA is to ensure that not only do the data meet the quantitative metrics of the project (MQOs for sample density, noise levels, etc.), but that they are suitable to support the overall qualitative requirements of the RAO (Section 1.2) within the technical limitations of the sensor system. The DUA is included in the Site-Specific Final Report and provides a review of the MQOs and the ability of the data to meet the project MPCs. Table 4-1 describes the DUA process.

Table 4-1. DUA Process

Step 1	**Review the project's objectives and sampling design** Review the data quality objectives. *Are underlying assumptions valid?* Review the sampling design as implemented for consistency with stated objectives. *Was site history/documented prior munitions used representative of actual site conditions? Were sources of uncertainty accounted for and appropriately managed?* Summarize any deviations from the planned sampling design and describe their impacts on the data quality objectives.
Step 2	**Review the data verification/validation outputs and evaluate conformance to MPCs documented in Table 2.4.** Review the Data Verification/Validation reports and supporting data, if necessary (e.g., daily/weekly QC reports, assessment reports, and corrective action reports. *Was the RCA/CA effective? Evaluate the implications of unacceptable QC results.* Evaluate conformance to MPCs documented in **Table 1-1. Measurement Performance Criteria (MPC).** Evaluate data completeness. *Were all data inputs satisfied? Identify data gaps.*
Step 3	**Document data usability and draw conclusions** Assess the performance of the sampling design and Identify any limitations on data use. *Considering the implications of any deviations and data gaps, can the data be used as intended? Are the data sufficient to answer the study questions?*
Step 4	**Document lessons learned and make recommendations** Summarize lessons learned. Prepare the data usability summary report.

5.0 PROJECT ORGANIZATION

Tetra Tech's organization chart is included as Figure 5-1. Additionally, the responsibilities of project personnel are provided in Table 5-1 (specific personnel may vary based on the timing of field start).

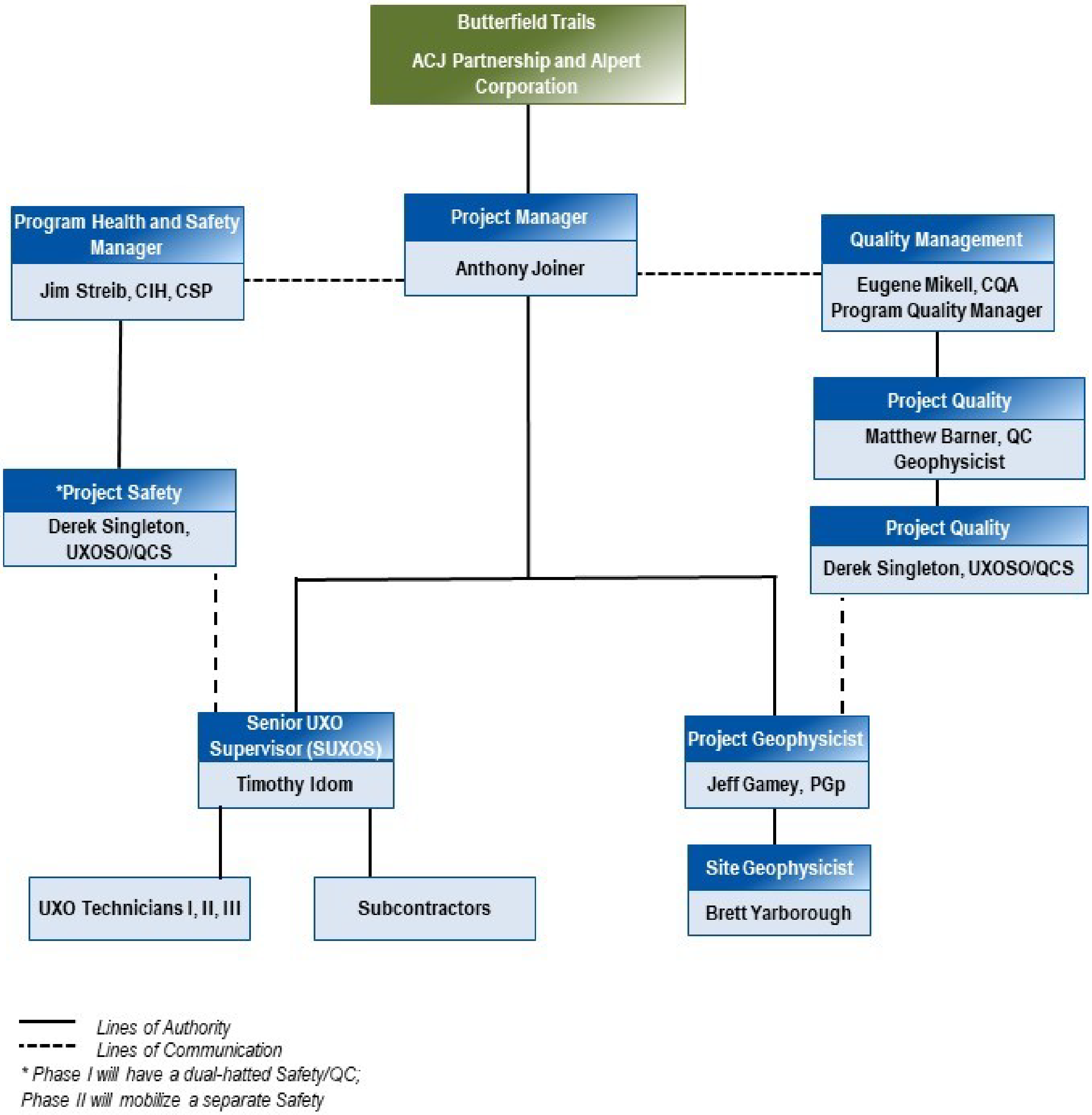

Figure 5-1. Project Organization Chart

Table 5-1. Project Team Responsibilities

Role	Responsibility
Project Manager	• Primary POC with the client and client environmental council (DeVoe Law) • Manages and directs day-to-day project execution and addresses project risks • Implements approved plans within approved cost, schedule, and technical baselines • Requisitions and manages all subcontracts • Ensures full integration of project safety, quality, and regulatory requirements • Stop Work for safety or quality issues; monitors implementation of corrective actions
SUXOS	• Supervises all field operation • Schedules field crew activities and plan the field schedule for the next day • Maintains daily field activities logbook • Establishes and maintains all equipment, computers, materials, and supplies necessary to perform the MR action • Daily reporting of MR action results to the PM • Stop Work for safety and quality issues; monitors implementation of corrective actions
UXOSO	• Directs on-site implementation of S&H programs • Ensures compliance with all applicable OSHA, and corporate S&H programs, SOPs, and other guidance documents • Ensures on-site personnel underwent required training • Audits work activity S&H compliance • Oversees safety incident investigations and maintains site-specific S&H statistics • Stop Work for safety and quality issues; monitors implementation of corrective actions
UXOQCS	• Directs implementation of the quality control program • Ensures compliance with all applicable USACE and corporate quality programs, SOPs, and other guidance documents • Implements project-specific QC policies/procedures and plans for MEC • Confirms on-site personnel received the required training • Audits MEC work activity ICAP compliance • Stop Work for safety and quality issues; monitors implementation of corrective actions
QC Geophysicist	• Responsible for all aspects of geophysical QC • Performs QC of processed geophysical data against project performance criteria • Designs blind seed program and oversee its implementation • Communicates QC failures to the CQM and initiates the root cause analysis process • Reviews implemented corrective actions for efficacy
Project Geophysicist	• Provides technical leadership in the discipline of geophysics • Monitors technical performance of team members • Assigns data processor • Interprets processed data • Provides technical recommendations to the Project Team • When requested by the PM, communicates with the client in areas of his technical expertise
Site Geophysicist	• Supervises geophysical field operations and related surveying activities, including directing geophysical field team activities • Coordinates with SUXOS for field planning • Maintains daily field activities logbook (all field personnel will maintain an individual logbook) • Checks areas to be surveyed and access routes in advance of data acquisition activities • Maintains data acquisition progress and uploading data to the processing center daily • Reports areas of geophysical coverage to the SUXOS and UXOQC daily • Performs repeatability checks of geophysical and navigational instrumentation at specified areas

6.0 COMMUNICATION PLAN

This section constitutes the Communication Plan for the project and will be implemented in support of field operations. The purpose of the Communication Plan is to clearly define lines of communication so that adequate information is gathered/used during the project and appropriate documentation is generated. All Tetra Tech personnel supporting the project will follow this plan to ensure maximum effective communication.

Tetra Tech's Project Manager (PM), Anthony Joiner, will be the primary point of contact for external communication to ACJ's project personnel.

6.1 Verbal Communication

Personnel supporting this project will direct communications to the Tetra Tech PM. The Tetra Tech PM will then correspond directly with the appropriate ACJ's team personnel.

A record of formal telephone conversations will be prepared for every call during which information affecting the project is passed. This practice will aid in creating the necessary level of documentation. The Tetra Tech PM will maintain the telephone conversation record.

All meeting minutes will be recorded and maintained on the Project SharePoint site.

6.2 Written Communication

The Tetra Tech PM shall be copied on all correspondence.

Internal memos should be used to document decisions and/or findings. Personnel who may require the use of the information should be carbon copied, as well as the Tetra Tech PM. E-mail is a suitable substitute for most internal memos.

6.3 Field Communications and Reporting

If changes or updates are made to the ICAP in the form of an FCR, or if a RCA is required to determine a problem or error, DeVoe Law and CDPHE will be notified and provided copies.

A Contractor Production Report will be completed daily by the SUXOS and sent to the Tetra Tech PM for distribution to all stakeholders to detail the on-site personnel, production, equipment, and summaries of safety and QC tasks.

6.4 Change Notifications

6.4.1 Internal

The PM will be notified immediately by Tetra Tech staff of changes to the scope of work, schedule, budget, or level of quality.

6.4.2 External

The Tetra Tech PM will notify ACJ by voice, e-mail, and/or letter of changes to the scope of work, schedule, budget, or level of quality as soon as possible using a project change request notice.

PM notification to ACJ will be direct to Ms. Michelle DeVoe for operational and contracting needs.

6.5 Informal Field Communication

The sections above primarily address the formal channels of communication for the project. This section is intended to address the less formal communication necessary to execute the project's day-to-day operations.

All leads on this project are seasoned professionals. It is expected communication in the field will be expeditiously executed with consideration of the project's best interest. The Tetra Tech field leads are authorized and encouraged to communicate directly with ACJ site personnel as required to support the project.

The Tetra Tech PM should be kept abreast of all salient communication for each field day. When in doubt, Tetra Tech field leads should err on the side of informing personnel up the chain of command rather than accept the risk of failing to ensure all project personnel are well informed.

7.0 HEALTH AND SAFETY

Tetra Tech's safety culture begins with *Zero Incident Performance* (*ZIP*) as an expectation and promotes continuous improvement in safety performance throughout the life of a project. A *ZIP* on a project (or task) is achievable through proper planning of the work, proper tasking of personnel on plan requirements, and proper execution of the work following the approved plans. The ZIP aims to achieve project completion with no injuries, illnesses, property damage, community, or environmental impacts.

7.1 Health and Safety Requirements

The Site-Specific Health and Safety Plan, Appendix A, establishes the project's minimum health and safety requirements. All operations will be performed in substantive compliance with DESR 6055.09. Specific discussion related to an explosive-related incident is provided below.

7.2 Explosive-Related Incident

If an explosive-related incident occurs, the senior UXO person available shall immediately notify 911, and all lead site personnel followed with notification to the PM. Additionally, the PM will notify Tetra Tech's Director of Technical Operations and Tetra Tech's Director of Health, Safety, and Environment.

7.3 Training

All personnel performing field operations at the BFT site will receive documented training to enable each individual to work safely in the scoped environment and understand the significance of project-specific hazards as follows:

- Recognizing hazards involved in the operation
- Recognizing signs and symptoms of exposure to extreme temperatures
- Administering cardiopulmonary resuscitation, first aid, and self-aid
- Executing emergency procedures

All personnel performing field operations at the BFT site will be trained to this ICAP, Health and Safety Plan (HASP), and all applicable munitions response-related procedures on the Tetra Tech Corporate Reference Library.

8.0 PROJECT DOCUMENTATION

Upon completion of the MR action, a Site-Specific Final Report (SSFR) be generated that contains the following:

- A summary of all field activities to include DGM operations, and intrusive investigations.
- DUA
- Figures detailing DGM results and intrusive investigation results.
- Documentation on all MEC/MPPEH, MD, range-related debris (RRD), and scrap disposal.
- Daily production reports
- Quality files and documents
- Site photos.

In addition to the project report, all field leads will maintain field logs to ensure the project's day-to-day activities are well documented, scanned, and included as an appendix to the SSFR.

After acceptance of the SSFR, CDPHE will issue a letter of No Further Action "NFA" allowing for residential development at the BFT site.

9.0 DEFINITIONS

Discarded Military Munitions (DMM) means military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage areas for disposal; provided, however, DMM does not include UXO, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of, consistent with applicable environmental Laws.

Munitions Constituents (MC) means any materials originating from UXO, DMM, or other military munitions, including explosive and nonexplosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions.

Munitions and Explosives of Concern (MEC) means (i) Unexploded Ordnance, (ii) Discarded Military Munitions and/or (iii) Munitions Constituents, which are present at the jobsite in high enough concentrations to pose an explosive hazard. For purposes of this Work Plan, determining whether the jobsite contains concentrations high enough to pose an explosive hazard shall be according to U.S. Department of Defense DOD Manual 6055.09-M, DoD Ammunition and Explosives Safety Standards (http://www.dtic.mil/whs/directives/corres/html/605509m.html).

Munitions Debris (MD) means remnants of munitions (e.g., penetrators, projectiles, shell casings, links, fins) remaining after munitions use, demilitarization, or disposal.

Unexploded Ordnance (UXO) means military munitions that have been primed, fuzed, armed, or otherwise prepared for action, and have been abandoned, fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installation, personnel, or material, and remain unexploded either by malfunction, design, or any other cause.

APPENDIX A

Health and Safety Plan

Butterfield Trails
Munitions Response Action
Aurora, Colorado

Health and Safety Plan

Prepared by:

TETRA TECH

Prepared by:		**Approved by:**	
	4/05/2021		04/17/2021
Name: Jeffrey (Jim) Streib, CIH, CSP, CHMM, CQA, SMS Title: HSE Director	Date	Name: Anthony Joiner Title: Project Manager	Date

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APPENDIXES

1.0 INTRODUCTION

This Health and Safety Plan (HASP) has been prepared by Tetra Tech, Inc. (Tetra Tech) for work activities at the Former Lowry Bombing and Gunnery Range (FLBGR) on Butterfield Trails property, Aurora, Colorado. The objective of this HASP is to provide reasonable assurance that field work conducted for this project will be performed in a safe and healthful manner in accordance with the Tetra Tech *Corporate Health and Safety Manual* (Tetra Tech, 2021) and regulatory agencies.

1.1 STATEMENT OF HEALTH AND SAFETY POLICY

Employers involved in hazardous materials handling are required by the United States Department of Labor, Occupational Safety and Health Administration (OSHA) to comply with general rules of workplace safety. This HASP has been designed to meet the requirements of OSHA, United States Environmental Protection Agency (USEPA), and other applicable state and local agencies. Changes in working conditions may necessitate modification of this HASP, but no deviations will be implemented without the prior notification and approval of the Tetra Tech project management team, except in emergency situations.

1.2 PURPOSE AND SCOPE

This HASP is designed to provide for a safe working environment for on-site field personnel during work activities. The goal of this HASP is to prevent and minimize personal injuries; illnesses; and damage to equipment, supplies, and property. All employees, subcontractors, and authorized site visitors involved with this project are required to adhere to this HASP, Tetra Tech Safety Manual, and appropriate requirements of OSHA.

1.3 SITE DESCRIPTION & HISTORY

The site description and history are addressed within the Integrated Corrective Action Plan (ICAP).

1.4 SCOPE OF WORK

The work elements will consist of the following primary work tasks, each of which is addressed in an Activity Hazard Analysis (AHA) described in Section 3.4. The scope of work for this project includes the following:

- Mobilization and Demobilization
- Surface Sweep
- Brush removal
- Boundary Survey
- Seeding
- Geophysical Field Survey
- Intrusive Investigation
- MEC/MPPEH Management

2.0 STAFF ORGANIZATION

The following sections summarize the organization of Tetra Tech staff members dedicated to HASP implementation, enforcement, and direction of fieldwork.

2.1 TETRA TECH PROJECT MANAGEMENT TEAM

2.1.1 Project Manager

The Project Manager designated for this site is Anthony Joiner. The PM or designee will oversee project field activities and is responsible for ensuring that appropriate resources and project personnel are available to implement the requirements set forth in this plan. Agency liaisons, if any, and client contact will be the responsibility of the PM.

2.1.2 Project Health and Safety Manager

Jeffrey (Jim) Streib, CIH, CSP, CHMM, SMS, CQA, is the Project Health and Safety Manager (PHSM). The PHSM is responsible for developing and revising the HASP. The PHSM will update and change the HASP, if warranted by changed conditions, and shall have the only authorization to affect such changes with input from the PM. The PHSM shall identify if and when the emergency action plan will be rehearsed and oversee periodic review of the Emergency Action Plan and update if necessary.

2.1.3 Senior UXO Supervisor

The Senior UXO Supervisor (SUXOS) for this project is responsible for the overall management of activities during clearance activities and will serve as the primary point of contact for all communication for onsite management issues. The SUXOS posts information at the site to ensure all occupants and visitors can safely exit during an emergency. The SUXOS ensures the HASP and other safety information (as necessary) are readily available to workers and site visitors. The SUXOS will be responsible to counsel employees under their direct authority and ensure compliance with health and safety standards and policies.

2.1.4 Tetra Tech UXO Safety Officer

The UXO Safety Officer (UXOSO) is responsible for field implementation of this HASP, including communicating site requirements to all personnel. For routine tasks, the PHSM may designate a responsible individual for field implementation of the HASP. Responsibilities of the SSHO or designee include:

- Enforcing the HASP;
- Conducting and documenting Tailgate Safety Meetings, Visitor Logs, and other health and safety forms;
- Stopping work as required to ensure personal safety and protection of property, or in the case of noncompliance with safety requirements;
- Taking prompt corrective measures to eliminate existing and predictable hazards;
- Taking the lead in emergency situation and arranging for emergency transportation to hospital;
- Examining work party members for symptoms of exposure or stress;
- Performing air monitoring as specified in this HASP; and

- Maintaining copies of health and safety files and training records in the site field office.

2.1.5 Subcontractors

The HASP will be made available to personnel working on the site, including subcontractors and site visitors. Individuals reviewing the HASP will be required to sign a written agreement after reviewing the document.

3.0 HAZARD RISK ANALYSIS

Field activities anticipated at the site may present a variety of chemical, physical, and biological hazards. Actual personal exposures to these hazards is dependent upon the specific work task, weather conditions, level of protection utilized, and personnel work habits. Control of these hazards will be accomplished through site reconnaissance and hazard identification, training of site personnel, PPE, use of appropriate survey procedures, and supervision of site activities.

3.1 CHEMICAL HAZARDS

Chemical hazards are not anticipated to be encountered during field activities, with the exception of residual explosives or hydrogen sulfide (H_2S), listed below. Personal exposures to the chemical may occur by inhalation, skin and eye contact, or a combination of these routes. The primary health hazard exposure limits associated with exposure to these contaminants are provided in the table below.

Compound	ACGIH TLV	OSHA PEL	Route of Exposure	Symptoms of Exposure	Target Organs	Physical Data
Explosives Residuals 2,4-DNT	0.2 mg/m3	1.5 mg/m3	Inhalation Ingestion Skin contact	Possible carcinogen. Mutagenic. Skin irritant, weakness, dizziness, blueness of the lips, eye irritation, respiratory tract irritation, nausea, drowsiness, vomiting, headache, fatigue, insomnia, tremors, chest pain, shortness of breath, heart palpitations, paralysis, unconsciousness	Blood, kidneys, liver, central nervous system	Yellow or yellow to red solid with a slight odor Melting point: 71°C Boiling point: 300°C Specific gravity: 1.32
Explosives Residuals RDX	n/a	n/a	Inhalation Ingestion	Not a carcinogen, mutagen, teratogen or reproductive toxin. Headaches, seizures, insomnia and nausea.	Central nervous system	Solid white powder, odorless. Melting point: 190°C Boiling point: Not Applicable Specific gravity: 1.8

Compound	ACGIH TLV	OSHA PEL	Route of Exposure	Symptoms of Exposure	Target Organs	Physical Data
H_2S	1 ppm	20 ppm	Inhalation Skin or eye contact	Irritation to eyes, respiratory system irritation, apnea, coma, convulsions, eye pain, lacrimation (discharge of tears), corneal vesiculation, dizziness, headache, GI disturbance, frostbite.	Eyes, respiratory system, central nervous system	Colorless gas with a strong odor of rotten eggs. MW 34.1 LEL 4% IP 10.46 eV

The primary health hazard exposure limits include applicable OSHA permissible exposure limits (PELs). The applicable PELs are defined by OSHA. Each PEL represents a time-weighted average (TWA) airborne concentration based on an 8-hour workday and a 40-hour workweek. OSHA also provides ceiling and short-term exposure limits (STELs), as appropriate. A ceiling value should not be exceeded at any time during a work shift (regardless of the TWA exposure). Exposure limits expressed as STELs generally represent an airborne concentration not to be exceeded for time periods longer than 15 minutes.

3.2 ENVIRONMENTAL HAZARDS

The principal physical hazards at the site include:

3.2.1 Temperature Stress

3.2.1.1 Heat Stress

Elevated temperatures, heavy physical labor, and the use of PPE present the possibility of heat stress to employees and subcontractors. Heat stress can occur at any time regardless of the season or weather. The occurrence of heat-related injuries is dependent on the amount of direct sun, wind, humidity, and degree of physical exertion.

Heat Rash: Skin irritation resulting from prolonged contact with wet clothing

Preventative measures: Rest in a cool place; keep skin dry and clean.

Heat Syncope (Fainting): Blood pools in legs and less blood goes to brain; caused by standing in heat for long periods of time and/or not acclimatizing to the heat.

Preventative measures: Moving around; not standing still

Heat cramps: Spasms in the abdomen or limbs, caused by loss of salts when sweating

Preventative measures: Drink electrolyte liquids.

Heat Exhaustion: Pale, clammy skin, profuse perspiration, weakness, headache, and nausea; loss of fluids and salts

Preventative measures: Rest in place, loosen clothing, drink electrolyte solution (slowly), elevate feet 8-12 inches from ground.

Heat Stroke: Life-threatening condition that occurs when the body's temperature regulating system no longer functions properly. Symptoms include hot, dry skin, a high fever [often 106 degrees Fahrenheit (°F) or higher], dizziness, nausea, rapid pulse, and unconsciousness. Brain damage and death may follow if the body temperature is not reduced.

Heat stroke will be treated as a medical emergency (Call 911, control situation, then call PHSM.)

Heat stroke should be treated immediately by bringing the affected person(s) out of direct sunlight and applying cool water or cold packs to the neck and armpits, and by following emergency procedures.

Procedures that shall be implemented to reduce the risk of heat stress include the following:

- Training to familiarize individuals with signs and symptoms of heat stress;
- Acclimating workers to site conditions, self-determining heat exposure, health status monitoring, and adjustment of expectations based on acclimatization;
- Implementing work/rest cycles, as appropriate, to periodically allow employees to remove protective clothing and warm up or cool down. Cotton undergarments can aid in absorbing perspiration and will hold it close to the skin, which will provide cooling from the limited evaporation that takes place underneath chemical-resistant clothing;
- Making liquids available to replace loss of body fluids and electrolytes during sweating. Perspiration is composed of sodium and potassium salts. Replacement fluids should be similar in composition (e.g., diluted Gatorade [3:1 ratio], or unsweetened fruit juices). The use of salt tablets is not recommended;
- Utilizing cooling devices if necessary;
- Monitoring of employee stress levels; and
- Replacing fluids.

The UXOSO will be responsible for monitoring symptoms of heat stress and the establishment of a work/rest regimen. The UXOSO may set up a physiological monitoring program that may include measurement of oral temperatures, body weight loss each day, and/or humidity, in order to assess work/rest regimens. If at any time a worker feels nauseated or dizzy, he/she will immediately stop work, cool off, rest (in a shaded area), and seek assistance if symptoms do not subside.

If determined necessary by the UXOSO scheduling of activities may occur so that work is performed early in the morning or late afternoon to minimize heat stress.

3.2.1.2 Cold Stress

Cold weather could be a problem during the winter months when temperatures may drop below freezing. As a result of the potential for freezing weather, workers will be educated regarding the following cold stress-related issues:

- Exposure to low temperatures presents a risk to employee safety and health through the direct effect of the low temperature on the body and collateral effects, such as slipping on ice, decreased dexterity, and reduced dependability of equipment.
- Work conducted in the winter months can become a hazard for field personnel due to cold exposure. Personnel must exercise increased care when working in cold environments to prevent accidents that may result from the cold. The effects of cold exposure include frostbite and hypothermia.
- Wind increases the impact of cold on a person's body. Systemic cold exposure is referred to as hypothermia. Local cold exposure is generally labeled frostbite. Recognition of the symptoms of cold-related illnesses will be discussed during the health and safety briefing conducted prior to the onset of site activities.

- Hypothermia is a life-threatening condition in which the core body temperature falls below 95°F. Hypothermia can occur at temperatures above freezing, particularly when the skin or clothing becomes wet. During exposure to cold, maximum shivering occurs when the core temperature falls to 95°F. As hypothermia progresses, depression of the central nervous system becomes increasingly more severe. This accounts for progressive signs and symptoms, ranging from sluggishness and slurred speech to disorientation and eventually unconsciousness.

Frostbite is both the general and medical term given to areas of cold injury. Unlike hypothermia, frostbite rarely occurs unless temperatures are colder than freezing and usually less than 20°F. Frostbite injuries occur most commonly on the distal parts of the body (nose, earlobes, hands, and feet) that are subject to intense vasoconstriction. The three general categories of frostbite are:

- Frostnip – a whitened area of the skin which is slightly burning or painful
- Superficial frostbite – waxy, white skin with a firm sensation but with some resiliency. Symptomatically feels "warm" to the casualty, with a notable cessation of pain
- Deep frostbite – tissue damage deeper than the skin, at times, down to the bone. The skin is cold, numb, and hard

3.2.2 Severe Weather

Windy conditions may increase airborne dust levels. Airborne dust in the eyes and respirable dust may pose a health hazard if nuisance dust reaches a level of 10 mg/m^3. In work areas visible dust must be controlled or workers may be required dust mask (N95 or better).

Thunderstorms may create electrical and other physical hazards during site activities. A lightning strike may cause significant injury or death. Whenever lightning is within visible range or thunder is within audible range, site activities will be shut down. Work vehicles such as pick-up trucks are generally the safest place for work crews to remain while thunderstorms are present, assuming that nothing grounds the vehicle. In addition, rainstorms may cause erosion of the site cover, slippery conditions, and flash floods in low lying areas.

3.2.3 Noise and Vibrations

Activities that involve heavy equipment operations may produce sound pressure levels exceeding 85 decibels, A–scale (dBA), 8-hour TWA, which would require the use of hearing protection. Long-term exposures to excessive sound pressure levels and vibrations can lead to temporary or permanent hearing loss and may also put stress on other parts of the body by causing abnormal secretions of hormones and tensing of muscles. Hearing protection (e.g., aural inserts or ear muffs) shall be worn by personnel in close proximity to operations producing excessive noise and vibration levels. Hazardous noise levels will be assumed when the ability to converse requires elevated voice levels.

Regardless of noise exposure, hearing protection will be available for use on site. The use of hearing protection for all Tetra Tech employees and subcontractors will be required if noise levels exceed 85 dBA TWA for 8 hours, and if efforts to control the noise at its source are not feasible, as per the OSHA standard for occupational noise exposure.

3.3 PHYSICAL HAZARDS

3.3.1 Slip, Trip, and Fall Hazards

All field personnel must be aware of hazardous site conditions, such as uneven terrain, that may present tripping or other safety hazards. Personnel must maintain clear footing and identify obstructions, holes, puddles, mud, and other tripping/slipping hazards at the site. PPE worn on the site can reduce dexterity, narrow the field of vision, and diminish communication and hearing capabilities. Personnel will ensure that slip, trip, and fall hazards are minimized by properly securing all equipment and by maintaining a neat, uncluttered site. A minimum distance of 3 feet is required from any vertical drop-off, as weathering of soils may cause instability.

3.3.2 Flammable/Explosive Materials

Munitions and explosives of concern (MEC) may be present at the site. SOPs have been developed and will be adhered to for handling MEC. An additional fire hazard is present when workers must fuel generators used to power equipment or use other equipment that may generate sparks. More information on fire protection, prevention, and storage of flammable materials can be found in Section 29 of the Code of Regulations (CFR) 1926 Subpart F.

Personnel will adhere to the following precautionary measures when working:

- Smoking is allowed in designated areas only.
- ABC-rated fire extinguishers will be located in field crew vehicles, and field personnel will be instructed in the proper use of this equipment.
- Electrical equipment shall be properly grounded and if a sparking hazard is present, equipped with spark-arrestors.
- Fuel for vehicles, generators, or other equipment and other flammable materials must be stored in approved portable containers appropriately labeled.

3.3.3 Pinch/Compression Points

Handling of tools, machinery, and other equipment on site may expose personnel to pinch/compression point hazards during normal work activities. Where applicable, equipment will have intact and functional guarding to prevent personnel contact with hazards. Personnel will exercise caution when working around pinch/compression points and will use additional tools or devices (e.g., pinch bars) to assist in completing activities.

3.3.4 Injury Due to Manual Material Handling

During execution of planned activities, there is some potential for strains, sprains, and/or muscle pulls due to the physical demands and nature of this site work, predominantly tasks that will involve manual material handling activities such as lifting, carrying, and depositing heavy and/or bulky loads. To avoid injury during these tasks, personnel are to lift and deposit loads in the following manner:

- First, inspect the area where the load will be lifted, the path on which it will be carried, and the area where it will be placed. Remove any obstructions that could present tripping hazards or select an alternate route/approach.
- Do a "test lift" by slightly moving the object to gauge its weight and your ability to safely lift, carry, and deposit it. The actual weight of an object may be deceptively heavier than its perceived or assumed weight (such as a section of sod which may have significant moisture content). If after the "test lift" you are not very confident that you can move the object safely and without injury, STOP! Get help, a mechanical aid (such as a dolly or wheel barrow, etc.), or both.

- Approach the load and position your body as close to the load as possible.
- Bend at the knees, and not the back.
- Ensure that you can obtain and maintain firm handholds on the load.
- Lift the load using your legs, not your back muscles.
- DO NOT turn or twist while lifting, carrying, or placing the load.
- Place the load by bending at the legs, again avoiding turning, twisting, or bending at the back.
- When lifting or handling heavy material or equipment, use an appropriate number of personnel. Keep the work area free from ground clutter to avoid unnecessary twisting or sudden movements while handling loads.

3.3.5 Confined Space Entry

Confined spaces are not anticipated. No permit-required confined space entry will be performed under this HASP.

3.4 BIOLOGICAL HAZARDS

The following subsections present a summary of biological hazards that may be present at the site. For each biological hazard presented, a short description and picture of the hazard are provided, followed by emergency procedures.

3.4.1 Dangerous Plants

The potential for contact with poisonous plants exists when performing surveys or vegetation removal tasks in undeveloped and vegetated areas. Poison ivy, oak, and sumac can be found as vines on tree trunks or as upright bushes. Poison ivy consists of three leaflets with notched edges. Two leaflets form a pair on opposite sides of the stalk, and the third leaflet stands by itself at the tip. Poison ivy is red in the early spring and turns shiny green later in the spring. Poison ivy has white berries and both poison ivy and oak have red or yellow foliage in the fall of the year.

Contact with poisonous ivy may lead to a skin rash in susceptible individuals. A rash result from a toxin found in the sap; it is extruded from the leaves and contained in the stems and roots. The rash is characterized by reddened, itchy, blistering skin requiring first aid treatment. In the event of contact with one of these plants, immediately wash skin thoroughly with Dawn soap and cool water, Technu or Zanfel, taking care not to touch face or other body parts. Seek medical advice if a severe reaction occurs, or if there is a known history of previous sensitivity. Employees will be trained in the identification of these species and will be advised to wear protective clothing such as gloves and long-sleeved shirts when working conditions permit. Employees should also consider applying barrier lotions (e.g. Ivy Block) to skin that has the potential to contact these species. Alcohol wipes, Dawn liquid soap and Technu can be used to decontaminate skin and reusable clothing to prevent exposure to poison ivy. Gloves should be worn when removing and decontaminating clothing potentially exposed to poison ivy.

3.4.2 Venomous Arthropods and Snakes

Snakes and venomous arthropods, including spiders, scorpions, ticks, and insects, create a hazard when their habitats are disturbed. The best defense is to understand where these creatures may be found and avoid them.

Venomous Arthropods

Spiders including brown recluse and black widows, scorpions, ticks, bees and wasps are common arthropods found in this area, some of which are poisonous or may carry other diseases. A sting or bite may cause persistent pain, numbness, and tingling. Personnel shall be especially careful walking in grass and underbrush. Boots and heavy pants should be worn. In the event of a bite or sting, normal treatment for this type of poisoning is an ice pack on the site, alternating every 10 minutes with the pack on, then off. Ticks can carry many diseases, including Lyme disease. When in the field, check often for ticks. Ticks are best removed by a physician.

Employees who are allergic to bee stings will avoid work in any areas where there are known bee hives or other activity. In the case of an accidental bee sting, an employee with allergies will be rushed to the hospital emergency room. Employees stung by scorpions should seek medical evaluation. This will be treated as an emergency and proper incident reporting procedures will be followed.

Other insects common to this area include mosquitoes, which may cause infection or spread diseases. Most common symptoms of mosquito bites are inflammation and itching of the affected area, and in some cases, mosquitoes may be carriers of diseases such as the West Nile virus. Mosquitoes are generally more active during the summer and are found in greater numbers in areas where stagnant surface water is present. Mosquito bites can be avoided by using insect repellant containing N,N–diethyl–meta–toluamide (DEET) and wearing long–sleeve shirts and long pants.

Venomous Snakes:

The best defense against any venomous snake is to simply never go near it. Many bites occur on hands and arms while people are reaching for the snake to move it. Rattlesnakes are not the only snake that shake their tail when threatened! The cottonmouth will also shake its tail very quickly, rustling the leaves to let you know its agitated. Heed the warnings and leave the snake alone!

Personnel shall be especially careful walking in grass and underbrush. Boots and heavy pants should be worn. In the event of a snakebite, the affected area will be immobilized, and the victim will be transported to the hospital. Snakebite kits are not used, as current American Red Cross first aid procedures do not advocate their use. Based on this recommendation, no other treatment will be performed by on-site personnel for this sort of injury.

In all cases of contact with venomous arthropods and snakes, the victim shall be transported to the identified medical facility for treatment.

3.4.3 COVID

Utilizing the Hierarchy of controls is the best approach to protecting yourself from COVID. This includes: access to soapy water and/or access to hand sanitizer; increasing the use of sanitizer or handwashing beyond the norm. Sneeze/cough into elbow if no tissue is available, but if tissue is available discard the tissue into an appropriate waste bin. Do not come to the office or go to client sites when unwell – work from home or take leave as required. Establish and implement high-touch surface spot cleaning for field and office. After grasping handles others have touched wash or sanitize hands and/or use a tissue (do not forget shared tools, mobile equipment handles, etc.).

Avoid touching your face. When possible travel in individual vehicles rather than having several personnel in one vehicle. When renting/checking out the vehicle wipe the door handle prior to touching. Once in, wipe the steering wheel and gear shifter. (Note that rental companies are increasing their cleaning, but you should as well.) During travel get takeout in the drive-thru instead of going in to eat (many locations no longer have sit-down service at this time).

While on job sites, if meeting/working with others then be alert and keep distance from one another; generally, 6+ feet apart is desirable. Wear face covering when social distancing cannot be maintained.

3.5 ACTIVITY HAZARD ANALYSIS

The following job safety analyses and specific hazards control procedures have been prepared for Tetra Tech personnel involved in field activities at the site. Physical hazards are discussed in Section 3, PPE levels are described in Section 6 and air monitoring requirements are described in Section 7. Field personnel will be briefed on the hazards discussed in this HASP at the beginning of this project and periodically during tailgate safety meetings. If evidence of physical hazards or a change in chemical hazards are discovered, the UXOSO will be notified immediately.

Safe handling and control of MEC are covered in the SOPs and the ICAP and will be reviewed prior to initiating site activities. Note that AHAs are specific to Tetra Tech tasks. Subcontractors will be required to adhere to the guidance in this HASP (e.g., land surveyors). In addition, AHAs will be revised as needed upon mobilization to the field.

4.0 TRAINING

Tetra Tech Health and Safety Program for Hazardous Waste Site Activities provides the corporate guidelines for the training program. The PM, and UXOSO will ensure personnel have completed the required training for the site, prior to field activities. All training must be documented, and the UXOSO keeps copies of training documentation in the project files.

4.1 SITE PERSONNEL

All site personnel engaged in MEC clearance activities shall be trained in accordance with 29 CFR 1910.120. Employees will have received a minimum of 40 hours of hazardous materials operations and emergency response (HAZWOPER) classroom training and a minimum of three days actual field experience under the direct supervision of a trained, experienced supervisor. The on-the-job training for each level of PPE is documented on the Form HST-1 or equivalent. In addition, all personnel subject to potential exposure to contaminants shall receive notification of the hazardous chemicals they may be exposed to.

Personnel performing non-intrusive fieldwork such as construction activities in controlled areas are exempt from HAZWOPER requirements and will only be allowed to work within designated areas where hazards are mitigated under the supervision of HAZWOPER-trained employees.

4.2 REFRESHER TRAINING

Personnel engaged in field activities that are subject to the training described in Section 4.1 above shall receive 8 hours of HAZWOPER refresher training annually.

4.3 PRE-ENTRY BRIEFINGS & INFORMATIONAL MATERIAL

The following training sessions and informational materials will be provided on the site:

- **Health and Safety Plan** – All Tetra Tech workers at the site shall be informed of the contents of the HASP. Signing the HASP Consent Agreement form is an acknowledgment of the worker that he/she understands the HASP.
- **Pre-job health and safety conference** - The UXOSO may conduct a pre-job health and safety conference before the commencement of work. This should cover site-specific hazards and updates to the HASP, and all personnel, subcontractors, and site visitors are required to have initial, 1 hour of site-specific training upon arrival to the site, in addition to daily tailgate safety briefings.

- **Tailgate safety meetings** – A tailgate safety meeting will be conducted at the beginning of each shift or work day by the UXOSO or designee. The health and safety considerations for the day's activities will be discussed and the necessary protective measures/equipment outlined. All Tetra Tech employees, subcontractors, and site visitors present for the daily tailgate safety meetings are required to sign the tailgate safety meeting form.
- **Visitor log/sign-in sheet** – All site visitors must sign in upon entry of the Tetra Tech work area. Access into a work area may be denied based upon inadequate safety training and/or PPE requirements.
- **Safety Data Sheets** – SDSs for the hazardous chemicals that are used on-site are presented in Attachment 3 and can also be found in the field office or vehicles located at the site.

4.4 HAZARD COMMUNICATION PROGRAM

The purpose of a Hazard Communication (HAZCOM) or Right-To-Know Program is to ensure that the hazards of all chemicals located at the site are communicated according to 29 CFR 1926.59 regulations and Globally Harmonized System of Classification and Labelling of Chemicals (GHS) to all Tetra Tech site employees. This program requires:

- **Hazard Determination:** Chemical hazards are classified for labeling and communication
  - **Health Hazards**: acute toxicity, skin corrosion/irritation, serious eye damage/irritation, respiratory or skin sensitization, germ cell mutagenicity, carcinogenicity, reproductive toxicity, single/repeated exposure, aspiration, and simple asphyxiants
  - **Physical Hazards**: explosives, flammable gas/aerosols, oxidizing gas, pressurized gas, flammable liquid/solid, self-reactive, pyrophoric liquid/solid/gas, self-heating, contact with water emitting gas, oxidizing liquid/solid/peroxides, corrosive to metals, and combustible dust
  - Hazards not otherwise classified; and Environmental Hazards (not governed by OSHA).
- **Chemical Inventory:** Includes hazardous nature and potential for exposure. SDSs are managed. Employers are required to train people about hazards associated with chemicals in site inventories.
- **Container Labeling** – Personnel will ensure that all containers are properly labeled according to contents. All labels will be checked for identity, hazard warning, and proper contact information. Use legible labels and other forms of warning (i.e., placards for storage tanks) to clearly and quickly communicate the identity and hazard(s) of chemicals in the workplace. Chemical IDs and other warnings (i.e., National Fire Protection Association) are to be conspicuously placed on secondary containers so that the message is readily visible. The Right to Know warning requirement mandates that a clear and reasonable warning be given to all individuals prior to exposure to any listed chemical. Under GHS, warnings used on labels include six new elements:
  - **Signal Word**: relative level of hazard (**warning** = less severe and **danger** = more severe)
  - **9 GHS Pictograms**: Chemical/physical (explosion, flame, oxidizers, gas cylinder, corrosion), health/risk (health hazard, skull and crossbones – severe toxics, exclamation mark – acute toxics, corrosives), and environment (non-OSHA). Note corrosive listed twice. Pictograms may be combined.
  - **Product name or identifiers**: Must be linked to SDSs and chemical inventories.
  - **Hazard Statements**: Describe the nature and often the degree of hazards.
  - **Precautionary Statements:** Describe general preventative response, storage, and disposal precautions.
  - **Manufacturer, importer, or other responsible party**: Specify company name.

  Warnings can be communicated by:
  - A warning on a product label

  - A warning or sign posted conspicuously in the workplace
  - A warning that complies with the federal OSHA “Hazard Communication Regulation” (29 CFR, Section 1910.1200).

- **Safety Data Sheets** –SDSs or their equivalent for hazardous materials used at the site shall be available for review by all project personnel (Attachment 3). SDSs utilize a standardized format, which includes: (1) product identification, (2) hazard identification (precautions, health hazards, carcinogenicity), (3) common names of ingredients, (4) first aid measures, (5) firefighting, (6) accidental release, (7) handling/storage, (8) exposure control (routes of exposure, exposure limits), (9) physical/chemical characteristics, (10) stability/reactivity, (11) toxicological info, (12) ecological information, (13) disposal considerations, (14) transport information, (15) regulatory information, and (16) date of SDS preparation/revision and manufacturer/importer contacts.
- **Employee Information Training** – Training employees on chemical hazards is accomplished through formal safety training conducted annually and informal safety meetings. Project-specific chemical hazards are communicated to employees through an initial site orientation meeting and during daily tailgate safety meetings. Employee training on new or revised SDS information must be provided **within 30 days** of the employers’ receiving that information. Employees are trained on all chemicals on or at a jobsite which pose a hazard, including: operations using chemicals; SDS/HAZCOM binder location; recognition of signs and symptoms indicating exposure, monitoring methods, physical hazards of chemicals, protective measures, and explanation of SDSs and labeling requirements.
- **Subcontractor Awareness** – All subcontractors and tiered subcontractors must comply with HAZCOM, read, and sign acceptance of the site-specific HASP, and know location(s) of SDS/HAZCOM information on the jobsite.

5.0 MEDICAL SURVEILLLANCE

5.1 PHYSICAL EXAMINATION

As required by Tetra Tech, all Tetra Tech field personnel will participate in annual or biennial physicals. These physicals must be in compliance with OSHA 1910.120 requirements for hazardous waste site operations.

The employee will be informed of any medical conditions that would result in work restrictions that would preclude him/her from working at hazardous waste sites.

5.2 MEDICAL RECORDS

Medical clearance documents and personnel exposure monitoring records will be maintained in accordance with the requirements of 29 CFR 1910.120 and will be kept for 30 years. Employees have the right to contact CORE (855-683-9006) and request copies of medical records. A copy of the medical examination is provided to the employee at his/her request. Tetra Tech does not keep medical records on file, in accordance with privacy laws.

5.3 INJURY AND ILLNESS TREATMENT

If an injury/illness is the result of a chemical exposure, the UXOSO will promptly initiate the steps necessary to identify the chemical(s). Chemical identification will be accomplished through use of monitoring equipment and any prior sampling results that are available. Such information will be made available to the treating physician.

5.4 DRUG SCREENING

In accordance with the Tetra Tech Substance Abuse Policy, drug screens may be required for individuals in the event of a motor vehicle incident or other serious incidents causing harm to people or property damage. The employee will be escorted for drug screening immediately following a serious incident.

6.0 PERSONAL PROTECTIVE EQUIPMENT

Selection of appropriate PPE is required prior to the commencement of work. Key factors involved in this process are identification of known and suspected hazards, routes of entry, and the performance of the PPE in providing a barrier to these hazards. Tetra Tech maintains a respirator fit test, usage, and maintenance program in accordance with 29 CFR 1910.134 and American National Standards Institute (ANSI) Z88.2-1969.

6.1 LEVELS OF PROTECTION

PPE is divided into four categories based on the amount of protection given. Level A is the highest level of protection and Level D is the lowest. The levels of protection prescribed with this plan is Level D. Levels A, B, and C will not be used for work activities at this site. Levels of protection and PPE requirements for this plan are summarized in table below. Supervised construction activities will be performed using Level D PPE which will include safety toe boots, safety glasses, hearing protection, work gloves (as needed), and work uniforms/overalls or long pants and shirts at a minimum.

The identified chemicals of potential concern may be present in recovered MEC. Nuisance dust may be generated during field activities. The major routes of exposure to these chemicals of potential concern are through inhalation and dermal contact. Level D PPE will be utilized for all activities.

Level of Protection	**Equipment List**
LEVEL D	
No respiratory hazards	Outer cut resistant work gloves
	ANSI-approved safety-toe boots
	ANSI-approved safety glasses or a face shield
	ANSI-approved hard hat (as required)
	NRR 25 or greater hearing protection (as required)

Notes:
ANSI – American National Standards Institute
NRR – noise reduction rating

6.2 PERSONAL PROTECTIVE EQUIPMENT LEVEL CHANGES

Upgrading of PPE requirement is not anticipated for this project.

6.3 LIMITATIONS OF PERSONAL PROTECTIVE EQUIPMENT

PPE is intended to shield or isolate individuals from the health and safety hazards that may be encountered on site. However, PPE is limited in its capability to completely protect users. In addition, the use of PPE can in itself create several worker hazards, including impaired mobility, impaired vision, impaired communication, increased workload, and exertion.

A person's medical condition can also limit the use of PPE. Some potentially limiting medical conditions include compromised pulmonary function, heart disease, physical handicaps, obesity, physical condition, and age. Finally, heat and cold can affect both the performance of the PPE and the user in his or her ability to tolerate PPE use. Heat and cold stress are discussed in detail in Safe Working Practice (SWP) 5-15 and 5-16.

6.4 TRAINING AND DONNING AND DOFFING PROCEDURES

Proper PPE donning and doffing procedures will be demonstrated and practiced before employees are permitted to wear the PPE on a project site. Each employee shall be trained to know and understand the following:

- When is PPE necessary?
- What PPE is necessary?
- How to don the PPE;
- How to doff the PPE;
- Limitations of the PPE;
- Proper care and maintenance of PPE;
- Useful life of PPE; and
- Proper disposal of PPE.

Each employee required to wear PPE shall demonstrate his/her understanding of the training elements listed above, before being allowed to perform work requiring the use of PPE.

Personnel engaged in hazardous waste site activities will receive training in the selection, use, maintenance, and decontamination of PPE (Levels B through D) during initial 40-hour or 24-hour HAZWOPER training, including lectures, classroom demonstrations, and videotape simulations. In addition to basic classroom instruction, all personnel must complete a minimum of 24 hours of supervised training in the field in each level of protection before that employee is considered competent to operate at that level of protection in the field without supervision. Documentation of employee training will be maintained in the site files.

During annual refresher training, employees will be provided with information on any new types of or changes to available PPE. General concepts on the proper use of PPE will also be covered and will include discussion of any instances of improper use of PPE during the previous year.

6.5 INSEPCTION OF PERSONAL PROTECTIVE EQUIPMENT

The following PPE inspection guidelines will be followed before, during, and after use of PPE during all work activities at the site:

6.5.1 Boots

All work boots must be equipped with steel or composite toe protection in accordance with ANSI Z41 Part 99.

6.5.2 Safety Glasses

All safety glasses must be tested for penetration and shattering resistance, in accordance with ANSI Z87.1. In addition, safety sunglasses should block at least 100 percent and 95 percent of ultraviolet A and B radiation, respectively, in accordance with ANSI Z80.3 optical standards.

6.5.3 Gloves

Before using nitrile or latex gloves, they should be inspected for any tears or holes. Used gloves shall be properly discarded and not re-used. Insulated gloves will be used for electrical tasks.

6.5.4 Clothing

The UXOSO will determine which level of protection is correct for the specific job or task at the site. All clothing must be visually inspected for tears, punctures, malfunctioning zippers or closures, and imperfect seams. During use, clothing should be checked for evidence of chemical alteration (i.e., discoloration, swelling, stiffening, and/or softening), failure of zippers or other closures, tears, punctures, and malfunctioning seams. Loose or baggy clothing or jewelry should not be worn around heavy equipment where snag hazards are present.

6.6 EVALUATION OF THE EFFECTIVENESS OF PERSONAL PROTECTIVE EQUIPMENT PROGRAM

In order to evaluate the effectiveness of the PPE program, the UXOSO will monitor activities to ensure equipment utilized is adequately protecting employees. If changes to PPE requirements are necessary, based on scope of work changes, new requirements will be added the task specific AHA, and reviewed will all employees involved in the task.

7.0 EXPOSURE MONITORING PLAN

Mitigation of silica dust will be performed in accordance with 29 CFR, Part 1926.1153 table one. If table one cannot be fully achieved, then the Exposure Control Plan located within Appendix D will be used. If visible dust is generated, operations will be modified, or water spray applied to control dust. Residual explosives that may be present in recovered MEC, is not anticipated to be found in quantities that would require monitoring.

7.1 ENGINEERING CONTROLS

Engineering controls that may be implemented in order to limit or mitigate emissions of dust. Engineering controls utilized for dust control measures include spraying down an area with water or controlling vehicle speeds.

7.2 EXPOSURE MONITORING RECORDS

If personal monitoring is performed on any site workers, their employee exposure records will include any personal monitoring results, laboratory reports, calculations, and air sampling data sheets. These records will be kept in accordance with 29 CFR, Part 1910.20 (8 CCR, Section 3204). For Tetra Tech, subcontractors, and other companies, the originals will be sent to the records coordinator of each company overseeing the employee's records.

8.0 SITE CONTROL

Daily control and accounting of all personnel present on site will be accomplished by a Daily Tailgate Safety Meeting form to be signed by all personnel on the site. Visitors will be noted in the field book and the Site Visitor Log.

8.1 SITE COMMUNICATIONS

Internal emergency communication among on-site personnel has been established and is detailed in Section 10.3, Emergency Communication.

The primary means of external communication will be cellular telephone. Telephone communications will be used to coordinate emergency response, report to management, and maintain contact with essential off-site personnel. Contact may be difficult in parts of the site and personnel may need to move to another area before external contact can be made. In the case of no phone reception or poor phone reception, use voicemail and paging features.

8.2 SITE WORK ZONES

As required for operations, work zones will be clearly identified as appropriate with safety cones, flags, barrier tape, signs, or other means.

The precise locations of the work zones, equipment storage areas, rest areas, restroom/hand washing facilities, and routes of exit will be established in the field. These zones will be established by the UXOSO and will be communicated to the site workers as part of the daily tailgate safety meetings.

8.2.1 Exclusion Zone (EZ)

This is the area of suspected contamination. Because the potential for exposure to contaminants exists within this zone, only those personnel meeting all requirements specified in the HASP and Workplan, may enter the EZ. The EZ will be enclosed with a marker system.

8.2.2 Support Zone (SZ)

This area is generally outside the EZ. A rest area will be located in the SZ. Equipment, vehicles, and personal items that are not directly used for site work should remain in the SZ.

8.3 INITIAL SITE ENTRY

A daily tailgate safety meeting will be conducted prior to initial site entry and, if warranted, before commencement of work at each task location. The site will be visually inspected and monitored for potential hazards prior to employees entering the area.

8.4 SITE CONDUCT

The following safe work practices and conduct will be followed by all persons working at the site, including subcontractors:

- All personnel working at the site are required to conduct themselves in a professional manner at all times. Such conduct is required to ensure compliance with procedures established in this plan for the health and safety of the employees and others. Violation of established work rules may result in disciplinary actions.
- Activities performed in potentially contaminated or otherwise hazardous areas will be conducted with a "buddy" who is able to provide assistance, if necessary.

- No alcoholic beverages, illegal drugs, or firearms will be allowed on site. Anyone reporting to work under the influence of alcohol or drugs will be subject to disciplinary action.
- Horseplay will not be tolerated. Horseplay encompasses any frivolous behavior that increases the probability of an accident.
- Eating, drinking, smoking, applying cosmetics, chewing gum, or tobacco is prohibited in the EZ. The consumption of liquids (e.g., Gatorade™) for heat-stress control will only be allowed in designated areas.
- Hand washing is required prior to eating or smoking.
- Smoking will be limited to designated smoking areas determined by the UXOSO.
- Employees will clean up at the end of their daily task before leaving the site. This includes pickup and proper storage of tools and PPE.
- Equipment will be shut down during fueling, and as appropriate, equipped with spark arresters. Proper procedure for fueling will be followed in order to protect the environment from fuel spills and refueling is only allowed in designated areas as determined by the UXOSO.
- Immediate access to an ABC-rated fire extinguisher and first aid kit will be provided. All vehicles will be equipped with ABC-rated fire extinguishers and first aid kits. All field personnel will be instructed in the proper use and location of fire extinguishers and first aid kits.
- The UXOSO or designee will ensure that an adequate supply of potable water is available in each vehicle on site prior to commencing field activities.
- Changes in work practices or work rules will be implemented only after approval by the UXOSO.

8.5 SPILL CONTAINMENT PLAN

Fuel and lubricating oil used in equipment could be the source of spills. Care should be exercised during refueling activities. Any spilled liquids will be treated as hazardous materials. If a spill occurs, the field team members will do the following:

- The spill area should be bermed in order to prevent the spill from spreading further, and any nearby drains should be blocked;
- Obtain appropriate sorbent materials and a container in which to collect the spilled material. These materials will be stored in site vehicles at all times.
- Pump or scoop up the spilled material and any additional contaminated surface debris and soil and place it in a suitable container or area.

In the event that a spill is too large to be handled safely by the field team, the area around the spill will be secured and the UXOSO contacted for further instructions.

9.0 DECONTAMINATION PROCEDURES

Traditional decontamination is not anticipated for this clearance activity. MEC with the potential of containing residual explosives will be handled in accordance with SOPs for Range Clearance Activities and the MEC Work Plan. Employees will implement good hygiene practices, including washing hands/face, before eating, drinking, smoking, etc. to remove general soil from manual activities. Soil will be removed from all equipment, as a general maintenance requirement, before leaving site.

9.1 EQUIPMENT DECONTAMINATION

9.1.1 Equipment

The vehicle towed array (VTA) will be inspected daily by the operators. Filters will be cleaned using an air compressor, to eliminate debris that could cause any issues to the vehicle. The VTA will not be operated on roadways. Additional procedures such as pressure washing may be used.

10.0 EMERGENCY ACTION PLAN (EAP)

The EAP has been developed for remedial construction activities at the site. The purpose of this EAP is to ensure decisive action in the event of a site emergency. The emergency hospital route map and contact number information are provided in Appendices B and C of this HASP.

10.1 EMERGENCY ACTION SEQUENCE - BASIC FIRST AID GUIDELINES

The UXOSO or designee will be responsible for determining the severity of an emergency situation. The sequence for basic first aid will be as follows:

- Assess the scene and determine if it is safe for victim and rescuer.
- Check airway, breathing, and circulation (i.e., the ABCs of cardiopulmonary resuscitation [CPR]).
- Have someone call for help (i.e., 911) and return to the scene to confirm the call.
- Perform secondary survey including head-to-toe examination and vital signs (i.e., pulse, skin, respiration, level of consciousness, eyes), control bleeding (i.e., apply direct pressure, elevate, pressure points), and treat for shock (i.e., keep warm, reassure, elevate feet unless suspected head or spinal injury or increased pain).
- All injured personnel will be taken to the designated local medical facility and all uninjured personnel will remain in a safe area.

10.2 GENERAL RESPONSE PROCEDURES

It will be the responsibility of the on-site UXOSO or designee to determine the appropriate response to an emergency incident. The following is a basic sequence of events to follow. This is only provided as a guideline; during an actual emergency, the UXOSO, or the designee must evaluate the situation on an ongoing basis and determine appropriate actions to follow.

- Remove all personnel from the source of the chemical or physical hazard; use predetermined alarm system (three short blasts of a compressed air horn or car horn).
- Assess the severity of the incident.
- Perform responses within the capacity of site personnel.
- Decontaminate as necessary.
- Contact appropriate emergency assistance if necessary.
- Swiftly move injured or exposed personnel to a rendezvous point for aid.

10.3 EMERGENCY COMMUNICATIONS

The primary means of external communication will be cellular phone. Telephone communications will be used to coordinate emergency response, report to management, and maintain contact with essential off-site personnel. In an emergency, personnel may need to relocate to obtain adequate signal strength for cellular phones to make outgoing calls or receive incoming calls, and then return to the scene.

10.3.1 Emergency Reporting

The emergency contact information contains contacts from within Tetra Tech and external agencies. First contact the agency required to control situation (e.g., fire department), then contact Tetra Tech PHSM or PM.

10.4 EMERGENCY RECOGNITION AND PREVENTION

This HASP has been developed to assist in emergency recognition and prevention (ERP). All site personnel must be familiar with the ERP and be knowledgeable of the information regarding site hazards and control methods.

10.5 EMERGENCY MEDICAL PROCEDURES

Prior to commencement of field operations, an emergency medical assistance network will be established. The fire department, ambulance, hospital with an emergency room, and directions to the hospital are identified in the list of emergency phone numbers on Appendix B of this HASP. In the event of an emergency, the appropriate agency will be contacted using a telephone. A vehicle will be available on-site during all activities to transport personnel with non-life-threatening injuries to the identified emergency medical facility. Telephone numbers and locations, including the location of the emergency facilities, will be readily available inside the field vehicle.

The UXOSO will be certified to render first aid and CPR prior to initiation of field activities. A first aid kit will be available at the work site as well as an adequate supply of fresh water.

10.5.1 Injury or Exposure

Employees are required to notify the UXOSO of any suspected exposure as soon as possible following the occurrence. In the event of an injury or suspected exposure, the UXOSO or designee will contact the appropriate emergency contact number(s).

Should an injury or exposure occur while the employee is in either the EZ or the CRZ, emergency decontamination procedures will be implemented. The employee will be brought immediately to the decontamination area where team members will decontaminate the employee as necessary.

As soon as possible after an injury or suspected exposure, the PHSM or UXOSO will investigate the circumstances surrounding the injury or exposure and file the electronic report in Tetra Tech's TOTAL incident reporting system. In the event of any incident the Tetra Tech PM will be notified as soon as possible. Within three working days of any reportable incident, the UXOSO will complete any additional incident reports as required. These reports will include investigation results and recommendations on how to prevent similar events.

10.5.2 Emergency Equipment and First Aid Requirements

On-site emergency equipment will include primarily items for general safety use. These include:

- Dry-chemical ABC–rated fire extinguisher
- Potable water
- First aid kit

Tetra Tech will supply these items.

10.6 ON-SITE EMERGENCY ALERT SYSTEM

The following alert system will be implemented by the PM or the UXOSO as a means of notifying site personnel of an emergency:

In the event of fire, hazardous spill, vapor release, or other hazardous event, three short blasts of a compressed air horn or car horn will be the signal to evacuate the site. All personnel evacuating the EZ will proceed to a predetermined upwind location where the UXOSO will conduct a head count and provide further instructions.

10.7 EMERGENCY ACTION PLANNING

The emergency hospital route map (Appendix C) and emergency contact information (Appendix B) should be readily available to all site personnel and will be located on the dashboard of the Tetra Tech work vehicles at the job site. A copy of this HASP will be maintained on site by the UXOSO at the project location. The following planning measures will be instituted to facilitate responses to emergency situations:

- The UXOSO or designee will conduct a tailgate safety briefing prior to the commencement of field work. Copies of this HASP will be made available to all project personnel. After reading the plan, all personnel will be required to sign the Site Safety Plan Consent Agreement form (Attachment 2).
- The UXOSO will review task AHAs with work crews, update as necessary, and employees will sign AHAs to acknowledge they understand the hazards and mitigation strategies for their tasks.
- All Tetra Tech field personnel will be instructed in the use of all field safety equipment before any field activity takes place.
- All personnel will be instructed in emergency communication protocols appropriate to the project.
- The UXOSO will verify that all field personnel have fulfilled the project training and medical monitoring requirements.
- The UXOSO or designee will check to see that all required safety equipment is at the job site prior to the start of each day's field activities.

10.8 INCIDENT REPORTING, DOCUMENTING, FOLLOW-UP

An incident is defined as an event that could or does result in unintended harm or damage. Incidents may result in harm to people, property, and process. An incident is not limited to human harm or injury but may include harm to anything in the work or external environment. Injuries and illnesses may result from incidents, but incidents are not limited to injury and illness. If an event results in damage or loss and no injury occurs, it is still considered an incident.

Tetra Tech will investigate all incidents. The intent is to document the full course of events (including cause, procedures followed, injuries, damages, on-site personnel at time of incident, and releases), as well as to determine follow-up actions and preventative measures. The PM will initiate the incident investigation in accordance with Document Control Number 2-2, Incident Reporting and Investigation Program (Attachment 1). The PHSM or UXOSO will investigate the circumstances surrounding the incident and document finding using TOTAL. Within three working days of any reportable incident, the UXOSO will complete any additional incident reports as required. These reports will include investigation results and recommendations on how to prevent similar events.

It may be necessary to report site emergencies to various agencies depending on the nature and size of the incident. In all cases the PM will notify SRA of such notification in writing and/or verbally, prior to completing any non-emergency contacts.

11.0 EVENT MANAGEMENT PLAN

The purpose of this event management plan is to minimize hazards to human health and the environment from potential incidents and to ensure minimal interruption to on-site activities. As a contractor, operations staff member you need to be familiar with this plan. Read it carefully. If you have any questions, consult your supervisor. Keep in mind the following as you read through this document:

- Evacuation routes, exit points, and assembly points
- Procedures for evacuating the site
- Locations of emergency supplies and materials that may be needed in an emergency, such as fire extinguishers, spill kits, and first aid kits
- Proper procedures for notifying emergency responders and key staff members about an emergency in the site or work area
- Additional responsibilities (such as being a roll taker)
- Fire hazards
- Potential exposure to hazardous materials, heavy equipment, or processes in and around the work area, as well as any means of protecting yourself in the event of an emergency
- Remedial work shutdown and safeguards needed during emergencies

11.1 EMERGENCY ASSEMBLY POINTS

On-Site Emergency Assembly Point for Fire, Accident, or Medical Emergency:

The designated rally point is the assembly point designated for rendezvous in the case of fire, accident, or medical emergency. (**to be added upon mobilization**)

11.2 SITE ALERTS AND UTILITY SHUT-OFFS

Emergency signals will be used at the site to alert workers of danger, and to maintain site control during emergencies. Compressed air horns will be the primary emergency signaling device. Emergency hand signals will be used as a secondary means of communication.

11.2.1 Alarm Identification and Response

The following table describes the different signals, the significance of each alarm, and the appropriate response to each alarm.

Alarm	Audio	Hand	Signal	Response
Evacuation	✓		One LONG blast on air horn; pause 5 seconds, repeat	▪ Stop work and leave the site immediately. Report to the designated Emergency Assembly Point.
Fire or Severe Weather or Accident	✓		Two LONG blasts on air horn; pause 5 seconds, repeat	▪ Stop work and immediately report to the rally point at the main gate for further directions. ▪ Tetra Tech On-site Supervisor may instruct workers to evacuate or take cover depending upon conditions.
All Clear	✓		Three short blasts on air horn	▪ Return to work.

11.3 EMERGENCY PROCEDURES

Always call from a safe location and remember to:

- stay calm.
- gather any other information that may be useful for the emergency responders and communicators, such as:
    - injuries,
    - number of injuries, and
    - nature of the injuries.

Note: Give the dispatcher a telephone number or safe location where the emergency responders can call or meet you and wait for the responders at that safe location.

11.4 SPECIFIC EVACUATION

All site occupants are required by law to evacuate the site when the fire alarm sounds.

Required Emergency Information

Posted information	Location
Evacuation diagrams, including routes	Field vehicle
Fire-alarm air horn	Field vehicle
Emergency assembly point maps	Field vehicles
First-aid kits	Field vehicles
Eye-wash bottles and fire extinguishers	Field vehicles
Spill kits	Field vehicle

Note: *If a field vehicle is not used, then the posted information and equipment shall be kept in the work area at a designated location.*

11.5 FIRE

A site occupant is required by law to evacuate the site when the fire alarm sounds. If there is a fire in your work area, use the following guidelines:

- If you have been trained and are able to safely extinguish the fire, do so. However, make sure that you have a safe exit from the fire area.
- If you are unable to extinguish the fire, leave the area immediately and sound the fire alarm. From a safe location, call 911 to report the fire (see “Emergency Notification Procedures” above).
- Evacuate the site as soon as the alarm sounds and proceed to the designated emergency assembly point.
- As you exit, warn others to evacuate.
- Do not re-enter the site or work area until you have been instructed to do so by the emergency responders (fire department, site manager, or assembly point leader).

11.6 SEVERE WEATHER

The potential for severe weather is possible as the site is located along the Rocky Mountain Front Range where storms can occasionally be severe, including thunderstorms with associated lightning and potentially strong winds.

The UXOSO will monitor the weather forecast a minimum or two times per day and more frequently as required (e.g., when a storm is forecast in the area). If particularly ominous weather conditions are predicted (e.g., approaching thunderstorm cell, winter storm, etc.), the UXOSO will monitor radio broadcasts, National Weather Service reports, or mobile apps, regularly and management will evaluate the situation and take appropriate action in advance of the storm to maintain worker safety, including travel to and from work and to evaluate shutting down of the site, securing of equipment and/or specific tasks as necessary before the storm arrives.

In preparation for an approaching storm, the UXOSO will determine the appropriate length of time that it will take to safely halt operations and secure equipment and operations in advance of the storm so that work can be halted with enough advance time for safety of crew and equipment. Equipment will be secured and all doors and windows of the equipment (e.g., equipment cabs) and offices will be closed. Tools and supplies will be stored in a designated secure location.

Nearby thunderstorms, if present could have lightning associated with them. Whenever a thunderstorm arises, the UXOSO will determine if lightning is within 10 miles of the site. Once lightning is seen, count the number of seconds until you hear the thunder. Divide the number of seconds by 5 to get the distance the lightning is away from you. If lightning is 10 miles away or less, work should stop until 30 minutes after the last audible thunder or visible flash of lightning. A lightning meter or mobile app may be used as well, if available on-site. If lightning is observed, all outdoor workers will seek shelter in a full enclosed vehicle cab or other fully enclosed structure such as the field office.

11.7 HAZARDOUS MATERIALS

If you are a hazardous material user or if you supervise a hazardous material user, you should be trained in the proper use and storage of hazardous materials. Take personal responsibility to know the hazards of the materials you work with or near. Know where the spill containment supplies are kept, and how to use them.

If you witness a hazardous material spill that you believe may be life threatening, evacuate the spill site and warn others to stay away. Call 911. If you determine that the spill is not life threatening, but think that it could pose a threat to human health or the environment, follow the procedures outlined below, but only if it is safe to do so:

- Stop the source of the spill.
- If the spilled material is flammable, eliminate ignition sources.
- Dial 911 for assistance.
- Contain the spill by surrounding its perimeter with containment material such as absorbent pads and berms, which will be located in the field vehicle and/or at the drum staging area.
- Cordon off the area.
- Remain in the area to direct emergency personnel to the scene.
- Follow the instructions of the 911 dispatcher and other responding emergency personnel.
- As soon as practical after an incident, notify:

- Tetra Tech Project Manager

Hazardous material spills that do not present a threat to human health or the environment can generally be handled by the hazardous material user. Small spills are generally cleaned up by the department or group responsible for the spill. Upon evaluation of the spill, the site manager may decide to call a subcontractor to assist with cleanup of the spill.

If you need to clean up after a spill:

- Wear appropriate personal protective gear.
- Clean up the spill according to the SDS and any instructions provided by the site waste management staff or emergency responders.
- Place the spilled materials and any contaminated material in a hazardous waste container.
- Call appropriate designated parties for container pickup and disposal as directed in the site-specific waste management plan.

12.0 HEALTH AND SAFETY PROGRAM DOCUMENTATION

12.1 HEALTH AND SAFETY DOCUMENTATION

Health and safety documentation for this project will consist of the following:

- **Health and Safety Plan**: All site work will be performed in accordance with the provisions stated in the HASP. Site workers must sign and date the HASP Consent Agreement Form stating that they have read and understood the HASP and attended the requisite site orientation and briefing.
- **Safety Data Sheets**: Completed SDSs or their equivalent, for the hazardous materials used at the site shall be available for review by all project personnel. SDSs for chemicals used on-site are presented in Attachment 3.
- **Personnel Training Documentation**: The UXOSO will maintain documentation of Tetra Tech personnel training and medical surveillance records. Training documentation for on-site field personnel will be maintained in the site field office.
- **Tailgate Safety Meeting Documentation**: The UXOSO or designee will conduct the initial HASP conference that will serve as the initial tailgate safety meeting. This and any subsequent daily meetings will be documented in writing and signed by the attendees. A file of daily tailgate safety meeting forms will be kept by the UXOSO. The UXOSO or designee will conduct a tailgate safety meeting prior to the field work, whenever new personnel arrive at the site, as conditions change, or as needed.
- **Heat Stress Worksheet Documentation**: The UXOSO or designee will document the number of employees per work area to determine the appropriate amounts of shade and water required for each work day where temperatures are anticipated to be at or above 80°F.
- **Site Visitors Log**: Visitors will be discouraged from entry into the designated EZ, and under no circumstances will they be allowed inside the EZ unless there is an emergency. The task manager will record visitors to the site in the daily field log and/or on a Site Visitor Log.
- **Incident Reporting Forms**: All completed incident investigation documents will be stored electronically, in the TOTAL system.

12.2 POSTING REQUIREMENTS

The following shall be posted in a conspicuous location in the site field office:

- OSHA 300A Log from the previous year is posted between February 1 and April 30
- Hearing conservation standard
- Identification of prime contractor (Tetra Tech)
- Emergency route map to the hospital
- Emergency contact information
- Tetra Tech Health and Safety and Labor Regulation Posters

Note that postings are not required for areas without a field office.

13.0 REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). 2021. *Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs).* TLVs were consulted and/or referenced in this HASP.

Tetra Tech. 2021. *Corporate Health and Safety Manual*. Accessed on 10/1/2019 at https://my.tetratech.com/go3/index.php?option=com_content&view=article&id=2070&Itemid=297

U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health (NIOSH), Public Health Services. 2010. *Pocket Guide to Chemical Hazards.* September. TLVs were consulted and/or referenced in this HASP.

U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), Code of Federal Regulations (CFR). n.d. Title 29, CFR, Part 1910, Occupational Health and Safety Standards was consulted and/or referenced in this Site Safety and Health Plan.

APPENDIX A: HASP SIGNATURE SHEET

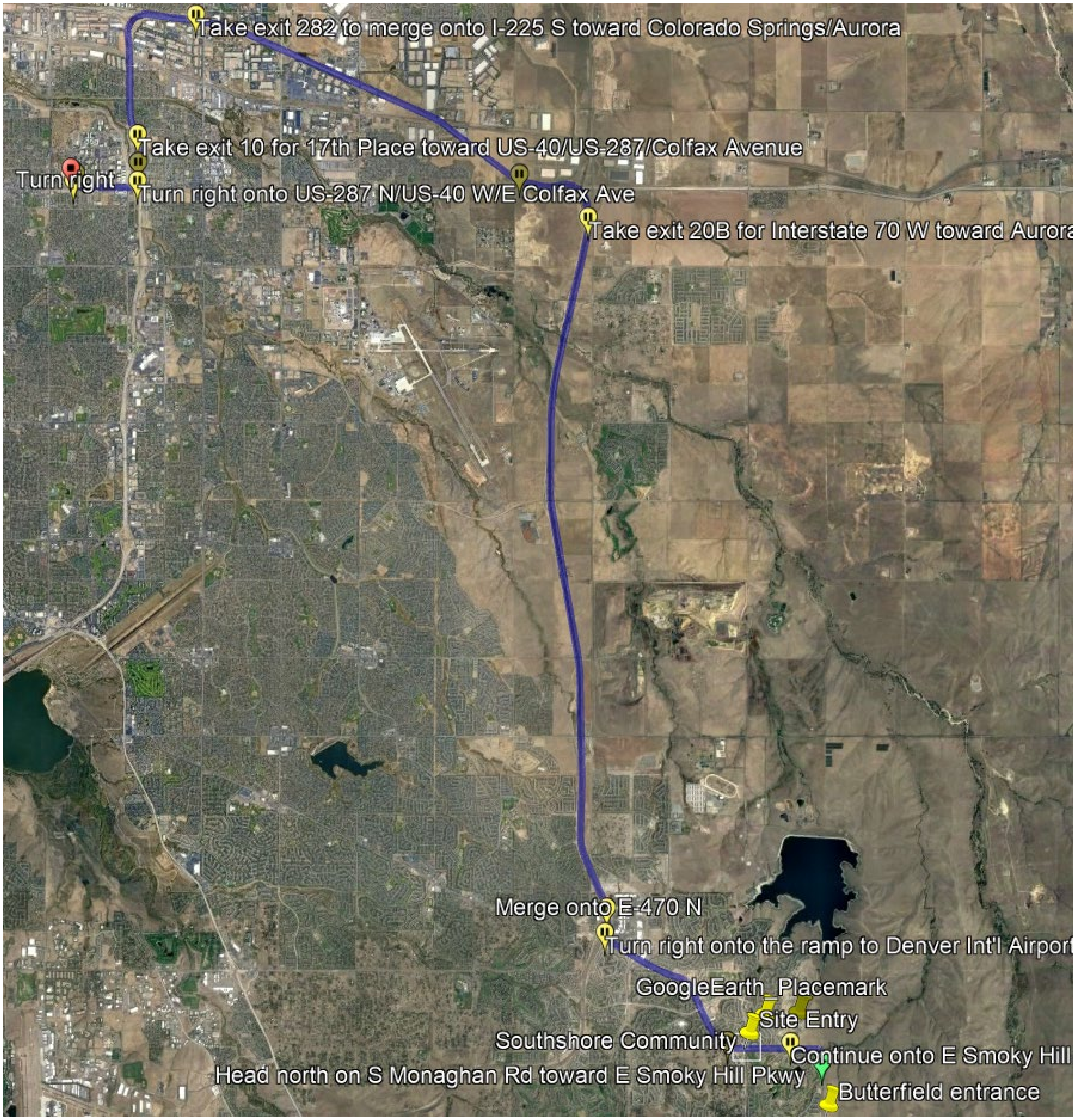
TETRA TECH	HASP ACCEPTANCE FORM	
I have reviewed the Tetra Tech, Inc. Health and Safety Plan for Butterfield Trails . I understand its purpose and consent to adhere to its policies, procedures, and guidelines as an employee or subcontractor of Tetra Tech. I understand that I could be prohibited from working on the project for violating any of the safety requirements specified in the plan.		
Print Name	**Signature**	**Date**

APPENDIX B: EMERGENCY CONTACT LIST

Name	Position	Phone
Anthony Joiner	Project Manager	cell: (256) 947-5050
Jim Streib, CSP, SMS, CQA, CHST	Project Health and Safety Manager (PHSM)	cell: (240) 727-9240

INFORMATION AND RESPONSE ORGANIZATIONS	Phone
Fire, Police (Emergency), Ambulance	911
Aurora Police Dept.	911 Non-emergency: (303) 739-6050
Centers for Disease Control (CDC)– Hotline CDC Clinician Information Line	(day) (404) 329-3311 (night) (404) 329-2888 (800) 311-3435 (888) 246-2675
Hospital: UC Health University of Colorado Hospital 12605 E 16th Ave., Aurora, CO 80045	(720) 848-0000
National Response Center (to report spills)	(800) 424-8802
Poison Control Center	1-800-222-1222
CORE Injury Management	1-855-683-9006
Toxic Substances Control Act (TSCA) Hotline	(800) 424-9065

APPENDIX C: EMERGENCY ROUTE TO HOSPITAL



Hospital Contact and Route Information:

Hospital: UC Health University of Colorado Hospital
12605 E 16th Ave,
Aurora, CO 80045

From Site:

- **From S Monaghan Rd, Turn right onto E County Line Rd**
- **Turn right onto S Powhaton Rd**
- **Turn left onto E Smoky Hill Rd**
- **Turn right onto S Aurora Pkwy**
- **Turn left**
- **Continue onto E Sixth Ave**
- **Turn right onto Airport Blvd**
- **Turn left onto E Colfax Ave**
- **The hospital, 12605 E 16th Ave, is on the right**

ALL ON-SITE PERSONNEL MUST HAVE A COPY OF THE MAP TO THE HOSPITAL AND EMERGENCY CONTACT INFORMATION POSTED THEIR VEHICLE.

ALL TETRA TECH PERSONNEL AND SUBCONTRACTORS ARE REQUIRED TO HAVE A PARTNER ON THE SITE AT ALL TIMES

APPENDIX D: EXPOSURE CONTROL PLAN

EXPOSURE CONTROL PLAN

NOTE: A Competent Person must complete the Exposure Control Plan. This plan must be updated at least annually. Place this as part of the project site Health and Safety Plan.

1. Describe each activity emitting lead or silica including the hazardous material(s) and the tools, equipment, and process that create the hazard:

2. List the specific Eng./ Administrative controls and studies reviewed. What controls will be used? What controls are not feasible and why?

Exposure Control	Implementation Expectations
Ventilation (local/general, positioning, air flow)	
Shrouded/exhausted tools or local exhaust	
Containment (describe)	
Wet methods (describe how water is used)	
Other (long handled torches, paint remover, etc.)	
Administrative controls (team member exposure time log kept for worker rotation, SOP's	

3. Air monitoring history (past/present), list or attach sampling results or other information used to make initial exposure assessment:

Date	Location	Job Descriptoin	Monitoriong Outcome

4. Work Practice Controls: Describe the types of practice controls implemented, how they will be implemented and expectations of the workers on how to comply with these controls.

Work Practice Control	Implementation Expectations
Employee Hygiene Plans (hand wash at minimum, showers if required, decon procedure	
Personal Protective Equipment (PPE)	
Housekeeping Plans (wet methods or HEPA vac)	
Specific Team Member Responsibilities	
Equipment Operating Procedures	
Equipment Maintenance Practices	
Identified Restricted Areas and Posting	

Competent person must do frequent and regular checks of the work area. Notify all other contractors in the area of potential exposure related to this project.

ANNEX A - AIR MONITORING WORKSHEET

Air Monitoring Worksheet

Project Name: ______________________________ Sample Date: ____________

Sample ID#: ______________ Length of Shift: ____ Total Length of Activity: ______

Activity Description: ____

Temperature	Humidity Percentage	Wind Speed	Wind Direction	Atmospheric Pressure (in. Hg)
Area characteristics (indoors/outdoors, boiler cavity, 2,000 sq. ft. tank, etc.):				
Equipment/tools used (please be specific).				
Respiratory protection used & other personal protective equipment:				
Engineering/admin. controls (ventilation, HEPA units, wet methods, containment, etc):				

Make	Model	Flow Rate	Equipment Positioning	Ohter
Work location, duration, exposure & activities while not wearing sample pump:				

Temperature	Humidity Percentage	Wind Speed	Wind Direction	Atmospheric Pressure (in. Hg)

Contaminant Name	ID#	Pump#	Run Time		Total Time (in minutes)	Avg.cal. flow rate (LPM)	Total volume (in liters)	Calibration Flow Rate	
			Start	Stop				Before	After

Industrial Hygienist (Print Name)	Date of Last Pump Calibration	Initials

Sample ID#	Name or Location of Sample	Personal=P Area=A	Monitoring Results	8-Hour (ug/m3) (TWA)	Above PEL Y/N	Above AL Y/N

ANNEX B - EMPLOYEE WRITTEN NOTIFICATION

Employee Written Notification

Note: Written notification is required by the standard within 15 days of receiving the results.

On________________________________air sampling was performed for the following tasks/activities. The crew consisted of the following people:

____ ____

____ ____

____ ____

____ ____

Below are the results of the air monitoring; the calculated PEL based on the shift length and the time weighted average of team member exposure.

Task Activity	Lab Result	Calcualted PEL

Check one of the following:

☐ Team member exposure (allowable PEL must be based on shift duration [8-hour shift] was below the allowable PEL of ___________________________.

☐ Team member exposures were at or above the allowable PEL of and the following corrective actions were taken to reduce the level below that level.

Corrective Actions:

Date posted or given to team member(s):_________________________

APPENDIX E: ACTIVITY HAZARD ANALYSES (AHAs)

Activity Hazard Analysis (AHA) #1

Activity/Work Task: Mobilization/ Site Setup and Demobilization	**Overall Risk Assessment Code (RAC) (Use highest code)**					**L**
Project Location: Butterfield Trails, Aurora CO	**Risk Assessment Code (RAC) Matrix**					
Contract Number: 179-47200021	**Severity**	**Probability**				
Date Prepared: April 5, 2021		Frequent	Likely	Occasional	Seldom	Unlikely
Prepared by: Matt Barner	Catastrophic	**E**	**E**	**H**	**H**	**M**
	Critical	**E**	**H**	**H**	**M**	**L**
Reviewed by: Jeffrey (Jim) Streib, CIH, CSP, CHMM, SMS, CQA Director, Environmental Health and Safety	Marginal	**H**	**M**	**M**	**L**	**L**
	Negligible	**M**	**L**	**L**	**L**	**L**

Notes: (Field Notes, Review Comments, etc.) In addition to the information listed in this AHA, all field personnel must review and be familiar with all provisions of the approved HASP. PPE for this AHA will consist of a hard hat (when overhead safety hazards exist), leather safety-toed boots, safety glasses with side shields, a standard work uniform (long pants, tee shirt), hearing protection (as required), work gloves worn when indicated. Other PPE described in this AHA.	Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (see above).	
	"Probability" is the likelihood to cause an incident, near miss, or accident and is identified as Frequent, Likely, Occasional, Seldom, or Unlikely.	**RAC Chart**
	"Severity" is the outcome/degree if an incident, near miss, or accident did occur and is identified as Catastrophic, Critical, Marginal, or Negligible.	**E = Extremely High Risk** **H = High Risk**
	Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on the AHA. Annotate the overall highest RAC at the top of the AHA.	**M = Moderate Risk** **L = Low Risk**

AHA #1 – Mobilization/ Site Setup and Demobilization			
Job Steps	**Hazards**	**Controls**	**RAC**
1. Unloading and initial staging of materials and equipment and demobilization of materials	Vehicle operations or unloading tasks could cause injury to personnel or others on site.	• Workers operating rental vehicles will have a valid state issued driver's license and will be authorized by Tetra Tech to operate rental vehicles per corporate procedures. • Any Commercial Driver's License truck and trailers will be operated by CDL qualified drivers who are vetted and authorized vendors. • Operate at safe speeds and obey traffic speeds and rules as instructed. • Wear seat belt at all times when vehicle is in operation. • Use parking brake when parked. • Use chocks when parked on inclines. • Use dedicated spotter and standard hand signals for backing operations. • No cell phone or radio use permitted by driver while vehicle is in motion	L
	Operating UTVs	• Workers operating UTVs will be trained and designated as operators for the equipment they will operate. • Operate at safe speeds and obey local traffic rules. • Wear seat belt at all times when equipment is in operation. • Use dedicated spotter and standard hand signals for backing operations. • No cell phone or radio use permitted by driver when vehicle is in motion	L
	Ergonomic hazards such as sprains, strains, or back injury could occur from lifting or repetitive actions.	• Use mechanical lifting equipment or team lift when possible rather than by hand and tool methods. • Do not bend at the waist, bend at the knees. • Do not twist at the waist and turn while lifting. • Keep the load centered and close to body. • Do not lift more than 50 pounds (may be lesser for some workers) alone. • Rotate tasks and take breaks when performing repetitive tasks and try to find the best position possible to perform the task.	L
	Handling sharp objects or using hand tools or knives could cause cuts, punctures, or scrapes.	• Wear leather work gloves when handling materials that may be sharp or have sharp edges. • Be familiar with the proper use and limitations of hand tools. • Report even minor injuries to your supervisor for evaluation. • Have a first aid kit available and have a minimum of 2 persons with first aid and CPR training onsite. • Never carry a knife in one's pocket. • Ensure knives have retractable blades.	L

AHA #1 – Mobilization/ Site Setup and Demobilization			
Job Steps	**Hazards**	**Controls**	**RAC**
		• Cut away from the body.	
Unloading and initial staging of materials and equipment and demobilization of materials (Continued)	Workers could be exposed to heat or cold stress.	• UXOSO will monitor for heat or cold stress in accordance with HASP. • All workers will be trained in heat and cold stress signs and symptoms and proper prevention measures and will employ the buddy system to watch for signs and symptoms in co-workers. • Provide fluids, rest breaks in heated or air-conditioned environment as appropriate; (e.g., work trucks. • Dress appropriately for the outdoor conditions and be prepared for changes that can occur throughout the day. • Provide a steady controlled work pace. • New workers not used to work in higher altitude environment may require more acclimatization to site conditions and may require more frequent breaks.	L
	Contracting or spreading coronavirus.	• Stay within your social/work group. • Monitor yourself for coronavirus symptoms, if displaying symptoms do not leave your room and self-isolate. • Seek medical advice. • Maintain social distance. • Wear a face covering. • Wash hands regularly. • Display posters and information for Covid -19 mitigation measures.	M
	Eye injuries could occur from dust or debris.	• Wear safety glasses with side shields at all times when working outside of an enclosed vehicle cab. • If something enters the eye, do not rub. • Set up portable eye wash for flushing of eye to try to remove object. • Use the eye wash for the full 15-minutes, regardless if you feel that the object has been removed. • Notify supervisor so eye can be monitored. • If object still irritates or stays in the eye, seek medical attention as soon as possible. • Follow up with eye exam is recommended any time an object gets into an eye since it is necessary to ensure object does not remain, even if it cannot be felt. • To keep dust down, travel at slower speeds on unpaved roads	L

AHA #1 – Mobilization/ Site Setup and Demobilization			
Job Steps	**Hazards**	**Controls**	**RAC**
Unloading and initial staging of materials and equipment and demobilization of materials (Continued)	Noise from operating equipment could cause hearing loss and make it hard to communicate	• Hearing protection is required when sound levels exceed 84 dBA continuously. • This rule applies to personnel working near or on heavy equipment and any other sources of loud noise. • If machinery or equipment is expected to be used, which has potential to generate excessive noise, the UXOSO will monitor. • Personnel on site will be informed of the need to wear hearing protection for activity or location, and it will be posted.	L
	Fall hazards (falls from heights of 6 feet or greater)	• No person will climb upon any equipment, shipping container, trailer, etc. where there is exposure to a fall of 6 feet or greater unless proper guarding and rails is in place.	L
	Potential trips or falls	• Survey the site for any slip, trip, or fall hazards as well as UTV navigational hazards. • Either eliminate the hazard or mark the hazard so it can be avoided. • Use caution when walking around the site and wear sturdy leather work boots. • Maintain a clean and orderly work site.	L
	Head injuries could occur from struck by or falling objects.	• Wear hard hat when overhead hazards exist and when working outside an enclosed vehicle cab.	L
	Contact with biting or stinging insects could occur; including bees, wasps, hornets, ticks, scorpions, snakes and spiders.	• Workers will apply DEET to work clothing following manufacturer's instructions as a preventative measure for biting insects as required. • Workers with allergies will let the UXOSO know using the medical data sheet and will carry their own prescription medication as applicable. • First aid and medical attention as required. Report all bites, stings, and rashes to the UXOSO. • Avoid reaching blindly into areas, depressions, debris, etc.	L
	Contact with wildlife	• Avoid direct contact with wildlife • If dangerous wildlife spotted onsite, retreat from immediate area in a slow orderly manner to an enclosed vehicle or structure • Notify Tetra Tech safety representative of spotted wildlife • Do not perform any activities which may attract wildlife (e.g., leaving food onsite)	L

AHA #1 – Mobilization/ Site Setup and Demobilization			
Job Steps	**Hazards**	**Controls**	**RAC**
		• Cattle gates must be properly closed after passing through the gates to prevent escape of animals from fenced areas	

AHA #1 – Mobilization/ Site Setup and Demobilization		
Equipment to be Used	**Training Requirements/Competent or Qualified Personnel Name(s)**	**Inspection Requirements**
Site vehicles and delivery vehicles	Drivers must have current country and local-issued driver's license. Drivers of rental vehicles must be authorized to drive the rental vehicle in accordance with Tetra Tech procedures.	Receipt inspection by UXOSO (as applicable). Vehicle inspection (including trailers and UTVs) by drivers. Operator's manual for each vehicle must be located with each motor vehicle.
Hand and power tools	Training in use of hand tools by the Tetra Tech Safety Representative or designee and review of operating manual. Use proper hand tools.	Daily inspection by users/operators. Take faulty tools out of service and clearly identify them as such to avoid others from using them.
First aid kit, fire extinguisher, eye wash station, emergency spill kit	Use of emergency equipment including first aid kits, fire extinguishers and eye wash must be done by personnel familiar with this plan; use and inspection criteria of the equipment, and what the equipment is used for, are by or under direction of the UXOSO. Emergency spill kit must be kept onsite in the event of a leak from UTV or spill during onsite refueling operations.	**Fire Extinguisher** • Initially and at least monthly thereafter by UXOSO **First Aid Kit** • Weekly and after use for restocking by Tetra UXOSO **Eye Wash Station** • Weekly by UXOSO • Potable water changed weekly unless a preservative solution is used **Spill Kit** • Weekly by UXOSO
Fuel storage cans for refilling UTVs onsite	Gasoline or diesel fuel must be kept in appropriate color-coded containers with spill proof lids, nozzles and caps with proper ventilation. Storage of fuel cans must be kept either in fire proof cabinet if not removed from the site at the end of each work day. Transport of fuel cans to and from the project site must ensure that fuel cans are properly secured in the bed of a truck or in other ventilated vehicle compartment. No hot refueling is permitted (i.e. engines must be turned off).	Daily inspection of fuel cans for damage or leaks. Replace damaged or defective cans.

AHA #1 – Mobilization/ Site Setup and Demobilization		
Cell phones or radios for site communication	Primary communication will be through use of cell phones, but if service is limited, radios will be used onsite for communication amongst field team members.	Daily inspection of radios for damage or low batteries. Maintain adequate supply of replacement batteries onsite.
PPE	Users must be trained in the proper use, limitations, inspection, and donning and doffing of PPE.	Daily by user. Replace damaged or degraded PPE as necessary.

Abbreviations and Acronyms:

CPR – Cardio Pulmonary Resuscitation

DEET – 33% diethyl-meta- toluamide

PPE – personal protective equipment

HASP – Health and Safety Plan

AHA Signature Sheet

I have reviewed the above AHA and acknowledge the hazards involved with this work task and the controls that will help to minimize illness or injury during the tasks.

NAME	SIGNATURE	TITLE	DATE
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Activity Hazard Analysis (AHA) # 2

<table>
<tr><td>Job/Task: Vegetation Removal and surface clearance</td><td colspan="5">Overall Risk Assessment Code (RAC) (Use highest code)</td><td>M</td></tr>
<tr><td>Project Location: Butterfield Trails, Aurora CO</td><td colspan="6">Risk Assessment Code (RAC) Matrix</td></tr>
<tr><td>Contract Number: 179-47200021</td><td rowspan="2">Severity</td><td colspan="5">Probability</td></tr>
<tr><td>Date Prepared: April 2021</td><td>Frequent</td><td>Likely</td><td>Occasional</td><td>Seldom</td><td>Unlikely</td></tr>
<tr><td rowspan="2">Prepared by: Anthony Joiner</td><td>Catastrophic</td><td>E</td><td>E</td><td>H</td><td>H</td><td>M</td></tr>
<tr><td>Critical</td><td>E</td><td>H</td><td>H</td><td>M</td><td>L</td></tr>
<tr><td rowspan="2">Reviewed by: Jeffrey (Jim) Streib, CIH, CSP, CHMM, SMS, CQA</td><td>Marginal</td><td>H</td><td>M</td><td>M</td><td>L</td><td>L</td></tr>
<tr><td>Negligible</td><td>M</td><td>L</td><td>L</td><td>L</td><td>L</td></tr>
<tr><td rowspan="7">Notes: (Field Notes, Review Comments, etc.)
In addition to the information listed in this AHA, all field personnel must review and be familiar with all provisions of the approved HASP. HASP will also be available on-site for review of specific materials and mitigation measures.
Personal Protective Equipment for this AHA will consist of hard hat (when overhead safety hazards exist), safety toed boots, safety glasses with side shields, standard work uniform (long pants, sleeve shirt). Hearing protection (as required). Work gloves worn when indicated, Class 2 high visibility safety vest. Other PPE as shown below.</td><td colspan="6">Step 1: Review each “Hazard” with identified safety “Controls” and determine RAC (see above).</td></tr>
<tr><td colspan="4">“Probability” is the likelihood to cause an incident, near miss, or accident and is identified as Frequent, Likely, Occasional, Seldom, or Unlikely.</td><td colspan="2">RAC Chart</td></tr>
<tr><td colspan="4" rowspan="2">“Severity” is the outcome/degree if an incident, near miss, or accident did occur and is identified as Catastrophic, Critical, Marginal, or Negligible.</td><td colspan="2">E = Extremely High Risk</td></tr>
<tr><td colspan="2">H = High Risk</td></tr>
<tr><td colspan="4" rowspan="2">Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each “Hazard” on the AHA. Annotate the overall highest RAC at the top of the AHA.</td><td colspan="2">M = Moderate Risk</td></tr>
<tr><td colspan="2">L = Low Risk</td></tr>
</table>

AHA #2– Job/Task: Vegetation Removal and Surface Clearance			
Job Steps	**Hazards**	**Controls**	**RAC**
	Lack of communication could lead to a delayed response in an emergency.	• Ensure that each work team has a cellular telephone or two-way radio, or access to a cellular telephone, for emergency communication.	M

AHA #2– Job/Task: Vegetation Removal and Surface Clearance			
Job Steps	**Hazards**	**Controls**	**RAC**
Establish limits of surface clearance and vegetation clearance Conduct surface clearance Cut vegetation		• A work team may substitute a 2-way radio for a cellular phone if the other radio party has access to a phone. • If more than one team at a time is working, ensure that there is communication between the work teams and project management. • Use the buddy system. • A minimum of two personnel will have first aid/CPR training and will be designated on the list of first aid/CPR qualified individuals.	
	Contact with biting or stinging insects can cause rash, anaphylactic shock, or illness	• Workers will apply DEET to work clothing following manufacturer's instructions as a preventative measure for biting insects as required. • Tuck in pant legs to socks and tuck in shirt to pants. Wear long sleeves. • Examine one's body thoroughly for evidence of tick being attached. Follow steps in the APP for removal of tick. Report bite to UXOSO for appropriate medical follow up to ensure entire tick has been removed (including mouth parts). • Report all bites or stings immediately. • Workers with allergies to bees, hornets, wasps, etc. are strongly encouraged to let the UXOSO know using the medical data sheet and will be advised to carry their own prescription medication as applicable. • First aid and medical attention as required. Stings to allergic persons or signs and symptoms of anaphylaxis should be considered an emergency situation.	M
	Slips, trips, and falls	• Pay attention to where you are walking. • Locate and mark or cover surface debris, holes, or depressions that could present a trip hazard. • Store and stage tools and equipment properly and follow good worksite housekeeping practices. • Do not walk on slopes greater than 45 degrees without fall protection	M
	Contracting or spreading coronavirus.	• Stay within your social/work group. • Monitor yourself for coronavirus symptoms, if displaying symptoms do not leave your room and self-isolate. • Seek medical advice. • Maintain social distance. • Wear a face covering. • Wash hands regularly.	M

AHA #2– Job/Task: Vegetation Removal and Surface Clearance			
Job Steps	**Hazards**	**Controls**	**RAC**
		• Display posters and information for Covid -19 mitigation measures.	
	Workers could be exposed to extreme temperatures and sunburn.	• UXOSO will monitor for heat or cold stress in accordance with HASP. • Keep an eye on your buddy. Know signs and symptoms of heat or cold stress. • Provide fluids and rest breaks in shaded location during warm weather, and while wearing protective clothing. • Wear broad-spectrum sunscreen lotion of SPF 15 or better.	M
	Brush clearance equipment is a hazardous activity if not performed properly or by qualified personnel	• Workers operating construction equipment will be qualified and designated operators. Heavy equipment used to de-limb will have a demolition cage over the operator's window and cab. • Operate at safe speeds and obey facility traffic speeds and any facility vehicle operation rules. • Wear seat belt at all times when equipment is in operation. • Use dedicated spotter and standard hand signals for backing operations. • Workers working around construction equipment will stay out of the swing and flying debris radius. To enter, one must make contact with the operator and have operator acknowledgement. • Only personnel necessary to perform work tasks will be in controlled work zones around heavy equipment and must remain visible to the operator. Ground workers will be away • Ground workers will wear class 2 high visibility safety vest at all times.	M
	Failure to clear work area for safety could cause injury personnel	• Each worker shall be instructed as to exactly what they are to do. • Workers working around construction equipment will stay out of the swing and flying debris radius. To enter, one must make contact with the operator and have operator acknowledgement. • All workers not directly involved in the operation shall be kept clear of the work area.	M
	Exposed to cutter heads	• Operator always to lower brush hog attachment to the ground and turn it off when unattended. Ensure that operator has view of path of cutter and ensure workers are not in the area of cutting. • Do not place hands or other body parts into cutters while engaged or energized or try to remove stuck debris unless proper guarding and (if required), lockout/tagout isolation is applied per manufacturer's instructions. Disconnect from hydraulic system prior to servicing or removing stuck debris.	M

AHA #2– Job/Task: Vegetation Removal and Surface Clearance			
Job Steps	**Hazards**	**Controls**	**RAC**
		• Know the limitations of what debris the brush hog attachment can handle and avoid or mark objects and obstacles (e.g., monitoring wells or bollards) for avoidance as necessary.	
	Noise could cause hearing loss	• Hearing protection is required when sound levels exceed 84 dBA continuously. This rule also applies to personnel working around heavy equipment.	M
	Struck by or against heavy equipment	• Wear class 2 high-visibility safety vests when working on ground in vicinity of powered or other clearing equipment. • Make eye contact with operators and get permission to enter before approaching equipment.	M
	Refueling of saws could cause fires or spills.	• Ensure saws are turned off and allowed to cool before being refueled. • Do not overfill saws by ensuring a small size fuel can is used which the worker can maintain good control over during refueling. • Place equipment on a spill pad for refueling. Visually inspect refueling point to ensure overfill is not done. • Do not fill to capacity; leave space for expansion in the tank. • Do not smoke in or near refueling areas. • Do not refuel in back of a pickup truck. • Have a ABC fire extinguisher present at the refueling site and ensure workers are trained in their use.	L
	Workers could experience eye hazards.	• Safety glasses are the minimum required eye protection for all work areas. • Locate a portable emergency eye wash at each work area. • Flush objects from eyes; do not rub.	M
	Non-essential workers or others could come into contact with or be affected by MEC/MPPEH.	• An exclusion zone (EZ) will be established in accordance with the requirements in the Work Plan. Only qualified UXO technicians will enter the EZ. • Monitor the EZ while work is underway so work can be stopped if any unauthorized personnel enter • Follow all applicable standard operating procedures in the Work Plan and ESS regarding surface clearance and MEC avoidance. • Only UXO technicians under the direct supervision of the SUXOS will handle MEC/MPPEH.	L

AHA #2 – Job/Task: Vegetation Removal and Surface Clearance

AHA #2– Job/Task: Vegetation Removal and Surface Clearance			
Job Steps	**Hazards**	**Controls**	**RAC**

Equipment to be Used	Training Requirements/Competent or Qualified Personnel Name(s)	Inspection Requirements
1. Vehicles	Drivers must have current state-issued driver's license and facility clearance. Drivers must follow Facility Security requirements and facility vehicle operation instructions. Operations manual must be available onsite.	Daily vehicle inspection by drivers. Receipt inspection by SS. Vehicles subject to inspection by Security.
2. Mobile construction equipment	Only trained equipment operators may operate mobile construction equipment. Operators manual must be available onsite.	Receipt inspection by SS. Operator qualification by SS. Inspect all equipment upon arrival at site and on each day of use. Use equipment checklist. Have operations manual onsite and be familiar with proper use of equipment and attachments.
3. Cutting tools –brush hog attachment to heavy equipment	Specific training for power and hand tools will be provided. Review operators' manual for each tool and ensure that directions are followed. Operations manual must be available onsite.	Operator to inspect before each use. Maintain as per manufacturer's recommendation.
4. First aid kit, fire extinguisher, eyewash station	Use of emergency equipment including first aid kits, fire extinguishers and eyewash must be done by personnel familiar with this plan; use and inspection criteria of the equipment, and what the equipment is used for, are by or under direction of the UXOSO	Fire Extinguisher • Initially and at least monthly thereafter by UXOSO First Aid Kit • Weekly and after use for restocking by UXOSO Eye Wash Station • Weekly by UXOSO • Potable water changed weekly unless a preservative solution is used
6. Personal Protective Equipment	Users must be trained in the proper use of, limitations of, inspection of, donning and doffing of, and replacement of PPE used.	Daily inspection by user before use.

Abbreviations and Acronyms:

AHA – Activity Hazard Analysis
APP – Accident Prevention Plan
CIH – Certified Industrial Hygienist
CRL – Corporate Reference Library
EHS – environmental health and safety
EM – Engineer Manual
mph – miles per hour
OSHA – Occupational Safety and Health Administration
PPE – personal protective equipment
RAC – Risk Assessment Code

SPF – sun protection factor

SS – Site Superintendent

UXOSO – Site Safety and Health Officer

UL – Underwriters Laboratories

AHA Signature Sheet I have reviewed the above AHA and acknowledge the hazards involved with this work task and the controls that will help to minimize illness or injury during the tasks.

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Activity Hazard Analysis (AHA) #3

<table>
<tr><td>Activity/Work Task: Site Surveys (Basic and Digital Geophysical Mapping (DGM) Surveys</td><td colspan="6">Overall Risk Assessment Code (RAC) (Use highest code)</td><td>M</td></tr>
<tr><td>Project Location: Butterfield Trails, Aurora CO</td><td colspan="7">Risk Assessment Code (RAC) Matrix</td></tr>
<tr><td>Contract Number: 179-47200021</td><td rowspan="2">Severity</td><td colspan="6">Probability</td></tr>
<tr><td>Date Prepared: April 2021</td><td>Frequent</td><td>Likely</td><td>Occasional</td><td colspan="2">Seldom</td><td>Unlikely</td></tr>
<tr><td rowspan="2">Prepared by: Matt Barner</td><td>Catastrophic</td><td>E</td><td>E</td><td>H</td><td colspan="2">H</td><td>M</td></tr>
<tr><td>Critical</td><td>E</td><td>H</td><td>H</td><td colspan="2">M</td><td>L</td></tr>
<tr><td rowspan="2">Reviewed by: Jeffrey (Jim) Streib, CIH, CSP, CHMM, SMS, CQA
Director, Environmental Health and Safety</td><td>Marginal</td><td>H</td><td>M</td><td>M</td><td colspan="2">L</td><td>L</td></tr>
<tr><td>Negligible</td><td>M</td><td>L</td><td>L</td><td colspan="2">L</td><td>L</td></tr>
<tr><td rowspan="6">Notes: (Field Notes, Review Comments, etc.)
In addition to the information listed in this AHA, all field personnel must review and be familiar with all provisions of the approved HASP.

Personal Protective Equipment for this AHA will consist of hard hat (when overhead safety hazards exist), safety toed boots, safety glasses with side shields, standard work uniform (long pants, short sleeve shirt). Hearing protection (as required). Work gloves worn when indicated. Other PPE as specified in this AHA.</td><td colspan="7">Step 1: Review each “Hazard” with identified safety “Controls” and determine RAC (see above).</td></tr>
<tr><td colspan="4">“Probability” is the likelihood to cause an incident, near miss, or accident and is identified as Frequent, Likely, Occasional, Seldom, or Unlikely.</td><td colspan="3">RAC Chart</td></tr>
<tr><td colspan="4" rowspan="2">“Severity” is the outcome/degree if an incident, near miss, or accident did occur and is identified as Catastrophic, Critical, Marginal, or Negligible.</td><td colspan="3">E = Extremely High Risk</td></tr>
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<tr><td colspan="4" rowspan="2">Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each “Hazard” on the AHA. Annotate the overall highest RAC at the top of the AHA.</td><td colspan="3">M = Moderate Risk</td></tr>
<tr><td colspan="3">L = Low Risk</td></tr>
</table>

<table>
<tr><td colspan="4">AHA #3 – Activity/Work Task: Site Surveys (Basic and Digital Geophysical Mapping (DGM) Surveys</td></tr>
<tr><td>Job Steps</td><td>Hazards</td><td>Controls</td><td>RAC</td></tr>
<tr><td>Movement of surveying equipment
Setting up and operating:

a. RTK GPS base station
b. VTA</td><td>Slip, trip and fall hazards when walking over soft ground or uneven terrain; navigation hazards for UTV (holes, soft ground, ditches)</td><td>• No cell phone or radio usage permitted by driver while UTV is in motion
• Determine the best access route before transporting equipment.
• If potential navigation hazards for UTV exist, operator will stop and get out to inspect ground conditions ahead of UTV.
• Avoid driving UTV in areas with potential for roll-over, soft ground (i.e.</td><td>L</td></tr>
</table>

AHA #3 – Activity/Work Task: Site Surveys (Basic and Digital Geophysical Mapping (DGM) Surveys			
Job Steps	**Hazards**	**Controls**	**RAC**
Securing survey equipment Geophysical Data Collection and QC seed emplacement		getting stuck) or protruding hazards which may cause damage and leaks from underside of UTV. • Wear slip resistant footwear with ankle support when walking onsite. Pay attention to footing and best path of travel to avoid tripping hazards when walking. • Prohibit jumping from truck/UTV beds or raised surfaces. • Be aware of rocks, brush, animal boroughs and other hazards. Choose firm ground for walking, if possible.	
	Dehydration, heat and cold stress, sunburn	• Drink a minimum of two liters of water per day. • Take frequent breaks in heated or air-conditioned vehicle or structure as appropriate. • Wear sunscreen, as needed, with sun protection factor of at least 45.	M
	Heavy lifting: Injury from physical exertion, sprains, strains, awkward bending/lifts, fatigue, and ergonomic hazards	• Use proper lifting technique to load bulky geophysical equipment into back of truck. Equipment can weigh >50 lbs. • Assure solid footing. • Maintain good personal level of fitness. Be alert to signs and symptoms of overexertion. • Do not lift greater than 50 lbs. • Use mechanical assistance or 2-person lift whenever possible for awkward or heavy objects. • Limit repetitive awkward motions. • Have water available and first aid supplies. • Take adequate work/rest periods based on personal limitations • Ensure rechargeable batteries used for equipment (e.g., to power RTK GPS) are in good condition and not leaking or otherwise defective.	M
	Theft or vandalism to equipment during non-working hours; improper storage of equipment or materials can create fire or environmental hazards	• Remove batteries from the site at the end of each work day to allow for charging • Store VTA in secure container or fenced, secure area. • If VTA is left outdoors overnight in secure area, ensure proper tarping of equipment components sensitive to rain and moisture or remove these components from the site at the end of each work day • Portable equipment (e.g., RTK GPS) that cannot be placed in secure container will be removed from the site each day • Hazardous materials (e.g., gasoline/diesel cans), spray paint, etc. will be stored in proper fire safe cabinet or removed from the site at the end of each work day	L

AHA #3 – Activity/Work Task: Site Surveys (Basic and Digital Geophysical Mapping (DGM) Surveys			
Job Steps	**Hazards**	**Controls**	**RAC**
	Contact with surface MPPEH	• Attend daily site safety briefings • Attend daily task-specific safety briefings given by Tetra Tech Safety Representative • Require completion of 3 R training. • All non UXO personnel escorted by a UXO Technician II or above. • Do not touch or disturb MPPEH. If observed, follow 3 R procedure. Adhere to further instruction of the UXO escort. • Qualified Tetra Tech will perform digging for placement of IVS and QC seed items.	M
	Adverse weather and lightning	• Monitor weather forecasts and warnings or indications of approaching severe weather. • Follow site protocols established in HASP as well as onsite direction and instruction from UXOSO. • Take appropriate precautions to protect personnel and property. • Be aware of lightning, use the lightning 30/30 Rule: If it takes less than 30 seconds to hear thunder after seeing the flash, lightning is near enough to pose a threat; after the storm ends, wait 30 minutes before resuming work activities. • A 30-minute wait time will be observed from last strike before field activities resume.	L
	Contracting or spreading coronavirus.	• Stay within your social/work group. • Monitor yourself for coronavirus symptoms, if displaying symptoms do not leave your room and self-isolate. • Seek medical advice. • Maintain social distance. • Wear a face covering. • Wash hands regularly. • Display posters and information for Covid -19 mitigation measures.	M
	Cold or heat stress and weather hazards	• Properly dress for the weather. • UXOSO to monitor weather and implement heat stress and cold stress controls in accordance with HASP. • Provide breaks for personnel to get either into cool or warm environment. Encourage a steady work pace. • Ensure adequate drinking water is available. • Know the signs and symptoms of exposure and keep an eye on your partner.	M

AHA #3 – Activity/Work Task: Site Surveys (Basic and Digital Geophysical Mapping (DGM) Surveys			
Job Steps	**Hazards**	**Controls**	**RAC**
	Contact with biting or stinging insects could occur; including bees, wasps, hornets, ticks, scorpions, snakes and spiders.	• Workers will apply DEET to work clothing following manufacturer's instructions as a preventative measure for biting insects as required. • Workers with allergies will let the UXOSO know using the medical data sheet and will carry their own prescription medication as applicable. • First aid and medical attention as required. • Report all bites, stings, and rashes to the UXOSO. • Avoid reaching blindly into areas, depressions, debris, etc.	L
	Contact with wildlife	• Avoid direct contact with wildlife • If dangerous wildlife spotted onsite, retreat from immediate area in a slow orderly manner to an enclosed vehicle or structure • Notify UXOSO of spotted wildlife • Do not perform any activities which may attract wildlife (e.g., leaving food onsite) • Cattle gates must be properly closed after passing through the gates to prevent escape of animals from fenced areas	L
	Eye injuries could occur from dust or debris.	• Wear safety glasses with side shields at all times when working outside of an enclosed vehicle cab. • If something enters the eye, do not rub. • Set up portable eye wash for flushing of eye to try to remove object. • Use the eye wash for the full 15-minutes, regardless if you feel that the object has been removed. • Notify supervisor so eye can be monitored. • If object still irritates or stays in the eye, seek medical attention as soon as possible. • Follow up with eye exam is recommended any time an object gets into an eye since it is necessary to ensure object does not remain, even if it cannot be felt. • To keep dust down, travel at slower speeds on unpaved roads	L
	Handling sharp objects or using hand tools or knives could cause cuts, punctures, or scrapes.	• Wear leather work gloves when handling materials that may be sharp or have sharp edges. • Be familiar with the proper use and limitations of hand tools. • Report even minor injuries to your supervisor for evaluation. • Have a first aid kit available and have a minimum of 2 persons with first aid and CPR training onsite. • Never carry a knife in one's pocket. • Ensure knives have retractable blades. • Cut away from the body.	L

AHA #3 – Activity/Work Task: Site Surveys (Basic and Digital Geophysical Mapping (DGM) Surveys			
Job Steps	**Hazards**	**Controls**	**RAC**
	Use of utility vehicles onsite for transport of personnel and equipment	• Workers operating UTVs will be trained and designated as operators for the equipment they will operate. • Operate at safe speeds and obey local traffic rules. • Wear seat belt at all times when equipment is in operation. • Use dedicated spotter and standard hand signals for backing operations. • No cell phone or radio use permitted by driver when vehicle is in motion • Not hot refueling onsite; vehicle engine must be turned off and vehicle securely parked when refueling.	
	Poor cell phone service in remote site location	• Use radios for onsite communication • In emergency situation, drive to area with adequate coverage to place phone call to 911 • No lone site worker scenario permitted	

Equipment to be Used	Training Requirements/Competent or Qualified Personnel Name(s)	Inspection Requirements
Site vehicles and delivery vehicles	Drivers must have current country and local-issued driver's license. Drivers of rental vehicles must be authorized to drive the rental vehicle in accordance with Tetra Tech procedures.	Receipt inspection by UXOSO (as applicable). Vehicle inspection (including trailers and UTVs) by drivers. Operator's manual for each vehicle must be located with each motor vehicle.
RTK GPS and VTA	Operators will be qualified and experienced operators for use of the equipment they operate. User manuals must be available onsite.	Receipt and daily inspection by Geophysics field team leader.
Hand and power tools	Training in use of hand tools by the UXOSO or designee and review of operating manual. Use proper hand tools.	Daily inspection by users/operators. Take faulty tools out of service and clearly identify them as such to avoid others from using them.
First aid kit, fire extinguisher, eye wash station and emergency spill kit	Use of emergency equipment including first aid kits, fire extinguishers and eye wash must be done by personnel familiar with this plan; use and inspection criteria of the equipment, and what the equipment is used for, are by or under direction of the UXOSO. Emergency spill kit must be kept onsite in the event of a leak from UTV or spill during onsite refueling operations.	**Fire Extinguisher** • Initially and at least monthly thereafter by UXOSO **First Aid Kit** • Weekly and after use for restocking by UXOSO **Eye Wash Station** • Weekly by UXOSO Potable water changed weekly unless a preservative solution is used **Spill Kit** • Weekly by UXOSO
Fuel storage cans for refilling UTVs onsite	Gasoline or diesel fuel must be kept in appropriate color-coded containers with spill proof lids, nozzles and caps with proper ventilation. Storage of fuel cans must be kept either in fire proof cabinet if not removed from the site at the end of each work day. Transport of fuel cans to and from the project site must ensure that fuel cans are properly secured in the bed of a truck or in other ventilated vehicle compartment. No hot refueling is permitted (i.e. engines must be turned off).	Daily inspection of fuel cans for damage or leaks. Replace damaged or defective cans.
PPE	Users must be trained in the proper use of, limitations of, inspection of, donning and doffing of, and replacement of PPE.	Daily by user

AHA Signature Sheet

I have reviewed the above AHA and acknowledge the hazards involved with this work task and the controls that will help to minimize illness or injury during the tasks.

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Activity Hazard Analysis (AHA) #4

Job/Task: Intrusive Investigation	**Overall Risk Assessment Code (RAC) (Use highest code)**					**M**
Project Location: Butterfield Trails, Aurora CO	**Risk Assessment Code (RAC) Matrix**					
Contract Number: 179-47200021	**Severity**	**Probability**				
Date Prepared: April 5, 2021		Frequent	Likely	Occasional	Seldom	Unlikely
Prepared by: Anthony Joiner	Catastrophic	**E**	**E**	**H**	**H**	**M**
	Critical	**E**	**H**	**H**	**M**	**L**
Reviewed by: Jeffrey (Jim) Streib, CIH, CSP, CHMM, SMS, CQA Director, Health, Safety and Environmental	Marginal	**H**	**M**	**M**	**L**	**L**
	Negligible	**M**	**L**	**L**	**L**	**L**

Notes: (Field Notes, Review Comments, etc.) In addition to the information listed in this AHA, all field personnel must review and be familiar with all provisions of the approved HASP. PPE for this AHA will consist of a hard hat (when overhead safety hazards exist), leather safety-toed boots, safety glasses with side shields, a standard work uniform (long pants, tee shirt), hearing protection (as required), work gloves worn when indicated. Other PPE described in this AHA.	Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (See above)	
	"Probability" is the likelihood to cause an incident, near miss, or accident and identified as: Frequent, Likely, Occasional, Seldom or Unlikely.	**RAC Chart**
	"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible	**E = Extremely High Risk** **H = High Risk**
	Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.	**M = Moderate Risk** **L = Low Risk**

AHA #4 – Job/Task: Intrusive Investigation			
Job Steps	**Hazards**	**Controls**	**RAC**
1. Entering the range area to perform intrusive investigation and clearance activities	Encountering MEC/MPPEH – UXO may be present and can explode if handled improperly or is misidentified.	• All workers performing UXO-related activities will be qualified UXO technicians under supervision of the SUXOS. • All activities will be performed following standard operating procedures and requirements covered in the Work Plan and ESS. • UXO technicians will have refresher training on the key identification and safety precautions for anticipated conventional munitions which could be found on site.	M
	Non-essential workers or others could come into contact with or be affected by MEC/MPPEH.	• An exclusion zone (EZ) will be established in accordance with the requirements in the Work Plan. Only qualified UXO technicians will enter the EZ. • Monitor the EZ while work is underway so work can be stopped if any unauthorized personnel enter • Follow all applicable standard operating procedures in the Work Plan and ESS regarding surface clearance and MEC avoidance. • Only UXO technicians under the direct supervision of the SUXOS will handle MEC/MPPEH.	L
	Communication between teams and communication with team outside of range area in emergency – lack of proper or working communication.	• SUXOS and UXOSO will ensure that the UXO teams can communicate with each other and that a means of communication outside the range area are possible. • In addition, emergency services, in the event of an emergency must be possible so that someone can either call for or radio someone to call for emergency services. • UXOSO will verify that all coordination with emergency services has been performed prior to start of clearance activities and communications checks will be performed at start of work day and periodically during the work day.	L
	Hand excavation could cause injury to workers.	• Use probes prior to use of hand tools. • Intrusive work to be performed by UXO-qualified personnel only. • Wear leather work gloves when using tools and digging. • Use the pivot technique when digging soil. Do not twist at the waist. • Rotate digging staff as to allow others a break as required.	L

	Failure to locate and mark utilities (if present) could cause electrocution or damage to utilities.	• If the clearance area has potential utilities, all dig locations will undergo utility surveys, private locates, and geophysical verification and marking prior to intrusive investigation and clearance. • A dig permit may be required. • If utilities are present, hand digging in the location of utilities will be required and utilities will be supported in an excavation as required.	L
	Workers could be injured by high winds and dust.	• Ensure that all debris/materials are secured. • Shut down operations when wind speed is > 25 mph sustained. • Monitor the local weather report daily and as necessary for any severe weather warnings, including potential dust storms. • Know the procedures to follow in the event of severe weather emergencies (safe refuge areas, emergency assembly areas).	L
	Removal of debris can cause back strains if objects are heavy and/or awkward and repetitive.	• If object is slightly too heavy for one person, use team lift. • Rotate repetitive tasks amongst the team so as one person is not performing awkward tasks or lifting.	L
	Workers could experience eye hazards from debris and dust when walking through the area and potential for dust storms is possible.	• Safety glasses are the minimum required eye protection for all work areas. • Locate a portable 15-minute emergency eye wash at each work area. Flush objects from eyes; do not rub. • Consider wind and dust safety and monitor for potential dust storms. Seek shelter if dust storms arise.	L
	Workers could be struck by lightning if storms are in the area.	• Follow the 30-second rule (time between lightning strike and thunder) for shutdown of operations, or as determined by the UXOSO. • Immediately suspend operations when lightning is in the immediate vicinity and seek shelter in a building (preferred) or vehicle. • Monitor the local weather report daily and as necessary for any severe weather warnings. • Wait 30 minutes after the last lightning strike before resuming work. • Don't use or be in contact with metal fixtures or telephone lines when inside structures.	L
	Workers not wearing the required PPE could be injured.	• All workers will wear composite toe boots with slip resistant sole, hard hat, safety glasses.	L

		• Workers performing geophysical tasks may wear regular or composite-reinforced toe work boots while performing the surveys as steel toe boots interfere with the instrumentation. • Workers will wear high visibility safety vests when working in areas with vehicular traffic.	
	Noise from adjacent activities (e.g., airfield operations) could cause hearing loss and make it hard to communicate.	• Hearing protection is required when sound levels exceed 84 dBA continuously. • This rule applies to personnel working near or on heavy equipment and any other sources of loud noise. • The UXOSO will monitor and post hearing protection required areas and activities.	L
	Workers could experience extreme sunburn or eye strain.	• Workers will apply a broad-spectrum sunscreen to exposed skin and reapply as necessary throughout the day. • Workers are encouraged to wear a hat with a wide brim (when hardhat is not worn) to keep sun of head and long sleeve breathable UV-blocking shirts when necessary. • Safety glasses should have appropriate tint for working in an outdoor environment with strong UV exposure.	L
	Workers could be exposed to heat or to a lesser degree, cold stress.	• UXOSO will monitor for heat or cold stress in accordance with SWP 5-15, Heat Illness prevention and SWP 5-16 General Safe work practices for cold stress. • All workers will be trained in heat (and cold) stress signs and symptoms and proper prevention measures and will employ the buddy system to watch for signs and symptoms in co-workers. • Provide fluids and rest breaks (in shade and/or air-conditioned environment (e.g., work trucks) will be taken during warm weather. • Dress appropriately for the outdoor conditions and be prepared for changes that can occur throughout the day. • Provide a steady controlled work pace.	L
	Exposure to hazardous plant life could occur– sharp needles.	• Identify types of hazardous plant life. • Avoid contact with these plants. • Wear long sleeve shirts and pants. • Avoid kneeling down on the ground.	L
	Contact with biting or stinging insects, scorpions, and spiders can cause rash, anaphylactic shock, or illness.	• Workers will apply DEET to work clothing following manufacturer's instructions as a preventative measure for biting insects as required. • Tuck in pant legs to socks and tuck in shirt to pants.	L

		• Wear long sleeves when necessary. • Examine one's body thoroughly for evidence of tick being attached. Follow steps in the APP for removal of tick. Report bite or rashes to UXOSO for appropriate medical follow up to ensure entire tick has been removed (including mouth parts). • Workers with allergies to bees, hornets, wasps, etc. are strongly encouraged to let the UXOSO know using the medical data sheet and will be advised to carry their own prescription medication as applicable. • First aid and medical attention as required. • Stings to allergic persons or signs and symptoms of anaphylaxis should be considered an emergency situation.	
	Potential contact with venomous snakes.	• Review biological hazards section of HASP. Wear snake gaiters or chaps when working and walking in vegetated areas, if required. • Report any bites to the UXOSO immediately. • If venomous bite is suspected, emergency services will be contacted. If it is possible to identify the suspected species of snake, provide that information to the emergency medical staff. • Provide first aid as required • Wear leather work gloves and use caution when pickup up, turning over, or handling debris. Do not blindly place hands into depressions, holes, under rocks or debris.	L
	MEC/MPPEH is known and/or anticipated to be present and consists of UXO (including potential sub munitions) which presents an explosive hazard if improperly handled and/or misidentified.	• Only UXO technicians under the direct supervision of the SUXOS will handle MEC/MPPEH. Inspection of MPPEH will include positive identification of the item and if MEC/MPPEH, a determination on whether the MEC/MPPEH is acceptable to move or not. • All MEC/MPPEH (and debris that cannot be certified explosives free) will be accounted for at all times. • Do not handle ammunition and explosives roughly or carelessly. • Extra care should be taken because in most cases the hazards of the ammunition and/or explosives increase with age, deterioration, or damage. • Keep all spark- and flame-producing materials away from energetic materials.	M

	Carrying and using geophysical equipment and not watching step. Equipment can cause trip hazards and strains.	• Always pay attention to the ground surface when walking. • Look up and ahead when moving forward. • Use proper posture to carry equipment. • Use and adjust straps provided. • If instrumentation is heavy, utilize team carry approach when allowed or rotate users.	L
	Excavating equipment could strike MEC/MPPEH and cause detonation.	• Proceed carefully with aid of geophysical equipment and hand digging to identify item and to avoid striking object. • Proceed carefully and in a controlled manner. • When equipment is moving an item, ensure non-essential personnel are removed per requirements and SOPs in the Work Plan and ESS.	L
	Dust generation and excavation hazards (excavation depth is anticipated presently to be less than 5 feet and most excavations will be a maximum of 1 meter in depth).	• All excavation will be overseen by the designated excavation competent person (TBD). • The excavation competent person must inspect excavations on a daily basis or more frequently as required. • Excavations will be backfilled as soon as quality control and quality assurance is attained to verify removal of detected anomalies to depth of detection. • Spoil banks and equipment must be at least 2 feet away from the excavation. • Personnel must wear class 2 high-visibility clothing around operating heavy equipment. • Handle soil carefully to avoid dust generation. Use a fine spray of water to control dust as needed if visible dusts are being generated. • Competent person will conduct inspection of the excavation to identify the proper precautions are in place to protect workers based on soil types and other site-specific factors associated with the location.	L
	Contracting or spreading coronavirus.	• Stay within your social/work group. • Monitor yourself for coronavirus symptoms, if displaying symptoms do not leave your room and self-isolate. • Seek medical advice. • Maintain social distance. • Wear a face covering. • Wash hands regularly. • Display posters and information for Covid -19 mitigation measures.	M

	Dust generation and excavation hazards (excavation depth is anticipated presently to be less than 5 feet and most excavations will be a maximum of 1 meter in depth) (continued).	• In the event workers are unable to effectively control dust through engineering controls (water misting, positioning upwind),	L
	If MEC is found broken open, filler could be exposed and present an explosive hazard or chemical hazard to workers who touch filler or contaminated soil around the item.	• Notify the UXOSO and SUXOS if a MEC items is broken open and filler is exposed. • Do not handle without leather work gloves and nitrile gloves underneath. • UXOSO will ensure decontamination procedures are put into place appropriately, and ensure a hand washing station is available and used in the Contamination Reduction Zone. • Work upwind from any contamination when possible. • Control the generation of dusts during earth disturbing activities.	L

AHA #4 – Job/Task: Intrusive Investigation

Equipment to be Used	Training Requirements/Competent or Qualified Personnel Name(s)	Inspection Requirements
Hand tools, shovels	Specific training for hand tools will be provided.	Inspect before each use. Discard defective tools.
Metals detector, GPS unit	Only qualified UXO Technicians and/or geophysical technicians trained on care, use, and limitations of instruments.	Receipt inspection by SUXOS. Daily inspection by UXO Technician (user). Geophysical verification at Instrumentation Verification Strip. Daily function checks.
First aid kit, AED, fire extinguisher, eye wash station	Use of emergency equipment including first aid kits, fire extinguishers and eye wash must be done by personnel familiar with this plan; use and inspection criteria of the equipment, and what the equipment is used for, are by or under direction of the UXOSO. Those who supply first aid or use AED as first responders must have current first aid/CPR and AED training. AED users must be trained to use the specific AED that will be supplied onsite with hands-on training element.	**Fire Extinguisher** • Initially and at least monthly thereafter by UXOSO **First Aid Kit and AED** • Weekly and after use for restocking by UXOSO **Eye Wash Station** • Weekly by UXOSO • Potable water changed weekly unless a preservative solution is used **Spill Kit** • Weekly by UXOSO

Abbreviations and Acronyms:

DEET – 33% diethyl-meta- toluamide

MEC – Munitions and Explosives of Concern

NRTL – nationally recognized testing laboratory

OSHA – Occupational Safety and Health Administration

UXOSO – UXO Safety Officer

PPE – personal protective equipment

SUXOS – Senior UXO Supervisor

UL – Underwriters Laboratory

UXO – unexploded ordnance

AHA Signature Sheet

I have reviewed the above AHA and acknowledge the hazards involved with this work task and the controls that will help to minimize illness or injury during the tasks.

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Activity Hazard Analysis (AHA) #5

Job/Task: MPPEH Inspection	Overall Risk Assessment Code (RAC) (Use highest code)	M
Project Location: Butterfield Trails, Aurora CO		
Contract Number: 179-47200021		
Date Prepared: April 5, 2021		
Prepared by: Anthony Joiner		
Reviewed by: Jeffrey (Jim) Streib, CIH, CSP, CHMM, SMS, CQA Director, Health, Safety and Environmental		

Risk Assessment Code (RAC) Matrix

Severity	Probability				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	E	E	H	H	M
Critical	E	H	H	M	L
Marginal	H	M	M	L	L
Negligible	M	L	L	L	L

Notes: (Field Notes, Review Comments, etc.)
In addition to the information listed in this AHA, all field personnel must review and be familiar with all provisions of the approved HASP.

PPE for this AHA will consist of a hard hat (when overhead safety hazards exist), leather safety-toed boots, safety glasses with side shields, a standard work uniform (long pants, tee shirt), hearing protection (as required), work gloves worn when indicated. Other PPE described in this AHA.

Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (see above).

	RAC Chart
"Probability" is the likelihood to cause an incident, near miss, or accident and is identified as Frequent, Likely, Occasional, Seldom, or Unlikely.	
"Severity" is the outcome/degree if an incident, near miss, or accident did occur and is identified as Catastrophic, Critical, Marginal, or Negligible.	**E = Extremely High Risk** **H = High Risk**
Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on the AHA. Annotate the overall highest RAC at the top of the AHA.	**M = Moderate Risk** **L = Low Risk**

AHA #5 – Job/Task: MPPEH Inspection

Job Steps	Hazards	Controls	RAC
1. MPPEH Processing (includes initial processing (e.g. during surface and intrusive investigation) and final inspection/processing	MPPEH classification failure Certification and Verification material as explosives free can be inaccurate and potentially explosive material can be sent off site improperly.	• Install and enforce exclusion zone (EZ) as outlined in ICAP. • Evacuate all non-essential personnel from EZ before processing MPPEH. • Ensure the SUXOS or designated UXO Tech III is present.	M

AHA #5 – Job/Task: MPPEH Inspection			
Job Steps	**Hazards**	**Controls**	**RAC**
for transport and disposal or recycling	Exposure to MEC (explosive hazards)	• MPPEH processing will be performed by an UXO Tech III and SUXOS with-qualified personnel only. • Under no circumstances will personnel work alone. • Positively identify all munitions and ensure all non-munitions are verified by inspection as explosives free. • Keep all spark- and flame-producing materials away from energetic materials. • Do not handle ammunition and explosives roughly or carelessly. Extra care should be taken because in most cases the hazards of the ammunition and/or explosives increase with age, deterioration, or damage. • All MPPEH and debris management will be performed in accordance with procedures in the Work Plan, including accountability requirements.	
	Ergonomic hazards such as sprains, strains, or back injury could occur from lifting or repetitive actions.	• Consolidate debris as much as possible in a general area that is aside from the investigation area. • Provide equipment to contain material, move it, and deposit it into containers. Maintain steady pace when using tools and take adequate rest periods. • If possible, rotate tasks among the workers.	L
	Workers could experience extreme sunburn or eye strain.	• Workers will apply a broad-spectrum sunscreen to exposed skin and reapply as necessary throughout the day. • Workers are encouraged to wear a hat with a wide brim (when hardhat is not worn) to keep sun of head and long sleeve breathable UV-blocking shirts when necessary. • Safety glasses should have appropriate tint for working in an outdoor environment with strong UV exposure.	L
	Workers could be exposed to heat or to a lesser degree, cold stress.	• All workers will be trained in heat (and cold) stress signs and symptoms and proper prevention measures and will employ the buddy system to watch for signs and symptoms in co-workers. • Provide fluids and rest breaks (in shade and/or air-conditioned environment (e.g., work trucks) will be taken during warm weather. • Dress appropriately for the outdoor conditions and be prepared for changes that can occur throughout the day. • Provide a steady controlled work pace.	L

AHA #5 – Job/Task: MPPEH Inspection			
Job Steps	**Hazards**	**Controls**	**RAC**
	Debris can host a variety of pests and during inspection of interiors and hidden parts of debris, spiders, scorpions, and other insects could be present. Contact with biting or stinging insects, scorpions, and spiders can cause rash, anaphylactic shock, or illness.	• Debris can host a variety of pests and during inspection of interiors and hidden parts of debris, spiders, scorpions, and other insects could be present. • Workers will apply DEET to work clothing following manufacturer's instructions as a preventative measure for biting insects as required. • Tuck in pant legs to socks and tuck in shirt to pants. Wear long sleeves when necessary. • Examine your body thoroughly for evidence of tick being attached. Report bite or rashes to UXOSO/UXOSO for appropriate medical follow up to ensure entire tick has been removed (including mouth parts). • Workers with allergies to bees, hornets, wasps, etc. are strongly encouraged to let the UXOSO know using the medical data sheet and will be advised to carry their own prescription medication as applicable. • First aid and medical attention as required. Stings to allergic persons or signs and symptoms of anaphylaxis should be considered an emergency situation.	L
	Contracting or spreading coronavirus.	• Stay within your social/work group. • Monitor yourself for coronavirus symptoms, if displaying symptoms do not leave your room and self-isolate. • Seek medical advice. • Maintain social distance. • Wear a face covering. • Wash hands regularly. • Display posters and information for Covid -19 mitigation measures.	M
	Potential contact with venomous snakes if hiding within recesses of debris.	• Report any bites to the UXOSO immediately. • If venomous bite is suspected, emergency services will be contacted. If it is possible to identify the suspected species of snake, provide that information to the emergency medical staff. • Provide first aid as required. • Wear leather work gloves and use caution when pickup up, turning over, or handling debris. • Do not blindly place hands into depressions, holes, under rocks or debris.	L

AHA #5 – Job/Task: MPPEH Inspection			
Job Steps	**Hazards**	**Controls**	**RAC**
	Handling drums for debris consolidation can cause cuts and/or pinch points.	• Use proper drum opening and closing tools to remove and seal lids. • Wear leather work gloves when handling debris and opening/closing drums. • Keep hands and body out of pinch point on ring of drum.	L
	Handling sharp objects or using hand tools could cause cuts, punctures, or scrapes.	• Wear leather work gloves when handling materials that may be sharp or have sharp edges. • Be familiar with the proper use and limitations of hand tools. • Report even minor injuries to your supervisor for evaluation. • Have a first aid kit available and have a minimum of two persons with first aid and CPR training on site.	L

AHA #5 – Job/Task: MPPEH Inspection		
Equipment to be Used	**Training Requirements/Competent or Qualified Personnel Name(s)**	**Inspection Requirements**
Hand tools	Specific training for hand tools will be provided.	Daily and before use. Use the equipment safety checklist.
First aid kit, fire extinguisher, eye wash station	Use of emergency equipment including first aid kits, fire extinguishers and eye wash must be done by personnel familiar with this plan; use and inspection criteria of the equipment, and what the equipment is used for, are by or under direction of the UXOSO.	Fire Extinguisher • Initially and at least monthly thereafter by UXOSO First Aid Kit • Weekly and after use for restocking by UXOSO Eye Wash Station • Weekly by UXOSO • Potable water changed weekly unless a preservative solution is used

Abbreviations and Acronyms:

AHA – Activity Hazard Analysis

DEET – 33% diethyl-meta- toluamide

EM – Engineer Manual

EZ – exclusion zone

MEC – munitions and explosives of concern

mph – miles per hour

MPPEH – material potentially presenting an explosives hazard

OSHA – Occupational Safety and Health Administration

PPE – personal protective equipment

RAC – Risk Assessment Code

SUXOS – Senior UXO Supervisor

UXO – unexploded ordnance

UXOSO – UXO Safety Officer

AHA Signature Sheet

I have reviewed the above AHA and acknowledge the hazards involved with this work task and the controls that will help to minimize illness or injury during the tasks.

NAME	SIGNATURE	TITLE	DATE
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APPENDIX B

Standard Operating Procedures

Standard Operating Procedures:

DGM_SOP-01 - Civil Survey

DGM_SOP-02 - QC Seeding

DGM_SOP-03 - IVS Construction

DGM_SOP-04 - Initial IVS Survey

DGM_SOP-05 - EM61 VTA Assembly

DGM_SOP-06 - EM61 VTA Data Collection

DGM_SOP-07 - EM61 Assembly

DGM_SOP-08 - EM61 Data Collection

DGM_SOP-09 - DGM Data Processing

UXO_SOP-01 – MEC Avoidance

UXO_SOP-02 – Vegetation Clearance

UXO_SOP-03 – Surface Sweep-Clearance Operations

UXO_SOP-04 – Intrusive Investigation Operations

UXO_SOP-05 - MPPEH and MDAS Management and Disposal

UXO_SOP-06 - MEC Management and Disposal

TETRA TECH

DGM SOP for Civil Survey

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct civil survey operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Geophysics. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director of Geophysics Matt Barner		Date:	

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read DGM SOP – Civil Survey and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP, or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

TABLE OF CONTENTS

1.0 PURPOSE AND SCOPE

The purpose of this Digital Geophysical Mapping (DGM) Standard Operating Procedure (SOP) is to provide procedures and technical guidance for acquiring land survey data to facilitate a variety of tasks. Tasks that are not solely civil survey operations will have additional requirements as detailed in their respective SOPs. These operations may be conducted using either Real Time Kinetic (RTK)-Global Positioning System (GPS) or Robotic Total Station (RTS) technologies. These operations include:

- Establishment of site-specific control for use during follow-up tasks;
- The establishment of area site boundaries and the internal grid infrastructure before survey operations;
- Marking and recording inaccessible areas;
- Recording recovered Munitions and Explosives of Concern (MEC) / Material Potentially Presenting an Explosive Hazard (MMPEH);
- Construction of the Instrument Validation Strip (IVS);
- Recording blind seed locations; and
- Reacquisition of targets.

All training on equipment or software will be either formal or on-the-job training (OJT). Site personnel will document training subject to review for accuracy and completeness. The Unexploded Ordnance (UXO) Quality Control Specialist (UXOQCS) will verify training is complete and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 PERSONNEL

The following individuals may be involved in civil survey activities:

- Professional Land Surveyor (PLS)
- Project Geophysicist
- Site Geophysicist
- Field Technician
- Quality Control (QC) Geophysicist
- UXO Technicians
- Unexploded Ordnance Quality Control Supervisor (UXOQCS)

2.2 EQUIPMENT

- Base station and Rover GPS (for RTK)
- Radio modem (for RTK)

- Robotic Total Station (RTS), if needed
- Survey stakes or flags

3.0 PROCEDURES AND GUIDELINES

Anomaly avoidance procedures will be carried out during this procedure if a MEC hazard exists at the site.

Control points will be established either by reference to existing National Geodetic Survey benchmarks or by High Accuracy Reference Network (HARN), Continuously Operating Reference Station (CORS), Virtual Reference Station (VRS) network, or Online Positioning User Service (OPUS) networks. Control points will be confirmed monthly and must be repeatable. If no existing documented control point is present on site, this will be accomplished by collecting GPS data for a minimum of four (4) hours and generating an OPUS solution.

When navigating to coordinates to mark boundary or grid corners, or to perform reacquisition of targets, the locations will be loaded on the system controller so that the technician can navigate to the location. A non-metallic flag with the target number should be placed at the location of a reacquired target. Boundary markers and grid corners will be placed at project defined intervals. Corners will be marked with a wooden stake (or similar) with the grid number written on it if applicable.

3.1 EQUIPMENT SET-UP

Instruments will be set-up according to manufacturer instructions, which will be shipped with the equipment or provided by the Site or Project Geophysicist. If a PLS is utilized and provides their own equipment, they will set it up according to their internal procedures.

Equipment shall be set up in the project defined coordinate system. All survey data should be temporarily stored in the GPS/Geophysical system, downloaded daily and submitted to the project data manager, geophysicist, or Geographic Information System (GIS) manager. For OPUS confirmation, raw ephemeris and range data will be collected on the base station and submitted to the Project Geophysicist.

Prior to set-up, all equipment will be confirmed to be in good working condition, including fully charged batteries.

3.2 EQUIPMENT OPERATIONS

Geodetic precision and functionality must be demonstrated before all civil surveying activities. The position offset of a known/temporary control point must be verified daily for each positioning system in use. The procedure for this is as follows:

- For RTK GPS:
    - Set up base station over a documented, independently established control point and rover according to manufacturer instructions;
    - Ensure the rover has “lock” and is receiving corrections from the base station;
    - Ensure the rover is level and record a data point over a known, independently established control point to ensure the accuracy meets the Measurement Quality Objective (MQO);
    - If offset exceeds the MQO, ensure set-up parameters are correct and try again; and
    - Perform a Root Cause Analysis (RCA) if necessary.

- For RTS:
  - Set up RTS gun over a documented control point and perform back sight following the equipment manual;
  - Set up RTS gun at any location and perform a resection following the equipment manual;
  - Record a data point at a known, independently established control point to ensure the accuracy meets the MQO;
  - If offset exceeds the MQO, ensure set-up parameters are correct and try again; and
  - Perform an RCA if necessary.

Where applicable, real-time data feeds (GPGGA strings and associated quality parameters) during equipment operations should be verified and monitored according to the relevant SOP.

4.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 INPUT DATA REQUIRED

The following data shall consist of a Point ID and coordinates. The specific survey task will determine which of these lists is relevant for each operation.

- List of local National Geodetic Survey (NGS) benchmarks
- List of survey boundary coordinates
- List of grid corner coordinates
- List of blind seed target coordinates
- List of reacquisition target coordinates

4.2 OUTPUT DATA

The primary output from this SOP for civil survey operations are stakes/flags in the ground and stored coordinates for their location. Additional data outputs, where applicable, will consist of raw GPS data for OPUS processing (ephemeris and range), or offsets from previously known or measured coordinates. These data files will be transferred daily (or more often as dictated by site procedures) to the data analyst.

5.0 QUALITY CONTROL

For QC of this SOP, a Checklist for Civil Survey will be used. This checklist will be completed and signed by the Field QC Designee, and the QC Geophysicist upon completion of any set of civil survey operations (e.g., after stakeout, after blind seeding, after reacquisition).

5.1 MEASUREMENT QUALITY OBJECTIVES

The MQOs for civil surveys and geodetic operations are presented in the QAPP or equivalent planning document, with results documented in the project database.

5.2 REPORTING

The project database will contain all civil survey records. Control documentation will be provided to verify Geodetic accuracy and precision. For any work performed by a land surveyor subcontractor, a surveyor's report will be generated by the subcontractor upon completion of the work.

5.3 QC CHECKLIST FOR CIVIL SURVEY

TEAM INFORMATION						
Team:	**Location:**				**Date:**	
Team Leader:						
Personnel Present:						
Contract #:						
Task Order #:						
QC CHECKLIST POINTS						
Item	**Ref.**	**Inspection Points**	**Yes**	**No**	**N/A**	**Comments**
1	This SOP	Have personnel read and signed the workers' statement?				
2	This SOP	Was the instrument assembled correctly?				
3	This SOP	Were the correct datum and base station coordinates used?				
4	This SOP	Are control points tied to an external network?				
5	This SOP, WS#22	Are daily position checks within specified tolerances?				
6	This SOP	Were grid corners marked at the specified intervals?				
7	This SOP	Were the data downloaded to the project database?				
8	This SOP, WS#22	Have the appropriate MQOs been achieved?				
9	This SOP	Have all batteries voltage checks been conducted?				
FINDINGS						
Item	**Comments**					

Signatures:

Field QC Designee:		Date:	
QC Geophysicist (indicating form reviewed):		Date:	

TETRA TECH

DGM SOP for QC Seeding

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct QC seeding operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Geophysics. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director of Geophysics Matt Barner		Date:	

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read DGM SOP – QC Seeding and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

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1.0 PURPOSE AND SCOPE

The purpose of this Digital Geophysical Mapping (DGM) Standard Operating Procedure (SOP) is to provide procedures and technical guidance for installing the second component of the Geophysical System Verification (GSV): quality control (QC) Blind Seeds. As part of the GSV process, the Blind Seeding Program ensures that the complete geophysical process, as deployed for data collection and as processed for detection and classification, is functioning correctly and will achieve project Measurement Quality Objectives (MQOs). This SOP also includes coverage seeds for surface sweep activities if they are performed in advance of a DGM or Analog Geophysical Mapping (AGM) survey.

All training on equipment or software will be either formal or on-the-job training (OJT). This training will be documented by site personnel and subject to review for accuracy and completeness. The Unexploded Ordnance (UXO) Quality Control Specialist (UXOQCS) will verify training is complete and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 PERSONNEL

The following individuals may be involved in the emplacement of QC Blind Seeds:

- Quality Control (QC) Geophysicist
- UXOQCS
- Field Technician
- UXO Personnel

2.2 EQUIPMENT

- Industry-standard objects (ISOs) and/or inert munitions (optional);
- Handheld analog or man-portable digital geophysical sensor;
- Hand tools including shovels, pickaxes, breaker bars, etc. to emplace the seeds;
- Compass and inclinometer for measurement of seed orientation and azimuth;
- Real-time kinetic (RTK) global positioning system (GPS) or Robotic Total Station (RTS) unit to record the location of seed items;
- Meter stick and straight edge to measure the depth of the seeded items;
- EM61-MK2 sensor alone for use in search mode (optional).

3.0 PROCEDURES

Anomaly avoidance procedures will be carried out during this procedure if a Munitions and Explosives Concern (MEC) hazard exists at the site.

The GSV is composed of two components: an IVS and a blind seeding program. This SOP outlines the installation of the blind seeds only. IVS construction and survey procedures are described in separate SOPs. Specific details about the number and placement of blind seed items must remain firewalled from the production survey team. Specific details related to the blind seeds are left out of this procedure to maintain a QC firewall.

3.1 BLIND SEED SELECTION

Blind QC seeds should be selected to represent the project conceptual site model (CSM) and will be defined in the project Quality Assurance Project Plan (QAPP) and/or a Production Area Seeding Plan. The sizes of items should be representative of the anticipated Targets of Interest (TOI), and the burial depths should not exceed 80% of the sensor detection depth for DGM surveys. For surface sweep teams, coverage seeds may be placed on the surface.

Blind QC Seeds will be emplaced at the rate defined in the QAPP or Production Area Seeding Plan. The expectation is that seeds will be placed to ensure data will be collected over at least one seed per team per day for digital detection methods, and 2 seeds per acre for analog methods in areas that will be resurveyed by digital methods (e.g., surface sweep in advance of vegetation clearance and subsequent DGM), or five seeds per team per day for areas with analog detection methods only.

3.2 ANOMALY AVOIDANCE

The site may contain some metallic items or electromagnetically active geology. The emplacement team should avoid emplacing seeds near any strong anomalies. First, the emplacement team should acquire the seed's intended location, as provided in the Production Area Seeding Plan. This may be general guidance rather than a specific location. The team should use a handheld instrument to survey within the immediate vicinity of the intended location. If there are no strong anomalies in the immediate vicinity, the team should emplace the seed at the intended location. If, however, the intended location is near any strong anomalies, the team should select a new location for the seed, as close as safety allows. The new location should not be within 2 meters of any strong anomaly and should not be within 60 centimeters (cm) of another seed.

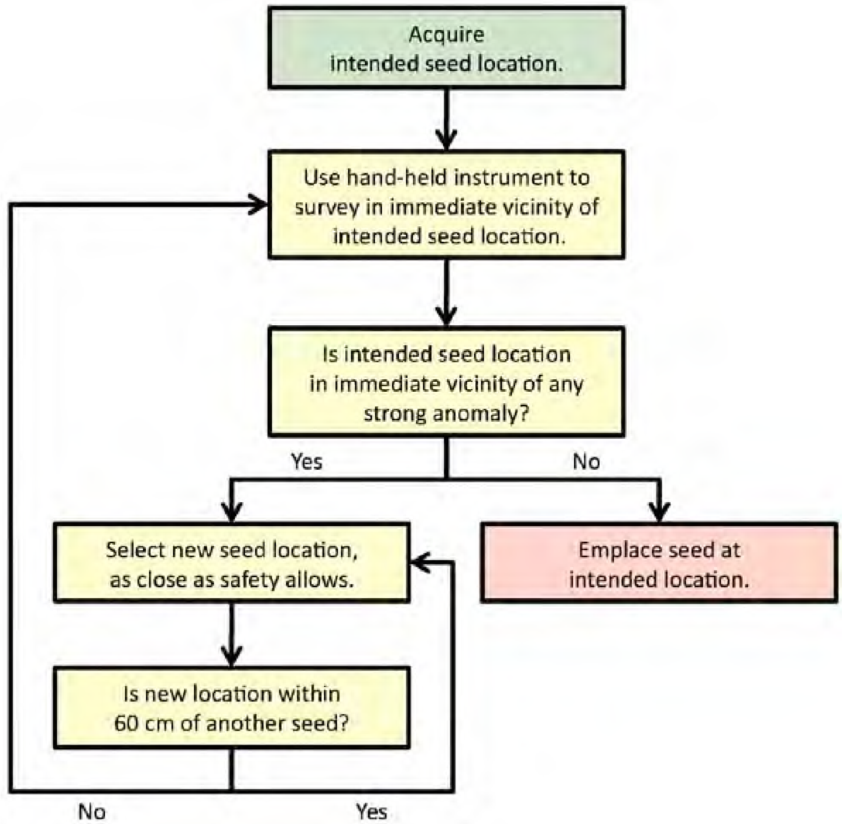

Figure 1: Anomaly avoidance during seed emplacement.

3.3 SEED EMPLACEMENT

It is critical for achieving project MQOs that the actual locations of the buried seeds are surveyed as accurately as possible. The emplacement team should dig in a fashion to minimize seed settling after burial. The burial locations should be measured to 2 cm precision, with the depths placed to 5 cm precision and the inclinations and azimuths to 10-degree precision. The locations and placement of the final burials should be surveyed using Real-time Kinematic Global Positioning System (RTK-GPS), Robotic Total Station (RTS), or equivalent.

The location and depth of the seeds must be measured before burial to ensure accurate measurements. After emplacing a seed in the ground, but before covering it with soil, the following information should be carefully recorded:

- The x, y, and z coordinates for the center of the seed;
- The depth of the seed measured as the vertical distance from the bottom of a straight edge placed across the opening of the hole down to the center of the seed;
- Seed inclination and azimuth measured with inclinometer and compass;
- A photograph of the seed in the open hole, showing its label. A ruler or similar scale should also be included in the photograph. A whiteboard containing the following information should also be included in the photo:

- Site Name
- Date
- Team Lead
- Seed ID
- Seed Type
- Depth to center of mass
- Inclination and azimuth

For each seed, the emplacement team should also:

- Ensure the seed is marked with blue paint (for inert items) and/or tagged to identify that it is a Tetra Tech seed;
- Replace the soil in the hole as completely as possible;
- Level the burial location;
- Replace the grass plug over the burial location (if possible);

4.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 INPUT DATA REQUIRED

The project QAPP and/or Production Area Seeding Plan containing site-specific seeding requirements.

4.2 OUTPUT DATA

The output data from this SOP is the Blind Seed Log. The Blind Seed Log is required to be maintained under the firewall procedures defined in corporate procedures and the Blind Seed Firewall Plan. The table should include the same information as the whiteboard, as defined in Section 3.3 of this SOP, and should be accompanied by a photograph of the item in the ground before being covered.

5.0 QUALITY CONTROL

For QC of this SOP, a Checklist for QC Seeding will be used. This checklist will be filled out and signed by the UXOQCS (or designee) and the QC Geophysicist upon completion of the QC Seeding.

The QC Seeding information must be firewalled from the production geophysical collection and processing team. This activity is performed solely by personnel with experience in positioning, geophysical surveying, and UXO anomaly avoidance. If control of the seed files is compromised, this should be evaluated, and consideration should be given to removal and re-emplacement of the seeds.

5.1 MEASUREMENT QUALITY OBJECTIVES

The MQOs for QC Seeding are presented in the QAPP or equivalent planning document. They should be consistent with those found in AppendixA of the DoD Quality System Requirement (QSR), with results documented in the project database.

5.2 REPORTING

This procedure will be documented in the Production Area Seeding Report. This report will consist of a brief narrative describing the seed emplacement, and a discussion of significant deviations from the Blind Seeding Plan. The bulk of the report includes the Blind Seed Log and accompanying photographs.

5.3 QC CHECKLIST FOR QC SEEDING

TEAM INFORMATION						
Team:			**Location:**			**Date:**
Team Leader:						
Personnel Present:						
Contract #:						
Task Order #:						
QC CHECKLIST POINTS						
Item	**Ref.**	**Inspection Points**	**Yes**	**No**	**N/A**	**Comments**
1	**This SOP**	Have personnel read and signed the workers' statement?				
2	**This SOP**	Were the seeds acquired and prepared IAW the Blind Seed Plan?				
3	**This SOP**	Were the seeds buried IAW the Blind Seed Plan?				
4	**This SOP**	Were the buried seeds positioned, photographed, backfilled, response verified, and documented for the Blind Seed Log?				
5	**This SOP**	Has an effective firewall been implemented?				
FINDINGS						
Item	**Comments**					

Signatures:

UXOQCS (or designee):		Date:	
QC Geophysicist: (indicating form reviewed):		Date:	

DGM SOP for Instrument Verification Strip Construction

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct IVS installation operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Geophysics. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director of Geophysics Matt Barner		Date:	

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read DGM SOP – IVS Construction and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

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1.0 PURPOSE AND SCOPE

The purpose of this Digital Geophysical Mapping (DGM) Standard Operation Procedure (SOP) is to provide procedures and technical guidance for installing the first component of the Geophysical System Verification (GSV): The Instrument Verification Strip (IVS). As part of the GSV process, the geophysical sensor system measures the response of each item in the IVS, and these responses are compared to expected responses to ensure and document the proper functioning of the system. Proper IVS installation is a critical step to ensure that the geophysical system will achieve the project Measurement Quality Objective (MQOs). Periodic checks of geophysical sensors will be made over this area to ensure that the project Measurement Quality Objectives (MQOs) are met. The configuration of the IVS (number, type, depth, and orientation of targets) will be detailed in the Quality Assurance Project Plan (QAPP) or equivalent planning document. Details of a typical configuration are provided for reference.

All training on equipment or software will be either formal or on-the-job training (OJT). This training will be documented by site personnel and subject to review for accuracy and completeness. The Unexploded Ordnance (UXO) Quality Control Specialist (UXOQCS) will verify training is complete and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 PERSONNEL

The following individuals may be involved in civil survey activities:

- Technical Manager
- Project Geophysicist
- Site Geophysicist
- Field Technician
- UXO Personnel
- Data Processor
- Quality Control (QC) Geophysicist
- UXOQC Staff
- Subcontracted professional land surveyor (PLS)

2.2 EQUIPMENT

- Inert munitions, schedule 80 small Industry Standard Objects (ISO), medium ISOs and/or large ISOs;
- Measuring tape and non-metallic markers (pin flags, stakes, tent pegs, spray paint, etc.) to mark the positions of the test items and the beginning and end of the IVS;
- Hand tools, including shovels, pickaxes, breaker bars, etc. to construct the IVS;
- Meter stick and straight edge to measure the depth of the IVS items;

- Real-time kinetic (RTK) global positioning system (GPS) or Robotic Total Station (RTS) unit to record the location of IVS items and IVS endpoints; and
- Analog sensors to provide anomaly avoidance.

3.0 PROCEDURES

The GSV is composed of two components, an IVS and a blind seeding program. This SOP outlines the installation of the IVS only. Blind seeding procedures are described in a separate SOP.

3.1 IVS LOCATION

Verification of the geophysical system is initially accomplished using an IVS. Multiple IVS locations may be constructed during the project for convenience (for example, to avoid long travel times to reach the IVS on large sites). The construction procedures described in this document apply to each IVS location.

IVS locations will be determined during the initial site reconnaissance. The IVS should be established in an area that is easily accessible, not prone to flooding and other weather-related phenomena, and is determined to be relatively free of surface and subsurface metal objects, and far away from utility lines or other sources of magnetic or electromagnetic noise. The IVS is constructed as one or more survey transects.

3.2 IVS SEED OBJECTS

Seed objects for the IVS can either be actual inert munitions or ISOs. Using inert munitions that match those expected to be found on the site demonstrates to stakeholders that the system can accurately detect the site-specific targets of interest. However, using ISOs is the technical equivalent of using inert munitions, allows for better instrument calibration, and extraordinary measures to obtain inert munitions are not warranted.

ISOs, if used, should approximate the size of the Munitions and Explosives of Concern (MEC) expected to be found on the site, and more than one type of ISO should be used if MEC of multiple sizes are expected. Small, medium, or large ISOs, individually or in combination, can be selected. Options for 20mm surrogates in the form of 2-inch bolts are also acceptable. Table 1 shows the specification for six possible ISOs, and Figure 1 is a photograph of the three ISO pipe sizes.

Table 1. Industry-Standard Objects Characterized For Use As Munitions Surrogates

Item	Nominal Pipe Size	Outside Diameter	Length	Part Number[1]	Schedule
Small ISO80	1"	1.315" (33 mm)	4" (102 mm)	4550K226	80
Small ISO40	1"	1.315" (33 mm)	4" (102 mm)	44615K466	40
Medium ISO40	2"	2.375" (60 mm)	8" (204 mm)	44615K529	40
Large ISO40	4"	4.500" (115 mm)	12" (306 mm)	44615K137	40
Med-Strength 5/8”-11 x 2” Bolt	--	--	2” (51mm)	92865A802	--
Heavy Steel Hex 5/8”-11 x2” Bolt	--	--	2” (51mm)	91571A266	--

[1] Part number from the McMaster-Carr catalog (http://www.mcmaster.com/).

Figure 1. Small, Medium, and Large ISO

3.3 IVS INSTALLATION

Figure 2 illustrates the overall IVS process and the procedures to be followed during the siting, emplacement, and use of the IVS.

1. An IVS location will be selected with a preference for the following (although none of the conditions are vital for the success of the IVS):
   - Terrain, geology, and vegetation similar to that of a majority of the survey area;
   - Geophysical noise conditions similar to those expected across the survey area;
   - Large enough site to accommodate all necessary IVS tests and equipment and for adequate spacing (at least a 3-meter (m) separation and preferably greater) between the ISO items to avoid ambiguities in data evaluation;
   - Readily accessible to project personnel; and
   - Close proximity to the actual survey site (if not within the site).
2. A potential IVS area that is relatively clear of surface and subsurface metallic objects will be located using analog sensors. The purpose of this step is to determine the appropriateness of the location for the IVS (e.g., few existing anomalies), and to verify that IVS targets are not seeded near existing anomalies.
3. Once the IVS area is deemed suitable for use (i.e., free of subsurface objects clearly identified to be avoided during seeding), seeds will be buried at the designated orientations and depths below ground surface (bgs). A blank space or empty hole will be included as one of the IVS target locations. A diagram of a typical IVS configuration is presented in Figure 3.

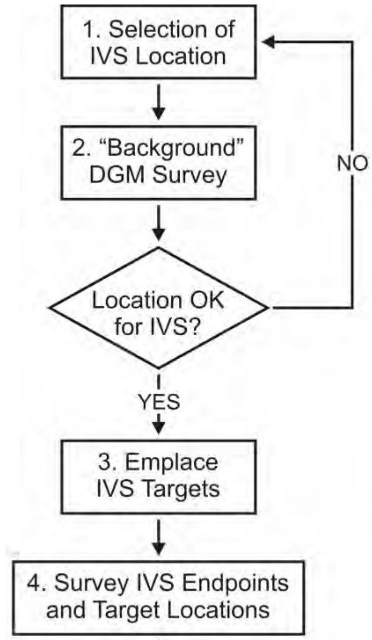

Figure 2. IVS Siting and Emplacement

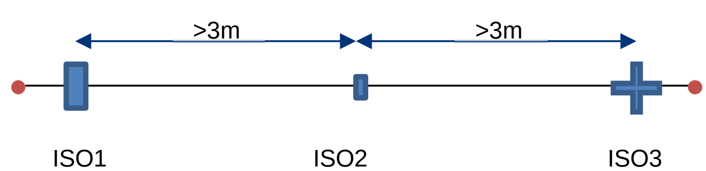

Figure 3. Layout of the IVS

Table 2. Example of IVS Item Details

IVS Position	Description	Depth to COM	Orientation
IVS01	ISO1, Small ISO40	3 inches	Horizontal
IVS02	ISO2, Small ISO40	7 inches	Vertical
IVS03	ISO3, Medium ISO	8 inches	Horizontal

Measurements of the item depths will be to the center of mass (COM) of each item. On-site personnel will bury the IVS targets using shovels to dig the holes to the appropriate depths for burial of the seed items in coordination with the QC Geophysicist. UXO personnel will implement MEC avoidance procedures using analog instruments during installation. The background survey data and anomaly avoidance techniques will be reviewed, so that transect start and end stakes and the seed items are not placed on top of or near existing anomalies. IVS construction personnel will emplace the ISOs and record the following information:

- Transect endpoints;
- Target type;
- Target emplacement location (with RTK- GPS or RTS);
- Target emplacement depth; and
- Target emplacement orientation.

4. A photograph will be taken before backfilling the holes, documenting the depth of the item in the hole, the date, the IVS item number, and a scale.

5. The holes will then be filled with soil, and a non-metallic pin flag or another suitable non-metallic marker will be placed at each buried item location, as well as the start and end location of the IVS. The markers will not interfere with the sensor when passing over them.

6. If dynamic mapping surveys are part of the scope of work, a background noise measurement strip will also be set up adjacent to the IVS, offset by at least 5m. The endpoints of the background line will also be recorded and marked with a non-metallic visual marker.

4.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 INPUT DATA REQUIRED

Input data required for this SOP are the locations and identities of the IVS items.

4.2 OUTPUT DATA

Output Data include:

- Spatial location (X, Y coordinates) for as-built IVS items and transect endpoints;
- Photographs of the items in the open hole;
- The IVS construction and initial survey results will be documented in an IVS Technical Memorandum;
- Updated project database.

5.0 QUALITY CONTROL

For QC of this SOP, a Checklist for IVS Construction will be used. This checklist will be filled out and signed by the Field QC Designee and the QC Geophysicist upon completion of the IVS Construction.

5.1 MEASUREMENT QUALITY OBJECTIVE

The MQOs for the IVS are presented in the QAPP or equivalent planning document, with results documented in the project database.

5.2 REPORTING

The IVS construction will be documented as part of the IVS Technical Memorandum. This will include information on the following:

- IVS location and setup, including IVS item description, type, spatial location, depth, and orientation;
- Completed QC checklist.

5.3 QC CHECKLIST FOR IVS INSTALLATION

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	This SOP	Have personnel read and signed the worker's statement?				
2	This SOP	Has an appropriate location for the IVS been selected?				
3	This SOP	Have appropriate IVS seed targets been selected and procured?				
4	This SOP	Were the target seeds buried appropriately, backfilled, and marked?				
5	This SOP	Are the required data from the IVS construction recorded for inclusion in the IVS Technical Memorandum?				

FINDINGS

Item	Comments

Signatures:

Field QC Designee:		Date:	
QC Geophysicist: (indicating form reviewed):		Date:	

DGM SOP for Initial IVS Survey

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct initial IVS survey operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Geophysics. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director of Geophysics Matt Barner		Date:	

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read DGM SOP – Initial IVS Survey and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

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FIGURES

1.0 PURPOSE AND SCOPE

The purpose of this Digital Geophysical Mapping (DGM) Standard Operation Procedure (SOP) is to provide procedures and technical guidance for collecting sensor verification data at the Instrument Verification Strip (IVS). As part of the Geophysical System Verification (GSV) process, the electromagnetic induction sensor system measures the response of each item in the IVS, and these responses are compared to expected responses to ensure and document proper functioning of the system. The initial tests at the IVS are critical to establishing several baseline metrics that will be used throughout the project and are compiled in the IVS Technical Memorandum. Also, periodic checks of geophysical sensors will be made over this area to ensure that the project Measurement Quality Objectives (MQOs) are met.

The following procedures apply to most digital geophysical mapping (DGM) sensor systems. Project-specific line spacing will be detailed in the project-specific Quality Assurance Project Plan (QAPP) or equivalent planning document and will depend on the sensor and the IVS configuration. Details of typical configurations (a single sensor with 0.5m production line spacing, and a three-sensor towed array with 1.0m sensor spacing) are provided for reference. Other configurations, such as airborne or marine magnetic or electromagnetic arrays will have different spacing requirements as detailed in the QAPP. Also, specific tests and metrics may not be possible or practical with these systems. All exemptions and deviations will be noted in the QAPP.

All training on equipment or software will be either formal or on-the-job training (OJT). Site personnel will document the training for review for accuracy and completeness. The Unexploded Ordnance (UXO) Quality Control Specialist (UXOQCS) will verify training is complete and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 PERSONNEL

The following individuals may be involved in sensor verification at the IVS:

- Project Geophysicist
- Site Geophysicist
- Field Technician
- UXO Personnel
- Data Processor
- Quality Control (QC) Geophysicist

2.2 EQUIPMENT

- Electromagnetic (EM) or magnetic (mag) sensor(s) coupled with a real-time kinematic (RTK) global positioning system (GPS) or Robotic Total Station (RTS) or operated in wheel-counter/fiducial mode and
- IVS installed following appropriate SOP.

3.0 PROCEDURES

Surveys of the IVS are performed periodically throughout the project (typically twice daily), and all follow the procedures outlined in this SOP. Initial IVS procedures will be followed at the start of the project and whenever a new instrument is brought on site or a new IVS site is established. Initial IVS results are reported in the IVS Technical Memorandum. QC inspection of the initial IVS survey is reported using the QC Checklist for this SOP. Daily IVS procedures are reported as part of the Data Collection SOP and use a separate QC Checklist.

3.1 INITIAL IVS DATA COLLECTION PROCEDURES

The operator(s) will collect initial sensor data along the IVS at the production line spacing listed in the project-specific QAPP or equivalent planning document, plus additional lines spaced at half the line spacing. Figure 1 illustrates this using an example line spacing of 0.5m. The background line will also be surveyed. The centerline should be surveyed several times, including in opposite directions, to verify the system lag/latency and to establish average response values for each seed item.

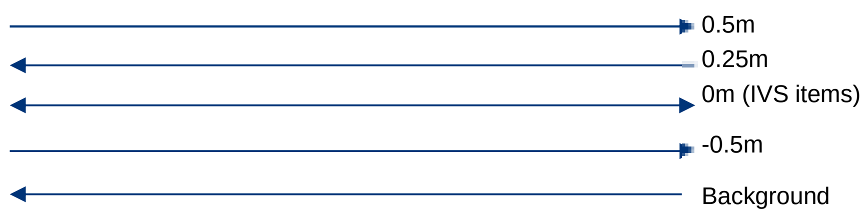

Figure 1. Initial Dynamic IVS Data Collection Example (EM61-MK2)

When an array of sensors is mounted on a vehicle-towed array (VTA), the IVS will be surveyed using overlapping swaths, including both directions at each offset to monitor latency. The centerline of the array will be towed along a line with an offset of 1m to either side of the IVS centerline (Figure 2). The background line will also be surveyed in at least one direction.

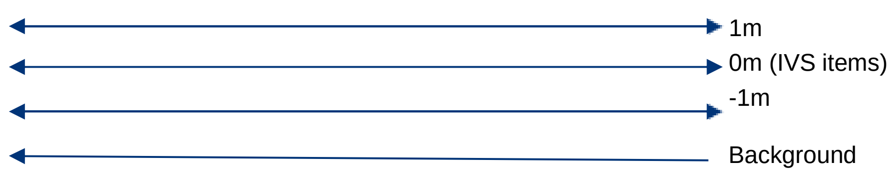

Figure 2: Initial Dynamic IVS Data Collection Example (VTA)

The accuracy of digital positioning systems will be verified by reference to a civil survey monument following the appropriate SOP and the project-specific QAPP. MQOs for the positioning system are provided in the QAPP. For some configurations, the derived target locations will suffice to meet this requirement.

A sensor function test (static spike) will also be collected at the IVS blank space (in background line). Multiple iterations of this should be collected to establish an average baseline value. This test may not be possible for some configurations (marine arrays).

The raw files for each of the IVS measurements will be provided to the data processor and Project Geophysicist. The data will be analyzed to derive the following parameters:

- Expected latency/lag;
- Average and standard deviation of static spike values;
- Average and standard deviation of values over each IVS seed item;
- Comparison of target locations versus known (surveyed) locations; and
- Evaluation of the background noise at the site.

3.2 DAILY IVS DATA COLLECTION PROCEDURES

Each morning before beginning field operations and each afternoon after concluding field operations, data will be collected with the sensor at the IVS. The IVS seeded line and two adjacent lines (at the project-specific line spacing) plus the background line must be collected.

The accuracy of digital positioning systems will be verified following the appropriate SOP and the project-specific MQOs in the QAPP.

A sensor function test will also be collected at the IVS blank space or background line at the start and end of daily operations. The raw data files for each of the data sets will be passed to the data processor to perform the following steps:

- Correct for position offset, instrument latency, and drift.
- Select targets along the profiles and verify that the derived target position meets the MQOs.

4.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 INPUT DATA REQUIRED

The data inputs required for initial IVS data collection are the as-built IVS configuration data (location, depth, type, orientation).

4.2 OUTPUT DATA

Output Data include:

- Raw and processed sensor data;
- IVS Technical Memorandum for initial IVS data collection;
- Updated project database.

5.0 QUALITY CONTROL

QC for this SOP will be achieved through the completion of the QC Checklist for Instrument Verification. This checklist will be filled out and signed by the Field QC Designee and the QC Geophysicist.

If the initial MQOs have not been met, the QC Geophysicist will initiate a root cause analysis. If modifications to the instrument or procedures can be made so that the MQOs can be achieved, these modifications will be made. If the MQOs cannot be met (for example, if the initial background amplitudes are too large), the Project and QC Geophysicist will meet with the project team to discuss potential resolutions.

5.1 MEASUREMENT QUALITY OBJECTIVE

The MQOs for IVS survey data are presented in the QAPP or equivalent planning document, with results documented in the project database.

5.2 REPORTING

This procedure will be documented through the completion of the IVS Technical Memorandum. This will include information on the following:

- IVS location and setup, including IVS item descriptions including types, locations, depths, and orientation, as applicable;
- Sensor(s) system performance against the MQOs established for the initial IVS survey including response amplitude, item position, and system noise levels;
- A recommendation on a minimum target threshold for anomaly selection;
- Completed QC checklist.

5.3 QC CHECKLIST FOR INSTRUMENT VERIFICATION

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	**This SOP**	Have personnel read and signed the workers' statement?				
2	**This SOP, WS#22**	Were sensor function tests performed, and did all function tests pass using the real-time assessment?				
3	**This SOP**	Were the initial IVS data collected per the SOP?				
4	**This SOP, WS#22**	Were project MQOs achieved or modified?				
5	**This SOP**	Was the project database updated?				

FINDINGS

Item	Comments

Signatures:

Field QC Designee:		Date:	
QC Geophysicist: (indicating form reviewed):		Date:	

TETRA TECH

DGM SOP for EM61 VTA Assembly

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct EM61 VTA assembly operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Geophysics. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director of Geophysics Matt Barner		Date:	

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read DGM SOP – VTA Assembly and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

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1.0 PURPOSE AND SCOPE

The purpose of this Digital Geophysical Mapping (DGM) Standard Operating Procedure (SOP) is to provide procedures and technical guidance for assembling the vehicle-towed array (VTA) ground time-domain electromagnetic (TEM) detection system using EM61-MK2 (EM61) sensors for dynamic data collection, and verify that all components are correctly assembled, operating normally, and capable of acquiring data of sufficient quality. It does not cover the initial Instrument Verification Strip (IVS) testing or production data collection. This SOP also applies to the EM61-MK1 (1m x 1m) and the EM61-MK2 HP versions of the sensor. Where necessary, additional instructions for the MK1 and HP units are provided as exceptions to the standard unit. Equipment assembly and operations manuals for the project-specific equipment configuration are included in Attachment 1.

The project-specific configuration of equipment for this project consists of the following (more than one configuration may be implemented on any given project):

Sensor

- ☐ EM61-Mk1 (1m x 1m coil)
- ☐ EM61-Mk1 (1m x 1m coil) with top coil
- ☐ EM61-MK2 (1m x 0.5m coil)
- ☐ EM61-MK2 (1m x 0.5m coil) with top coil
- ☐ EM61-MK2 HP (1m x 0.5m coil)
- ☐ EM61-MK2 HP (1m x 0.5m coil) with top coil

Positioning

- ☐ RTK-GPS (Leica 1200 series)
- ☐ RTK-GPS (Leica Viva series)
- ☐ RTS (Leica 1200 series)
- ☐ RTS (Leica TS16 series)

All training on equipment or software will be either formal or on-the-job training (OJT). This training, documented by site personnel, will be subject to review for accuracy and completeness. The Unexploded Ordnance (UXO) Quality Control Specialist (UXOQCS) will verify training is complete and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 PERSONNEL

The following individuals may be involved in the assembly and verification of the VTA:

- Project Geophysicist
- Site Geophysicist
- Field Technician
- UXO Personnel
- Quality Control (QC) Geophysicist

2.2 EQUIPMENT

- EM61 coils;
- VTA cart;
- Tow vehicle (ATV);
- Function test item and jig;
- RTK GPS or RTS system.

The function test item may be any metallic object that can be repeatedly placed within range of the receivers to provide a strong but not saturating instrument response. Typically, this is a small Industry Standard Object (ISO) on a wooden jig that is kept with the system. The Site Geophysicist will be responsible for ensuring that the correct test item is used for sensor function tests and that the test item is maintained in a manner to avoid physical damage or corrosion.

2.3 VTA OVERVIEW

The EM61 is a high-resolution time-domain electromagnetic (EM) instrument designed to detect shallow ferrous and non-ferrous metallic objects. The standard configuration consists of two coils, a digital data recorder, batteries, and processing electronics. The top coil is optional but requires a grounding plug to be installed in the bottom coil if it is omitted. The transmitter generates a pulsed primary magnetic field, which then induces eddy currents in nearby metallic objects. Each of the two spatially separated receiver coils measure these eddy currents. With the single coil option, the recorder measures the eddy currents at four distinct time intervals (216, 366, 660, and 1266 microseconds) after the transmitter current has turned off. With the two-coil option, three intervals are recorded in the bottom coil and one in the top coil. These time gates are typically referred to as Channels 1-4, respectively. The secondary voltages induced in the coil are measured in millivolts (mV). The data are collected using the Geonics EM61-MK2 or Geomar's Nav61MK2 program and temporarily stored in a handheld data logger before downloading to a laptop computer.

The “Towed Array” mounts 3 or 5 EM61 coils ganged together on a non-conducting mobile platform that is towed by an ATV (Figure 1). Instruments are tied together electronically with sensors Slaved to a single Master console. Sensors fire independently in sequence at a combined 10Hz sample rate.

Figure 1. EM61 VTA Assembly Utilizing 3 Coils

3.0 PROCEDURES AND GUIDELINES

Anomaly avoidance procedures will be carried out during this procedure if a MEC hazard exists at the site.

3.1 EQUIPMENT SET-UP

Open the box and inspect for damage or loss during shipping. Compare the manifest to the actual contents. Complete the Quality Receiving Inspection Report (QRIR) form to confirm receipt of equipment and deliver a copy to the warehouse manager. Quarantine any damaged goods and proceed with the assembly and out-of-box testing.

Assemble the VTA cart, sensors, electronics box, and positioning system according to the instructions in the manufacturer's user manual and/or Attachment 1. These instructions should be followed precisely; however, the order of operations may be modified to facilitate efficient assembly. The VTA array should arrive at the site already constructed or with detailed instructions on how to assemble the array platform.

These instructions should be followed precisely; however, the order of operations may be modified to facilitate efficient assembly.

1. Assemble the cart
2. Place EM61 coils in cart
3. Attach the GPS or RTS receivers on the cart
4. Attach and connect the cart to the tow vehicle via the tow bar
5. Connect the power, transmitter, receiver, GPS, and supplementary cables to the console, securing the cables for the survey
6. Establish a GPS or RTS base station over a known civil survey monument or at a temporary location
7. Conduct daily pre-survey inspections of all equipment for drivability by operator and geophysicist

The EM61s should be powered on (Master/Slave switch set, fuse depressed) and allowed to warm-up for 15 minutes before the initial function tests. Confirm that the mode switches (D for differential when using the upper coil, 4 for 4 channel operation on a single coil) and optional power switches (HP only) are correctly set.

Prior to data collection, all equipment will be verified to be in good working condition, and all batteries fully charged. The Checklist for Out of the Box Equipment Tests shall be used to document the instrument functionality the first time it is assembled.

3.2 INSTRUMENT POSITIONING

Depending on site conditions, the positioning of the system is accomplished with either GPS or RTS. The decision on which system to use will be documented in the Quality Assurance Project Plan (QAPP) or equivalent planning document. The positioning system will be assembled and integrated into the sensor following the manufacturer's user manual. A general description of each is provided below. Unless determined during the IVS process that a different height is needed to meet the project objectives, setup the coil height will be the standard height of approximately 16 inches (40 cm).

The RTK GPS systems uses a base station unit setup on a control point to send real-time differential corrections via radio modem to the rover receiver mounted on the instrument. The rover GPS antenna is typically mounted over the center of the EM61 coil and provides real-time positional tracking capabilities that are streamed into the same software program as the EM61 data. This provides sub-centimeter accuracy and can be combined with DGM data in real-time. The reported accuracy for real-time corrections is 8 mm + 1 ppm (horizontal), and 15 mm + 1 ppm (vertical). This system requires a relatively open sky view to achieve differential corrections in real-time.

The RTS precision angle-measurement system uses a visible red laser mounted on a tripod, has auto-lock capability, and measures the distance to prisms and reflective tape mounted on the instrument. The position and orientation of the base station tripod is determined by back-sight reference to at least two known points, typically surveyed grid corners. The positional data of the rover is merged with the EM61 data in real-time through a pseudo-NMEA (National Marine Electronic Association) stream. This system requires a line-of-sight connection between the base station and the rover prism. Positions blocked by brief obstructions are linearly interpolated between fixed locations. The range is 3 km to a single prism and the accuracy is 1 mm + 1.5 ppm.

3.3 VERIFY OPERABILITY

System operability will be verified once the instrument is fully assembled. With the instrument set to record data at 10Hz sample rate and the sensor stationary, conduct the following tests. Observe the data on screen and submit the recorded data for additional analysis. Tolerances for these tests are not usually established, but they should be recorded for project records.

Cable shake – For 60 seconds, shake cables as they might be expected to operate in the field, including intermittent pulls at the connector ends. If data spikes are observed, replace or repair the cable/connector and repeat. If noise events that correlate to the movement of the cables are observed, re-secure the corresponding cable section and repeat.

Drift and noise – For 60 seconds, record data with the instrument and operator motionless. If excessive drift is observed, allow additional warm-up time and repeat. If excessive noise is observed, check for sources of outside interference (powerlines, fences, radios, operator pockets, backpack equipment), relocate, and repeat. If high drift and noise persist, begin replacing components one at a time to isolate the potential problem and contact the warehouse manager.

Decays – After nulling, place a random metallic object within the range of the sensor and observe the response. The early time-gates (channel 1) should produce a higher amplitude response than successively later time-gates. If decays are not so ordered, try renulling and using a different object. If the phenomenon persists, contact the warehouse manager.

3.4 VERIFY GPS QUALITY

When used, GPS fix information is parsed out of the NMEA string. The first number displayed is the GPS quality. Status of 2 indicates GPS position without RTK correction. Status of 4 indicates GPS position with RTK correction. When GPS quality status RTK-4 (NMEA GGA message) is achieved, a picture of a satellite will appear. The second number is the number of satellites used. Clicking on the GPS status window will display the entire NMEA string that is being read by the software. If the GPS status is showing something other than quality 4, stop and troubleshoot before continuing.

3.5 VERIFY DATA RECORDING

EM61 data are temporarily stored in the data logger via Geonics' EM61-MK2 or Geomar's NAV61 software and then downloaded into a laptop computer for further processing using Geonics' DAT61-MK2 or Geomar's Trackmaker and Geosoft Oasis Montaj software. When GPS is used, the positional data are merged with the EM61 data in real-time and stored in the same way. RTS data are stored on the robot and downloaded to a field laptop at the end of each day. All raw data will be uploaded to the project server or SharePoint site daily. Data recording will be verified by processing a complete dataset. If data are not recording (as indicated by the on-screen counter), stop and troubleshoot before continuing.

3.6 VERIFY INSTRUMENT GAIN

The EM61 instrument is checked daily for repeatable consistency of the amplitude response (precision). Upon initial assembly, the amplitude response will also be checked against theoretical models (accuracy). This may be conducted using a small ISO oriented vertically on a jig or placed horizontally on the ground surface or in an open hole before burial (e.g., IVS installation). The distance from the coil to the center of the target will be measured and recorded. Null the instrument in a quiet area without the target, place the ISO directly under/over the center of the coil, record a 30-second file with the instrument at 10Hz sample rate. For ground targets, you may slowly roll over the target if necessary, to position for the maximum response before recording. Maximum responses are recorded in the logbook and on the Out of Box form. To confirm the null point has not drifted the target must be removed. Response amplitudes will be compared to those provided in the NRL report (Nelson et al., 2009, EM61-MK2 Response of Three Munitions Surrogates).

Extracted amplitudes over the relevant ranges are shown in Table 1. Tolerances for this gain calibration test will be specified in the QAPP or equivalent planning document. If the response is not within specified tolerances, recheck the height, re-null, re-center, and repeat. If the failure persists, contact the warehouse manager.

The recorded values from the jig (not the theoretical values) will be used as the baseline value for daily static spike tests. If a ground-surface horizontal target is used for accuracy gain testing, a second test with the jig will be required to establish a baseline for the daily static spike tests.

The response values shown are calculated for the standard EM61-MK2. The MK1 and the high-power (HP) variants of the sensor have not been calibrated for this test. The HP variant is reported to increase the response by approximately 8 times.

Repeat this process for each sensor in the array.

Table 1. Depth below coil vs. EM61-MK2 response amplitude for a small ISO (after NRL/MR/6110—09-9183.

Distance of Target Center Below Lower Coil (cm)	Target Depth Assuming Deployment on Standard Wheels (cm)	Gate 1 (mV)		Gate 2 (mV)		Gate 3 (mV)		Gate 4 (mV)	
		Most Favorable Orientation	Least Favorable Orientation	Most Favorable Orientation	Least Favorable Orientation	Most Favorable Orientation	Least Favorable Orientation	Most Favorable Orientation	Least Favorable Orientation
40	-2	*443.0	51.0	*308.4	28.3	*181.6	12.7	*85.4	4.4
41	-1	*410.2	47.2	*285.5	26.2	*168.2	11.8	*79.1	4.1
42	0	378.3	43.6	263.3	24.2	155.1	10.8	72.9	3.8
43	1	350.7	40.4	244.1	22.4	143.8	10.0	67.6	3.5
44	2	325.2	37.5	226.3	20.8	133.3	9.3	62.7	3.3
45	3	301.8	34.8	210.0	19.3	123.7	8.6	58.2	3.0
46	4	280.1	32.3	194.9	17.9	114.8	8.0	54.0	2.8
47	5	260.1	30.0	181.0	16.6	106.7	7.4	50.1	2.6
48	6	241.7	27.9	168.2	15.4	99.1	6.9	46.6	2.4
49	7	224.7	25.9	156.4	14.4	92.1	6.4	43.3	2.3
50	8	208.9	24.1	145.4	13.4	85.7	6.0	40.3	2.1
51	9	194.4	22.4	135.3	12.4	79.7	5.5	37.5	2.0
52	10	181.0	20.9	126.0	11.6	74.2	5.2	34.9	1.8
53	11	168.6	19.4	117.3	10.8	69.1	4.8	32.5	1.7
54	12	157.1	18.1	109.3	10.0	64.4	4.5	30.3	1.6
55	13	146.4	16.9	101.9	9.4	60.0	4.2	28.2	1.5
56	14	136.6	15.8	95.1	8.7	56.0	3.9	26.3	1.4
57	15	127.5	14.7	88.7	8.1	52.3	3.6	24.6	1.3
58	16	119.0	13.7	82.8	7.6	48.8	3.4	22.9	1.2
59	17	111.2	12.8	77.4	7.1	45.6	3.2	21.4	1.1
60	18	103.9	12.0	72.3	6.6	42.6	3.0	20.0	1.0

*Response extrapolated using EM Response Calculator to extend depth range.

4.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 INPUT DATA REQUIRED

The data inputs required for VTA data collection are:

- EM61 Assembly Manual;
- RTK GPS or RTS Operations Manual;
- VTA assembly instructions;
- List of potential civil survey monuments;
- QRIR report form;
- Out of Box inspection form.

4.2 OUTPUT DATA

The site geophysicist will inspect system installation.

The initial sensor connectivity, lag, and function tests must be recorded and filed in the project database as required. The GPS base station data will be collected and submitted for Online Positioning User Service (OPUS) solution to compare against the published location.

Output Data include:

- Raw and processed EM data for instrument gain verification (spike test);
- Raw and processed EM and GPS data for the IVS, or DGM datasets; and
- Logbook reports of any analog results.

5.0 QUALITY CONTROL

For QC for this SOP, a Checklist for VTA Assembly will be used. This checklist will be filled out and signed by the Field QC Designee and the QC Geophysicist upon completion of the VTA assembly.

5.1 MEASUREMENT QUALITY OBJECTIVES (MQOS)

The MQOs for VTA assembly are presented in Worksheet #22 of the QAPP, with results documented in the project database.

5.2 REPORTING

The VTA assembly will be documented as part of the IVS Technical Memorandum. This will include information on the following:

- A brief description of the assembly and test process, along with any pertinent photograph(s)
- The initial sensor connectivity test data
- The initial sensor function test data
- The initial GPS base station data
- Completed QC Checklist
- Out of box checklist

In addition, the QRIR will be completed and forwarded to the warehouse manager.

5.3 QC CHECKLIST FOR VTA ASSEMBLY

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	**This SOP**	Have personnel read and signed the workers' statement?				
2	**This SOP**	Was the instrument assembled correctly?				
3	**This SOP**	Was the positioning system assembled and integrated with the sensor following the published instructions?				
4	**This SOP**	Did the Site Geophysicist ensure that the function test item is adequate for the project?				
5	**This SOP, WS#22**	Have the appropriate MQOs been achieved?				
6	**This SOP**	Were digital/manual records taken and backed up?				

FINDINGS

Item	Comments

Signatures:

Field QC Designee:		Date:	
QC Geophysicist: (indicating form reviewed):		Date:	

5.4 CHECKLIST FOR OUT OF BOX EQUIPMENT TESTS

Project Name:	
Project Location:	
Contractor Point of Contact:	
Equipment Source:	
Equipment Serial Numbers:	
Reviewer's Name and Title:	
Date of Review:	

	Yes	No	N/A
1. Has the equipment been inventoried and inspected for damage or wear? Please fill out check sheets accompanying the equipment and send them back to the warehouse.	☐	☐	☐
2. When the cable shake test was performed, were the data free of spikes or correlated noise?	☐	☐	☐
3. When the instrument was nulled, did it exhibit a minimal amount of drift and noise?	☐	☐	☐
4. Did the system produce the expected response during the gain calibration test?	☐	☐	☐
5. Did the system produce the expected order of decay responses?	☐	☐	☐

DGM SOP for EM61 VTA Data Collection

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct EM61 VTA survey operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Geophysics. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director of Geophysics Matt Barner		Date:	

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read DGM SOP – EM61 VTA Data Collection and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

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1.0 PURPOSE AND SCOPE

The purpose of this Digital Geophysical Mapping (DGM) Standard Operating Procedure (SOP) is to provide procedures and technical guidance on performing a collection of dynamic survey data using a vehicle-towed array (VTA) consisting of the Geonics EM61-MK2 sensor (EM61) in conjunction with either real-time kinematic global positioning system (RTK-GPS) or robotic total station (RTS) positioning system. It does not cover instrument assembly or the initial Instrument Verification Strip (IVS) testing (covered in dedicated SOPs). This SOP also applies to the EM61-MK1 (1m x 1m) and EM61-MK2 HP versions of the sensor. Where necessary, additional instructions for the HP units are provided as exceptions to the standard unit.

All training on equipment or software will be either formal or on-the-job training (OJT). Site personnel will document the training for review for accuracy and completeness. The Unexploded Ordnance (UXO) Quality Control Specialist (UXOQCS) will verify training is complete and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 PERSONNEL

The following individuals may be involved in the VTA data collection:

- Project Geophysicist
- Site Geophysicist
- Field Technician
- UXO Personnel
- Quality Control (QC) Geophysicist

2.2 EQUIPMENT

- EM61 sensors;
- VTA cart;
- Tow vehicle (ATV);
- Positioning equipment for RTK-GPS or RTS as appropriate;
- A function test item and jig.

The function test item may be any metallic object that can be repeatedly placed within range of the sensor to provide a strong but not saturating instrument response. Typically, this is a small Industry Standard Object (ISO) item on a wooden jig that is kept with the system. The Site Geophysicist will be responsible for ensuring that the correct test item is used for sensor function tests and that the test item is maintained in a manner to avoid physical damage or corrosion.

3.0 PROCEDURES AND GUIDELINES

Anomaly avoidance procedures will be carried out during this procedure if a Munitions and Explosive Concern (MEC) hazard exists at the site.

3.1 EQUIPMENT OPERATION

Detailed work instructions for equipment setup and operation are in the VTA Assembly SOP. After assembly, the field team will proceed with the geophysical survey, without disassembly. DGM teams should ensure they are not operating within 200ft of another DGM team at any time. Daily survey procedures include:

- Sensor warm-up for at least 15 minutes.
- Null sensor, check sensor response, and RTK DGPS or RTS input check.
- Perform morning Static-Spike and IVS QC tests (Section 5.4). Transfer IVS data for morning evaluation and mobilize to the production area if the onsite processor is available.
- Mobilize to survey the site.
- Input and record the file name for the survey.
- Acquire survey data along the longest area survey line or site slope.
- Complete a Survey Area Report Form (SARF) for each area to be mapped (Section 5.5).
- Pauses, greater than one minute, during data collection, should trigger an incremented line.
- Monitor sensor response, battery levels and RTK DGPS or RTS periodically.
- Ensure sensor overlap on adjacent transects meets the project required line-spacing, move, or add marking guides to outer coil coverage.
- Continue until the area is completely covered, batteries need replacing, RTK GPS power light flashes or a break is required.
- Change and charge batteries, as required.
- Perform afternoon Static-Spike and IVS QC tests (Section 5.4).
- Following these tests, perform end-of-day tasks, including:
    - Download survey data with instrument checks.
    - Secure the vehicle, electromagnetic (EM) sensors and positioning equipment.
    - Charge all batteries overnight.
    - The logbook pages are photocopied/photographed and transferred to the Project Geophysicist.
    - The data files are submitted to the Project Geophysicist.
    - The completed survey areas are recorded in the tracking log and/or reported to the Project Geophysicist.
    - The logbook pages are accessible for verification by the field QC staff that may inspect them weekly.
    - Plan the next day's activities.

3.2 INSTRUMENT NAVIGATION

Depending on site conditions, positioning of the system is accomplished either RTK GPS or RTS systems. Regardless of the positioning system, where DGM data are being collected as either transects or full grids, navigation will be established by visual reference to flags or cones set out at the start and end of each line. Completed surveyed lines may be marked by flags, beanbags, chalk, environmentally responsible spray paint, or other methods. This may be to denote the current limits of coverage or to provide markers for subsequent lines. Alternatively, a navigation computer may be used to provide a digital display of survey lines for the operator to follow. This does not preclude the use of visual ground references above. The spacing between adjacent lines and the Measurement Quality Objectives (MQOs) for achieving acceptable coverage is presented in the Quality Assurance Project Plan (QAPP) or equivalent planning document.

3.3 DATA ACQUISITION

Whether the survey area is established as grids or as transect lines, the VTA is operated at a speed less than 4 miles per hour (mph) unless a higher speed is demonstrated at the instrument verification strip (IVS). Data are collected in automatic mode at 10Hz sample rate. During data collection, the battery level will be monitored, and the battery will be replaced immediately if the voltage drops below the level specified in the QAPP or equivalent planning document. In all cases, data will be recorded and monitored on the data logger using appropriate collection modes, file names, and line numbers. These will be recorded in the field logbook.

3.4 COVERAGE AND OBSTACLES

Coverage should be obtained at the line-spacing specified in the QAPP. Obstacles encountered during the geophysical survey will be determined and documented in the field using the SARF. Each field team will be responsible for the completion of the required forms, logbook entries, and photo documentation (as necessary). Coordinates will be obtained for each obstacle by collecting a GPS/RTS track around or along the obstacle. The DGM team will be responsible for determining whether an area is considered inaccessible due to site conditions. The DGM forms provide examples of such conditions and may be used in the field by the survey team to assist in documenting deviations.

3.5 FIELD RECORDS

The field records collected include the VTA data, raw and RTK GPS or RTS data, digital photographs, forms, and logbooks. All records will follow Tetra Tech Procedures. At the end of each workday, the scanned or digital logbooks, forms, and copies of the daily QC and Production data files will be saved to the project server and/or SharePoint site. The Project Geophysicist Data Processor will review each deliverable for completeness and notify the field staff that the day's data delivery requirements, for each DGM team, have been met. If there are deficiencies in the daily DGM data deliverables, the field team will be notified for follow-up and correction.

3.5.1 Data Storage and Preliminary Processing

Digital EM61 data are temporarily stored on a field laptop and then downloaded to a processing laptop for further pre-processing using Geonics' DAT61MK2 or Geomar's Trackmaker and Geosoft Oasis Montaj software. When GPS or RTS is used, the positional data is merged with the EM61 data in real-time and stored in the same manner.

3.5.2 Photographs

If deemed necessary, digital photographs will be taken by the Site Geophysicist, Project Geophysicist, or Data Processor to document site conditions and/or obstructions during geophysical surveying. Each team will maintain a photo log in their field logbook. Photos taken will include date, time, and subject. The digital images and copies of the logbooks will be uploaded with the raw data daily.

3.5.3 Logbooks

One member of the team will be responsible for maintaining the logbook following Tetra Tech procedures. Ensure the following information is recorded in the logbook and/or on the SARF:

- Survey area ID
- Time survey started
- Time survey completed
- Names of team members
- Weather conditions
- Serial numbers of RTK GPS rover unit and geophysical instrumentation
- File names for the digitally recorded data. Each page of the logbook will be dated, sequentially numbered, and identified by the logbook number; all entries will be signed

In addition, the DGM team will document all aspects of their activities using the following checklists:

- Checklist for Daily IVS Checks (Section 5.4)
- Survey Area Report Form (Section 5.5)
- QC Checklist (Section 5.3)

4.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 INPUT DATA REQUIRED

The data inputs required for EM61 data collection are:

- EM61 Manual;
- Daily IVS Checklist;
- Survey Area Report Form;
- Coordinates of the DGM areas to be surveyed.

4.2 OUTPUT DATA

The data outputs of the EM61 data collection are:

- Raw data files (*.RAW, *.R61, *.M61, *.N61, or *.Survey)
- Digitized DGM Logbooks (*.pdf)
- Digitized Daily IVS Checklist (*.pdf)
- Digitized DGM Survey Area Report Forms (*.pdf)
- Survey area pictures (*.jpg or equivalent)

5.0 QUALITY CONTROL

For QC for this SOP, a Checklist for VTA Collection (Section 5.3) will be used. This checklist will be filled out and signed by the Field QC Designee and the QC Geophysicist upon completion of the EM61 data collection for each deliverable package (e.g., weekly deliverable of grids).

5.1 MEASUREMENT QUALITY OBJECTIVES (MQOS)

The MQOs for the data collection are presented in Worksheet #22 of the QAPP or equivalent planning document, and results documented in the project database.

5.2 REPORTING

The VTA data collection will be documented in logbooks and daily production reports. This will include information on the following:

- Daily IVS Checklist;
- Areas surveyed;
- Survey Area Report Form;
- Field notes and issues.

5.3 QC CHECKLIST FOR EM61 COLLECTION

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	**This SOP**	Have personnel read and signed the workers' statement?				
2	**This SOP**	If used, was the RTK DGPS base station setup on a known survey control point?				
3	**This SOP, WS#22**	Were morning and afternoon IVS/Spike tests completed and within specified tolerances?				
4	**This SOP, WS#22**	Were survey line spacings based on QAPP specifications?				
5	**This SOP**	Were appropriate forms used to documents DGM activities?				
6	**This SOP**	Were any photographs appropriately documented and logged?				
7	**This SOP**	Were the data and corresponding documentation uploaded to the project server or SharePoint?				

FINDINGS

Item	Comments

Signatures:

Field QC Designee:		Date:	
QC Geophysicist: (indicating form reviewed):		Date:	

5.4 DAILY IVS CHECKLIST

Project Name		**Location**	
Team			
Date	Click or tap to enter a date.		

SS Test AM (example G1SS021420AM)

File Name: ____________________ Battery Start: __________ Battery End: __________

Line 0: Background (1 min.)

Line 1: Spike (1 min.) CH1: ________ CH2: ________ CH3: ________ CH4: ________

Line 2: Background (1 min.)

IVS Test AM (example G1IVS021420AM)

Line 0: Run IVS out.

Line 1: Run IVS back

Line 2: Background Line

SS Test PM (example G1SS021420PM)

File Name: ____________________ Battery Start: __________ Battery End: __________

Line 0: Background (1 min.)

Line 1: Spike (1 min.) CH1: ________ CH2: ________ CH3: ________ CH4: ________

Line 2: Background (1 min.)

IVS Test PM (example G1IVS021420PM)

Line 0: Run IVS out.

Line 1: Run IVS back

Line 2: Background Line

5.5 SURVEY AREA REPORT FORM

Project Name		**Survey Area ID**	
Field Team Lead		**Raw Data File Name**	
Date	Click or tap to enter a date.		

Survey Type:
☐Grid
☐Transect
☐Meandering Path
☐Other__________

Positioning:
☐RTK
☐RTS
☐Fiducial
☐Other__________

Coordinate System:
☐UTM
☐State Plane
☐Local
☐Other__________

Unit of Measure:
☐Meters
☐Feet

Terrain:
☐Level
☐Moderate Slope
☐Steep
☐Rolling
☐Ruts
☐Gullies
☐Rocky
☐Swampy
☐Dangerous
☐Level

Tree Cover:
☐None
☐Light
☐Medium
☐Thick Brush

Height: ________

Weather:
☐Sunny
☐Cloudy
☐Drizzle
☐Rain
☐Thunderstorms
☐Hail
☐Fog
☐Humid
☐Snow

Comments

Project Name		**Survey Area ID**	

Sketch of the survey area.

Grid Corner coordinates (UTM/SPC):			
NW		**NE**	
SW		**SE**	
Grid Corner coordinates (local):			
NW		**NE**	
SW		**SE**	

DGM SOP for EM61 Assembly

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct EM61 assembly operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Geophysics. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director of Geophysics Matt Barner		Date:	

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read DGM SOP – EM61 Assembly and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

TABLE OF CONTENTS

TABLES

1.0 PURPOSE AND SCOPE

The purpose of this Digital Geophysical Mapping (DGM) Standard Operating Procedure (SOP) is to provide procedures and technical guidance for assembling the EM61-MK2 (EM61) sensor system in conjunction with either real-time kinematic global positioning system (RTK-GPS) or robotic total station (RTS) or wheel-counter/fiducial marker positioning systems or analog operation without positioning. This includes verifying that all components are correctly assembled, operating normally, and capable of acquiring data of sufficient quality. It does not cover the initial Instrument Verification Strip (IVS) testing or production data collection. This SOP also applies to the EM61-MK1 (1m x 1m) and the EM61-MK2 high-power (HP) versions of the sensor. Where necessary, additional instructions for the MK1 and HP units are provided as exceptions to the standard unit. Equipment assembly and operations manuals for the project-specific equipment configuration are included in Attachment 1

The project-specific configuration of equipment for this project are listed below. More than one configuration may be implemented on any given project:

Sensor

- ☐ EM61-Mk1 (1m x 1m coil)
- ☐ EM61-Mk1 (1m x 1m coil) with top coil
- ☐ EM61-MK2 (1m x 0.5m coil)
- ☐ EM61-MK2 (1m x 0.5m coil) with top coil
- ☐ EM61-MK2 HP (1m x 0.5m coil)
- ☐ EM61-MK2 HP (1m x 0.5m coil) with top coil

Platform

- ☐ Standard wheels
- ☐ Two-person litter carry
- ☐ One-person skirt carry

Positioning

- ☐ RTK-GPS (Leica 1200 series)
- ☐ RTK-GPS (Leica Viva series)
- ☐ RTS (Leica 1200 series)
- ☐ RTS (Leica TS16 series)
- ☐ Wheel counter/fiducial
- ☐ None (analog)

All training on equipment or software will be either formal or on-the-job training (OJT). This training, documented by site personnel, will be subject to review for accuracy and completeness. The Unexploded Ordnance (UXO) Quality Control Specialist (UXOQCS) will verify training is complete and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 PERSONNEL

The following individuals may be involved in the assembly and verification of the EM61:

- Project Geophysicist
- Site Geophysicist
- Field Technician
- UXO Personnel
- Quality Control (QC) Geophysicist

2.2 EQUIPMENT

- EM61 sensor alone for use in search mode;
- Positioning equipment for RTK-GPS, RTS or wheel counter/fiducial positioning as appropriate;
- A function test item and jig.

The function test item may be any metallic object that can be repeatedly placed within range of the sensor to provide a strong but not saturating instrument response. Typically, this is a small Industry Standard Object (ISO) on a wooden jig that is kept with the system. The Site Geophysicist will be responsible for ensuring that the correct test item is used for sensor function tests and that the test item is maintained in a manner to avoid physical damage or corrosion.

2.3 EM61 OVERVIEW

The EM61 is a high-resolution time-domain electromagnetic (EM) instrument designed to detect shallow ferrous and non-ferrous metallic objects. The standard configuration consists of two coils, a digital data recorder, batteries, and processing electronics. The top coil is optional but requires a grounding plug to be installed in the bottom coil if it is omitted. The transmitter generates a pulsed primary magnetic field, which then induces eddy currents in nearby metallic objects. Each of the two spatially separated receiver coils, measures these eddy currents. With the single coil option, the recorder measures the eddy currents at four distinct time intervals (216, 366, 660, and 1266 microseconds) after the transmitter current has turned off. With the two-coil option, three intervals are recorded in the bottom coil and one in the top coil. These time gates are typically referred to as Channels 1-4, respectively. The secondary voltages induced in the coil are measured in millivolts (mV). The data are collected using the Geonics' EM61MK2 or Geomar's Nav61MK2 program and temporarily stored in a handheld data logger before downloading it to a laptop computer.

The HP version of the sensor uses a specialized battery and alternative mounting bracket to produce a higher transmitter power and deeper penetration than the standard unit. The MK1 version uses the standard battery and transmitter power and achieves deeper penetration than the standard unit by virtual of the larger transmitter coil, but at the expense of lower spatial resolution.

3.0 PROCEDURES AND GUIDELINES

Anomaly avoidance procedures will be carried out during this procedure if a munitions and explosive concern (MEC) hazard exists at the site.

3.1 EQUIPMENT SET UP

Open the box and inspect for damage or loss during shipping. Compare the manifest to the actual contents. Complete the Quality Receiving Inspection Report (QRIR) form to confirm receipt of equipment and deliver a copy to the warehouse manager. Quarantine any damaged goods and proceed with the assembly and out-of-box testing.

Assemble the sensor, platform, electronics box, and positioning system according to the instructions in the manufacturer's user manual. These instructions should be followed precisely; however, the order of operations may be modified to facilitate efficient assembly.

When the instrument is operated in wheel mode, it is set up according to Geonics EM61 manual. For litter mode, the EM61 coils are centered and suspended on two fiberglass poles. The instrument is attached to the poles using polymerizing vinyl chloride (PVC)/fiberglass standoffs and/or webbing so that the coil height meets the project requirements when the litter is carried. For skirt mode, the MK1 coil is worn like a skirt with an adjustable harness that is set to the project defined coil height. For all modes of data collection, the cables are secured to prevent them from getting tangled and possibly disturbed by movement or vegetation. If GPS or RTS is used, a PVC or fiberglass GPS mount is used to position the receiver/prism over the center of the coil. If the positioning device cannot be mounted directly over the center of the coil, note the offsets in the logbook.

The EM61 should be powered on (Master/Slave switch set to M, fuse depressed) and allowed to warm-up for 15 minutes before the initial function tests. Confirm that the mode switches (D for differential when using the upper coil, 4 for 4 channel operation on a single coil), and optional power switches (HP only) are correctly set.

Prior to data collection, all equipment will be verified to be in good working condition, and all batteries are fully charged. The Checklist for Out of the Box Equipment Tests shall be used to document the instrument functionality the first time it is assembled.

3.2 INSTRUMENT POSITIONING

Depending on site conditions, the positioning of the system is accomplished either by GPS, RTS, or wheel-counter/ fiducial (fid) data. The decision on which system(s) to use will be documented in the Quality Assurance Project Plan (QAPP) or equivalent planning document. The positioning system will be assembled and integrated into the sensor following the manufacturer's user manual. A general description of each is provided below. The coil height will be the standard height of approximately 16 inches (40 cm) unless it is determined during the IVS process that a different height is needed to meet the project objectives.

The RTK GPS systems use a base station unit set up on a control point to send real-time differential corrections via radio modem to the rover receiver mounted on the instrument. The rover GPS antenna is typically mounted over the center of the EM61 coil and provides real- time positional tracking capabilities that are streamed into the same software program as the EM61 data. This provides sub-centimeter accuracy and can be combined with DGM data in real-time. The reported accuracy for real-time corrections is 8 mm + 1 ppm (horizontal), and 15 mm + 1 ppm (vertical). This system requires a relatively open sky view to achieve differential corrections in real-time.

The RTS precision angle-measurement system uses a visible red laser mounted on a tripod, has auto-lock capability, and measures the distance to prisms and reflective tape mounted on the instrument. The position and orientation of the base station tripod is determined by back-sight reference to at least two known points, typically surveyed grid corners. The positional data of the rover is merged with the EM61 data in real-time through a pseudo-NMEA (National Marine Electronics Association) stream. This system requires a line-of-sight connection between the base station and the rover prism. Positions blocked by brief obstructions are linearly interpolated between fixed locations. The range is 3 km to a single prism, and the accuracy is 1 mm + 1.5 ppm.

The wheel-counter/fiducial positioning system is used in areas where vegetation, dense-canopy, buildings, or other obstructions make GPS or RTS positioning unavailable or impractical. This method uses painted ropes and/or flags to mark the start and end of each line, plus intermediate points. The wheel-counter triggers the EM61 to take a reading at specific distance intervals. The line number is recorded, and distances down-line are assigned to each reading. Positions are generated in local grid coordinates (line x distance) and then refined by manually entering fiducial markers into the data at intermediate points along the lines (approximately 25ft). In post-processing, positions are warped to a universal geodetic system using the coordinates of the grid corners (or other survey markers).

Analog measurements do not require a positioning system and are usually referenced to a specific target ID, as noted in the logbook.

3.3 VERIFY OPERABILITY

The operability of the system will be verified after the instrument is fully assembled. Tests will be conducted with the instrument set to record data at 10Hz sample rate and the sensor stationary. Observe the data on screen and submit the recorded data for additional analysis. Tolerances for these tests are not usually established, but they should be recorded for project records.

> Cable shake – For 60 seconds, shake cables as they might be expected to operate in the field, including intermittent pulls at the connector ends. If data spikes, replace or repair the cable/connector and repeat. If noise events occur, which correlate to the movement of the cables are observed, re-secure the corresponding cable section and repeat.
>
> Drift and noise – For 60 seconds, record data with the instrument and operator motionless. If excessive drift is observed, allow additional warm-up time and repeat. If excessive noise is observed, check for sources of outside interference (powerlines, fences, radios, operator pockets, backpack equipment), relocate, and repeat. If high drift and noise persist, begin replacing components one at a time to isolate the potential problem and contact the warehouse manager.
>
> Decays – After nulling, place a random metallic object within range of the sensor and observe the response. The early time-gates (channel 1) should produce a higher amplitude response than successively later time-gates. If decays are not so ordered, try renulling and using a different object. If the phenomenon persists, contact the warehouse manager.

3.4 VERIFY GPS QUALITY

When used, GPS fix information is parsed out of the NMEA string. The first number displayed is the GPS quality. Status of 2 indicates GPS position without RTK correction. Status of 4 indicates GPS position with RTK correction. When GPS quality status RTK-4 (NMEA GGA message) is achieved, a picture of a satellite will appear. The second number is the number of satellites used. Clicking on the GPS status window will display the entire NMEA string that is being read by the software. If the GPS status is showing something other than quality 4, stop and troubleshoot before continuing.

3.5 VERIFY DATA RECORDING

EM61 data are temporarily stored in the data logger via Geonics' EM61-MK2 or Geomar's NAV61 software and then downloaded into a laptop computer for further processing using Geonics' DAT61-MK2 or Geomar's Trackmaker and Geosoft Oasis Montaj software. When GPS is used, the positional data are merged with the EM61 data in real-time and stored in the same way. RTS data are stored on the robot and downloaded to a field laptop at the end of each day. All raw data will be uploaded to the project server or SharePoint site daily. Data recording will be verified by processing a complete dataset. If data are not recording (as indicated by the on-screen counter), stop and troubleshoot before continuing.

3.6 VERIFY INSTRUMENT GAIN

The EM61 instrument is checked daily for repeatable consistency of the amplitude response (precision). Upon initial assembly, the amplitude response will also be checked against theoretical models (accuracy). This may be conducted using a small ISO oriented vertically on a jig or placed horizontally on the ground surface or in an open hole before burial (e.g., IVS installation). The distance from the coil to the center of the target will be measured and recorded. Null the instrument in a quiet area without the target, place the ISO directly under/over the center of the coil, record a 30-second file with the instrument at 10Hz sample rate. For ground targets, you may slowly roll over the target if necessary, to position for the maximum response before recording. Record the maximum responses in the logbook and on the Out of Box form. Remove the target to confirm the null point has not drifted. Response amplitudes will be compared to those provided in the NRL report (Nelson et al., 2009, EM61-MK2 Response of Three Munitions Surrogates). Extracted amplitudes over the relevant ranges are shown in Table 1. Tolerances for this gain calibration test will be in the QAPP or equivalent planning document. If the response is not within specified tolerances, recheck the height, re-null, re-center, and repeat. If the failure persists, contact the warehouse manager.

The recorded values from the jig (not the theoretical values) will be used as the baseline value for daily static spike tests. If a ground-surface horizontal target is used for accuracy gain testing, a second test with the jig will be required to establish a baseline for the daily static spike tests.

The response values shown are calculated for the standard EM61-MK2. The MK1 and the HP variants of the sensor have not been calibrated for this test. The HP variant is reported to increase the response by approximately 8 times.

Table 1. Depth below coil vs. EM61-MK2 response amplitude for a small ISO (after NRL/MR/6110—09-9183.

Distance of Target Center Below Lower Coil (cm)	Target Depth Assuming Deployment on Standard Wheels (cm)	Gate 1 (mV)		Gate 2 (mV)		Gate 3 (mV)		Gate 4 (mV)	
		Most Favorable Orientation	Least Favorable Orientation	Most Favorable Orientation	Least Favorable Orientation	Most Favorable Orientation	Least Favorable Orientation	Most Favorable Orientation	Least Favorable Orientation
40	-2	*443.0	51.0	*308.4	28.3	*181.6	12.7	*85.4	4.4
41	-1	*410.2	47.2	*285.5	26.2	*168.2	11.8	*79.1	4.1
42	0	378.3	43.6	263.3	24.2	155.1	10.8	72.9	3.8
43	1	350.7	40.4	244.1	22.4	143.8	10.0	67.6	3.5
44	2	325.2	37.5	226.3	20.8	133.3	9.3	62.7	3.3
45	3	301.8	34.8	210.0	19.3	123.7	8.6	58.2	3.0
46	4	280.1	32.3	194.9	17.9	114.8	8.0	54.0	2.8
47	5	260.1	30.0	181.0	16.6	106.7	7.4	50.1	2.6
48	6	241.7	27.9	168.2	15.4	99.1	6.9	46.6	2.4
49	7	224.7	25.9	156.4	14.4	92.1	6.4	43.3	2.3
50	8	208.9	24.1	145.4	13.4	85.7	6.0	40.3	2.1
51	9	194.4	22.4	135.3	12.4	79.7	5.5	37.5	2.0
52	10	181.0	20.9	126.0	11.6	74.2	5.2	34.9	1.8
53	11	168.6	19.4	117.3	10.8	69.1	4.8	32.5	1.7
54	12	157.1	18.1	109.3	10.0	64.4	4.5	30.3	1.6
55	13	146.4	16.9	101.9	9.4	60.0	4.2	28.2	1.5
56	14	136.6	15.8	95.1	8.7	56.0	3.9	26.3	1.4
57	15	127.5	14.7	88.7	8.1	52.3	3.6	24.6	1.3
58	16	119.0	13.7	82.8	7.6	48.8	3.4	22.9	1.2
59	17	111.2	12.8	77.4	7.1	45.6	3.2	21.4	1.1
60	18	103.9	12.0	72.3	6.6	42.6	3.0	20.0	1.0

*Response extrapolated using electromagnetic (EM) Response Calculator to extend depth range.

4.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 INPUT DATA REQUIRED

The data inputs required for EM61 data collection are:

- EM61 Assembly Manual;
- RTK GPS or RTS Operations Manual;
- List of potential civil survey monuments;
- QRIR report form.
- Out of Box inspection form;

4.2 OUTPUT DATA

The site geophysicist will inspect the installation of the system.

The initial sensor connectivity, lag, and function tests must be recorded and filed in the project database as required. The GPS base station data will be collected and submitted for Online Positioning User Service (OPUS) solution to compare against the published location.

Output Data include:

- Raw and processed EM data for the operability tests (cable shake, drift, noise, decays);
- Raw and processed EM data for instrument gain verification;
- Logbook reports of any analog results.

5.0 QUALITY CONTROL

For QC of this SOP, a Checklist for EM61 Assembly will be used. This checklist will be completed and signed by the Field QC Designee and the QC Geophysicist upon completion of the EM61 assembly.

5.1 MEASUREMENT QUALITY OBJECTIVES (MQOS)

The MQOs for equipment assembly are presented in Worksheet #22 of the QAPP or equivalent planning document, with results documents in the project database.

5.2 REPORTING

The EM61 assembly will be documented as part of the IVS Technical Memorandum, including:

- A brief description of the assembly and test process, along with any pertinent photograph(s)
- The initial sensor function test data
- Completed QC Checklist
- Out of box checklist

The QRIR will be completed and forwarded to the warehouse manager.

5.3 QC CHECKLIST FOR EM61 ASSEMBLY

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	**This SOP**	Have personnel read and signed the workers' statement?				
2	**This SOP**	Was the instrument assembled correctly?				
3	**This SOP**	Was the positioning system assembled and integrated with the sensor following the published instructions?				
4	**This SOP**	Did the Site Geophysicist ensure that the function test item and jig are adequate for the project?				
5	**This SOP, WS#22**	Have the appropriate MQOs been achieved?				
6	**This SOP**	Were digital/manual records taken and backed up?				

FINDINGS

Item	Comments

Signatures:

Field QC Designee:		Date:	
QC Geophysicist: (indicating form reviewed):		Date:	

5.4 CHECKLIST FOR OUT OF BOX EQUIPMENT TESTS

Project Name:	
Project Location:	
Contractor Point of Contact:	
Equipment Source:	
Equipment Serial Numbers:	
Reviewer's Name and Title:	
Date of Review:	

	Yes	No	N/A
1. Has the equipment been inventoried and inspected for damage or wear? Please fill out check sheets accompanying the equipment and send them back to the warehouse.	☐	☐	☐
2. When the cable shake test was performed, were the data free of spikes or correlated noise?	☐	☐	☐
3. When the instrument was nulled, did it exhibit a minimal amount of drift and noise?	☐	☐	☐
4. Did the system produce the expected response during the gain calibration test?	☐	☐	☐
5. Did the system produce the expected order of decay responses?	☐	☐	☐

TETRA TECH

DGM SOP for EM61 Data Collection

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct EM61 survey operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Geophysics. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director of Geophysics Matt Barner		Date:	

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read DGM SOP – EM61 Data Collection and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

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1.0 PURPOSE AND SCOPE

The purpose of this Digital Geophysical Mapping (DGM) Standard Operating Procedure (SOP) is to provide procedures and technical guidance on performing collection of dynamic survey data using the Geonics EM61-MK2 sensor (EM61, done in conjunction with either real-time kinematic global positioning system (RTK-GPS) or robotic total station (RTS) or wheel-counter/fiducial marker positioning systems or in analog operation without positioning. The instrument may be used for DGM with data recorded digitally on the instrument, or in search mode (analog) with data recorded manually in the logbook or other approved form. It does not cover instrument assembly or the initial Instrument Verification Strip (IVS) testing (covered in dedicated SOPs). This SOP also applies to the EM61-MK1 (1m x 1m) and the EM61-MK2 high-power (HP) versions of the sensor. Additional instructions for the MK1 and HP units, when necessary, are provided as exceptions to the standard unit.

All training on equipment or software will be either formal or on-the-job training (OJT). This training, documented by site personnel, will be subject to review for accuracy and completeness. The Unexploded Ordnance (UXO) Quality Control Specialist (UXOQCS) will verify training is complete and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 PERSONNEL

The following individuals may be involved in the EM61 data collection:

- Project Geophysicist
- Site Geophysicist
- Field Technician
- UXO Personnel
- Quality Control (QC) Geophysicist

2.2 EQUIPMENT

- EM61 sensor;
- Positioning equipment for RTK-GPS, RTS or wheel counter/fiducial positioning as appropriate;
- A function test item and jig.

The function test item may be any metallic object that can be repeatedly placed within range of the sensor to provide a strong but not saturating instrument response. Typically, this is a small Industry Standard Object (ISO) item on a wooden jig that is kept with the system. The Site Geophysicist will ensure the correct test item is used for sensor function tests and that the test item is maintained to avoid physical damage or corrosion.

3.0 PROCEDURES AND GUIDELINES

Anomaly avoidance procedures will be carried out during this procedure if a Munitions and Explosives of Concern (MEC) hazard exists at the site.

3.1 EQUIPMENT OPERATION

Detailed work instructions for equipment setup and operation are in the EM61 Assembly SOP. After assembly, the field team will proceed with the geophysical survey, without disassembly. DGM teams should ensure they are not operating within 200ft of another DGM team at any time. Daily survey procedures include:

- Sensor warm-up for at least 15 minutes.
- Null sensor, check sensor response, and RTK DGPS or RTS input check.
- Perform morning Static-Spike and IVS QC tests (Section 0). Transfer IVS data for morning evaluation and mobilize to the production area if the onsite processor is available.
- Mobilize to survey the site.
- Input and record the file name for the survey.
- Acquire survey data along the longest area survey line or site slope.
- Complete a Survey Area Report Form (SARF) for each area to be mapped (Section 5.5).
- Pauses, greater than one minute, during data collection, should trigger an incremented line.
- Monitor sensor response, battery levels, and RTK DGPS or RTS periodically.
- Ensure sensor overlap on adjacent transects meets the project required line-spacing, move, or add marking guides to outer coil coverage.
- Continue until the area is completely covered, batteries need replacing, RTK GPS power light flashes, or a break is required.
- Change and charge batteries, as required.
- Perform afternoon Static-Spike and IVS QC tests (Section 0).
- Following these tests, perform end-of-day tasks, including:
  - Download survey data with instrument checks.
  - Secure the EM61 sensors and positioning equipment.
  - Charge all batteries overnight.
  - The logbook pages are photocopied/photographed and transferred to the Project Geophysicist.
  - The data files are submitted to Project Geophysicist.
  - The completed survey areas are recorded in the tracking log and/or reported to the Project Geophysicist.
  - The logbook pages are accessible for verification by the field QC staff that may inspect them weekly.
  - Plan the next day's activities.

3.2 INSTRUMENT NAVIGATION

The positioning of the system, depending on site conditions, is done using either RTK GPS, RTS, or wheel-counter/fiducial systems. Regardless of the positioning system, Where DGM data are collected as either transects or full grids, irrespective of the positioning system, navigation will be established by visual reference to flags or cones set out at the start and end of each line. Completed surveyed lines may be marked by flags, beanbags, chalk, environmentally responsible spray paint, or another method. This may be to denote the current limits of coverage or to provide markers for subsequent lines. The spacing between adjacent lines and the measurement quality objectives (MQO) for achieving acceptable coverage is in the Quality Assurance Project Plan (QAPP) or equivalent planning document.

3.3 DATA ACQUISITION

The EM61 is operated at a walking pace by one or two people, whether the survey area is established as grids or as transect lines. When using GPS or RTS positioning, data are collected in automatic mode at a 10Hz sample rate. For fiducially positioned data, the data will be collected on clicks of a wheel-counter at one reading/20cm. Non-wheeled platforms (litter or skirt mode) are collected at a 10Hz sample rate, and positioning accuracy relies heavily on maintaining a steady pace between fiducial marks in the data. The selection of the appropriate method is determined in the QAPP or equivalent planning document and is based primarily on local site terrain conditions. The battery level will be monitored during data collection, and the battery will be replaced immediately if the voltage drops below the level specified in the QAPP or equivalent planning document. In all cases, data will be recorded and monitored on the handheld data logger using appropriate collection modes, file names, and line numbers, and recorded in the field logbook.

When operated in analog mode for anomaly avoidance or clearing intrusive holes or verifying blind seed responses, the instrument will be operated at a 10Hz sample rate; however, the data will not necessarily be recorded digitally. Where required, response values will be recorded manually in the field logbook.

3.4 COVERAGE AND OBSTACLES

As specified in the QAPP, coverage should be obtained at the line spacing. This typically ranges between 0.5m and 1m for full coverage with the EM61. Obstacles encountered during the geophysical survey will be determined and documented in the field using the SARF. Each field team will be responsible for the completion of the required forms, logbook entries, and photo documentation (as necessary). Coordinates will be obtained for each obstacle by collecting a GPS/RTS track around or along the obstacle. During fiducial DGM collection, obstacles will be noted by gaps in the line log for that grid. The DGM team will be responsible for determining whether an area is considered inaccessible due to site conditions. The DGM forms provide examples of such conditions and may be used in the field by the survey team to assist in documenting deviations.

3.5 FIELD RECORDS

The field records collected include the EM61 data, Raw and RTK GPS or RTS data, digital photographs, forms, and logbooks. All records will be managed following Tetra Tech Procedures. At the end of each workday, the scanned or digital logbooks, forms, and copies of the daily QC and Production data files will be saved to the project server and/or SharePoint site. The Project Geophysicist Data Processor will review each deliverable for completeness and notify the field staff that the day's data delivery requirements, for each DGM team, have been met. The field team will be notified for follow-up and correction if there are deficiencies in the daily DGM data deliverables.

3.5.1 Data Storage and Preliminary Processing

Digital EM61 data are temporarily stored in the Allegro CX data logger via Geonics' EM61MK2 or Geomar's NAV61 software and then downloaded to a laptop computer for further pre-processing using Geonics' DAT61MK2 or Geomar's Trackmaker and Geosoft Oasis Montaj software. When GPS or RTS is used, the positional data is merged with the EM61 data in real-time and stored in the same manner.

3.5.2 Photographs

The Site Geophysicist, Project Geophysicist, or Data Processor will take digital photographs, if necessary, to document site conditions and/or obstructions during geophysical surveying. Each team will maintain a photo log in their field logbook. The photographs will be identified with the date, time, and subject when taken. The digital images and copies of the logbooks will be uploaded with the raw data daily.

3.5.3 Logbooks

One member of the team will be responsible for maintaining the logbook following Tetra Tech procedures. Ensure the following information is recorded in the logbook and/or on the SARF:

- Survey area ID
- Time survey started
- Time survey completed
- Names of team members
- Weather conditions
- Serial numbers of RTK GPS rover unit and geophysical instrumentation
- File names for the digitally recorded data. Each page of the logbook will be dated, sequentially numbered, identified by the logbook number, and signed

Also, the DGM team will document all aspects of their activities using the following checklists:

- Checklist for Daily IVS Checks (Section 0)
- Survey Area Report Form (Section 5.5)
- QC Checklist (Section 5.3)

4.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 INPUT DATA REQUIRED

The data inputs required for EM61 data collection are:

- EM61 Manual;
- Daily IVS Checklist;
- Survey Area Report Form;
- Coordinates of the DGM areas to be surveyed.

4.2 OUTPUT DATA

The data outputs of the EM61 data collection are:

- Raw data files (*.RAW, *.R61, *.M61, *.N61, or *.Survey)
- Digitized DGM Logbooks (*.pdf)
- Digitized Daily IVS Checklist (*.pdf)
- Digitized DGM Survey Area Report Forms (*.pdf)
- Survey area pictures (*.jpg or equivalent)

5.0 QUALITY CONTROL

For this SOP, a Checklist for EM61 Collection (Section 5.3) will be used. This checklist will be completed and signed by the Field QC Designee and the QC Geophysicist upon completion of the EM61 data collection for each deliverable package (e.g., weekly deliverable of grids).

5.1 MEASUREMENT QUALITY OBJECTIVES

Worksheet #22 of the QAPP or equivalent planning document presents the MQOs for the data collection, with results documented in the project database.

5.2 REPORTING

The EM61 data collection will be documented in logbooks and daily production reports. This will include information on the following:

- Daily IVS Checklist;
- Areas surveyed;
- Survey Area Report Form;
- Field notes and issues.

5.3 QC CHECKLIST FOR EM61 COLLECTION

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	This SOP	Have personnel read and signed the workers' statement?				
2	This SOP	If used, was the RTK DGPS base station set up on a known survey control point?				
3	This SOP, WS#22	Did the daily Geodetic Functionality Test measure a second known survey control point within specified tolerances?				
4	This SOP, WS#22	Were morning and afternoon IVS/Spike tests completed and within specified tolerances?				
5	This SOP, WS#22	Were survey line spacings based on QAPP specifications?				
6	This SOP	Were appropriate forms used to documents DGM activities?				
7	This SOP	Were any photographs appropriately documented and logged?				
8	This SOP	Were the data and corresponding documentation uploaded to the project server or SharePoint?				

FINDINGS

Item	Comments

Signatures:

Field QC Designee:		Date:	
QC Geophysicist: (indicating form reviewed):		Date:	

5.4 DAILY IVS CHECKLIST

Project Name		**Location**	
Team			
Date	Click or tap to enter a date.		

SS Test AM (example G1SS021420AM)

File Name: ____________________ Battery Start: __________ Battery End: __________

Line 0: Background (1 min.)

Line 1: Spike (1 min.) CH1: ________ CH2: ________ CH3: ________ CH4: ________

Line 2: Background (1 min.)

IVS Test AM (example G1IVS021420AM)

Line 0: Run IVS out.

Line 1: Run IVS back

Line 2: Background Line

SS Test PM (example G1SS021420PM)

File Name: ____________________ Battery Start: __________ Battery End: __________

Line 0: Background (1 min.)

Line 1: Spike (1 min.) CH1: ________ CH2: ________ CH3: ________ CH4: ________

Line 2: Background (1 min.)

IVS Test PM (example G1IVS021420PM)

Line 0: Run IVS out.

Line 1: Run IVS back

Line 2: Background Line

5.5 SURVEY AREA REPORT FORM

Project Name		**Survey Area ID**	
Field Team Lead		**Raw Data File Name**	
Date	Click or tap to enter a date.		

Survey Type:	**Positioning:**	**Coordinate System:**	**Unit of Measure:**
☐Grid	☐RTK	☐UTM	☐Meters
☐Transect	☐RTS	☐State Plane	☐Feet
☐Meandering Path	☐Fiducial	☐Local	
☐Other__________	☐Other__________	☐Other__________	

Terrain:	**Tree Cover:**	**Weather:**
☐Level	☐None	☐Sunny
☐Moderate Slope	☐Light	☐Cloudy
☐Steep	☐Medium	☐Drizzle
☐Rolling	☐Thick Brush	☐Rain
☐Ruts		☐Thunderstorms
☐Gullies	**Height:** ________	☐Hail
☐Rocky		☐Fog
☐Swampy		☐Humid
☐Dangerous		☐Snow
☐Level		

Comments

Project Name		**Survey Area ID**	

Sketch of the survey area.

Grid Corner coordinates (UTM/SPC):			
NW		**NE**	
SW		**SE**	
Grid Corner coordinates (local):			
NW		**NE**	
SW		**SE**	

TETRA TECH

DGM SOP for DGM Data Processing

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct DGM data processing operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Geophysics. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director of Geophysics Matt Barner		Date:	

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read DGM SOP – DGM Data Processing and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

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FIGURES

1.0 PURPOSE AND SCOPE

The purpose of this Digital Geophysical Mapping (DGM) Standard Operating Procedure (SOP) is to provide the procedures and technical guidance for processing dynamic survey data using digital geophysical mapping (DGM) systems. These systems include time-domain electromagnetic (TEM) and magnetometer (Mag) sensor systems when used in conjunction with a digital positioning system. These may be used in conjunction with real-time kinematic/post-processed differential Global Positioning System (RTK-DGPS), robotic total station (RTS), wheel-counter/fiducial marker positioning systems, ultrashort baseline (USBL) acoustic underwater positioning, and/or tow cable layback systems. This SOP is therefore applicable to all terrestrial, airborne and marine platforms which use:

- EM61-MK2, the EM61-MK1 (1m x 1m), the EM61-MK2 HP, G858 magnetometer, underwater and surface configurations of the marine systems (TEMA-MK3 and TEMA-Lite);
- configurations of the marine magnetic gradiometer array (MGA); and
- airborne TEM-8, VG16 and VG22 sensor platforms, and the terrestrial TEM-8g vehicle towed array.

The project-specific configuration is described in the Quality Assurance Project Plan (QAPP) along with any exceptions or deviations from this SOP. Where necessary, this SOP includes instructions for specific configurations.

This SOP does not substitute for training or provide click-through software documentation. For this SOP, it is assumed that personnel directly involved with data processing have sufficient training and experience in the required software and have access to the software manufacturer's user manuals.

All training on equipment or software will be either formal or on-the-job training (OJT). This training, documented by site personnel, will be subject to review for accuracy and completeness. The Unexploded Ordnance (UXO) Quality Control Specialist (UXOQCS) will verify training is complete and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 PERSONNEL

The following individuals may be involved in the DGM data processing:

- Project Geophysicist
- Data Processor
- Site Geophysicist
- Quality Control (QC) Geophysicist

2.2 EQUIPMENT

The required equipment is a data processing computer suitable for and equipped to run the processes provided in a validated version of the UXO-Land module of Geosoft's Oasis Montaj geophysical processing environment. The computer should also have the most current version of the Windows Office Suite of products with text and graphics editors recommended.

3.0 PROCEDURES AND GUIDELINES

This section describes the procedures used to process the dynamic production data, including positioning and leveling of the data, processing/assessing the QC activities related to dynamic data collection, and selecting target anomalies from the final processed data.

3.1 PROCESSING OF DYNAMIC DETECTION DATA

The steps for processing of dynamic data are:

1) Raw data conversion and import into Geosoft
2) QC test data processing
3) Production DGM data processing
4) Target selection

3.2 DATA CONVERSION AND IMPORT

The raw data files are converted to a compatible format that can be imported into a Geosoft Database (*.gdb). This is achieved by using instrument-specific software such as DAT61, Trackmaker61, Mag Mapper, HYPACK, Xcrib, or other custom software. Additional data fields may be imported or synchronized to the geophysical data as required based on the timestamp of the original geophysical data. Once imported, the data are inspected and assessed against the measurement quality objectives (MQOs) provided in QAPP Worksheet #22.

3.3 DATA POSITIONING AND LEVELING

A latency correction may be applied to account for instrument delay. If chevron-shaped anomalies are present in the processed grid data, the instrument latency has not been adequately addressed and will need to be reworked. Depending on the number of sensors collected in a single pass, additional positions will be calculated for each data trace, as part of the data conversion or afterward in Geosoft.

A site-specific de-median (or similar) filter is applied to each stream of DGM data to derive an estimate of the background model. This model is subtracted from the raw data to provide a background removed or ‘leveled’ data set. Figure 1 shows an example of raw data (top panel, red trace), the background model derived from these data (top panel, green trace), and the resulting background removed data (bottom panel).

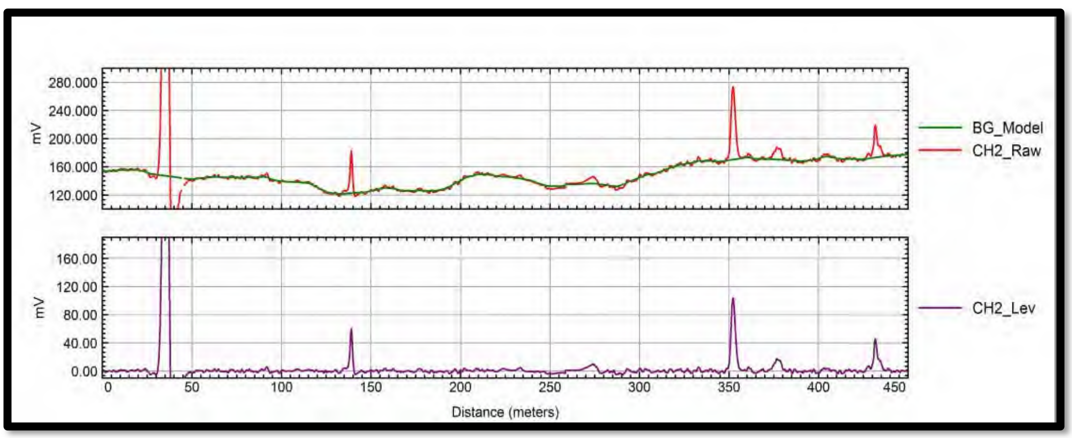

Figure 1. Example of Raw and Leveled Data

The leveled data will be gridded and mapped using conventional Geosoft tools. If required, additional data products may be generated from geophysical responses and gridded for presentation and analysis (analytic signal, electromagnetic decay, etc.). The mapped data are then used for amplitude-response-based target selection whereby the position of peak responses in the data that exceeds the project threshold are selected and identified as target anomalies for further analysis.

3.4 QUALITY CONTROL DATA

QC measurements are performed daily to verify the operation of the sensors and associated components. Not all tests are required for all projects. The list of required tests is in the QAPP or equivalent planning document. These tests may include pre- and post-survey static noise tests, static spike tests, and transects along the Instrument Verification Strip (IVS), as well as on-line survey data parameters to monitor data density, coverage, and positional quality. The successful completion of these tests daily is required to validate the survey data collected on that day. Data measurements that do not pass the measurement quality objectives (MQOs) must be identified and investigated for either equipment problems, collections problems, or processing problems. Once identified, problems will be corrected according to the nature of the problem and the failure resolution procedures listed in the QAPP or equivalent planning document. Failures that are identified and resolved at this stage do not constitute a QC failure requiring a root cause analysis (RCA) and Corrective Action Report.

3.4.1 Static Noise

Static noise test measurements are performed daily at the rate specified in the QAPP to confirm that all sensors are working with minimal interference from internal or external noise sources. The data from each test are assessed relative to the MQOs presented in QAPP and compiled for review. Results that do not pass the MQOs are identified, and appropriate action is taken.

3.4.2 Static Spike Test

Static Spike Test measurements (also called function tests) are performed daily at the rate specified in the QAPP to confirm that the geophysical sensor components are registering anomalies with a consistent amplitude. The data from each test are assessed relative to the MQOs presented in QAPP and compiled for review. Results that do not pass the MQOs are identified, and the appropriate action taken.

3.4.3 Daily Instrument Verification Strip (IVS) Survey Processing

System measurements over the IVS targets are performed daily at the rate specified in the QAPP to confirm that the entire system (including data positioning and data processing) is functioning as expected. The data from each test are assessed relative to the MQOs presented in QAPP and compiled for review. This typically includes the location of the detected anomaly peak and its amplitude. Results that do not pass the MQOs are identified, and the appropriate corrective action taken.

3.4.4 Data Density and Coverage

For production survey data, down-line data density and crossline data coverage metrics will be specified in the QAPP to confirm that the overall data density is maintained. Any gaps identified in data coverage must be either filled or documented as obstructions. Data will be monitored throughout the data collection process, and assessed relative to the MQOs presented in the QAPP and compiled for review. Results that do not pass the MQOs are identified, and the appropriate corrective action taken.

3.5 TARGET SELECTION

Depending on the data collection method, data sets collected in a single sortie may cover more than one deliverable unit (survey grid). Similarly, it may require multiple sorties to complete coverage of a unit, either due to time limits or gaps that require return trips. In these cases, data will be processed and compiled into deliverable units by the data processor according to the deliverable schedule presented in the QAPP. Once a deliverable unit is complete, target selection will be performed using a traditional amplitude response metric, where amplitudes greater than a site-specific threshold are selected as a target.

Traditional anomaly selection is based almost entirely on signal response amplitude. After the data have been gridded, the Geosoft automatic grid peak detection algorithm (e.g., Blakely Test) is used to extract locations of all grid peaks that are above the project detection threshold. The target selection threshold should be set to no less than 5x the root mean square (RMS) noise at the site unless otherwise specified in the project QAPP or IVS Technical Memorandum.

For electromagnetic systems using the Geonics EM61-MK2, if a specific munition and depth of interrogation are required, the analyst will utilize the Depth/Response curve (generated in Geosoft or the Naval Research Laboratory [NRL] Response Calculator) to estimate the minimum response of the most difficult expected munition/depth combination defined in the project conceptual site model. If the mark/model of the expected munition is unknown, then the smallest relevant option available should be used to develop the threshold. The project team may elect to add a buffer to the calculated value to be conservative. This process should also be detailed in the project QAPP or IVS Technical Memorandum.

Automated target selections will be plotted on the gridded data and visually inspected. Missing targets may be added manually from the gridded data or the profile data. Single targets with large footprints will be noted in the target list as having a larger search radius. Multiple overlapping targets will be replaced by an enclosing polygon and denoted as a saturated response. Obstacles will be drawn on the map and exported as digital files for subsequent follow-up. Anomalies exhibiting abnormal signatures or decays will be masked or categorized separately (noise) from valid anomalies. Efforts will be made to ensure those boundary anomalies are identified with a single grid. Final selected target locations will be assigned a unique target ID, imported into the project database, and plotted on the area map. The QC Geophysicist will review the final list before providing it to the UXO teams for intrusive investigation.

If the site background noise indicates that the detection survey will not achieve the project goals for detection depth as specified in the QAPP, the project team must meet and evaluate the effect on the usability of the data relative to the data quality objectives derived in Worksheet #11. The Data Processor and Project Geophysicist will monitor the sensor noise levels and background response models to evaluate whether notable variations occur across the site concerning the background response model or sensor noise levels. If the background noise level varies across the project site, different thresholds may be used for different grids. These thresholds will be approved by the project delivery team (PDT) and documented in meeting minutes and on the data processing checklist.

3.6 DATA DELIVERY

Once data processing and target selection are complete, packaged data will be delivered to the client. The QC Geophysicist will review the data package for completeness and content according to the QAPP. The QC Geophysicist, along with the Project Geophysicist, will resolve problems or nonconformances before delivery to the client.

4.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 INPUT DATA REQUIRED

The data inputs required for processing dynamic data are:

- Site boundaries
- Raw survey data files
- Raw function check and IVS data files
- All field notes and photos
- Amplitude response detection threshold

4.2 OUTPUT DATA

The data outputs of the processing of dynamic data are:

- Project database summarizing daily QC measurement results
- Converted and processed data
- Target anomaly list (identifier (ID, X, Y)
- List of obstructions and saturated response areas
- Data processing checklist (Section 5.4)

5.0 QUALITY CONTROL

For QC of this SOP, a Checklist for DGM Data Processing will be used. This checklist will be completed and signed by the Project or Processing Geophysicist and the QC Geophysicist upon completion of the data processing for each deliverable package (e.g., weekly deliverable of grids).

5.1 MEASUREMENT QUALITY OBJECTIVES

The MQOs for the data processing are in the QAPP or equivalent planning document, with results documented in the project database.

5.2 REPORTING

The DGM data processing will be documented for each deliverable dataset (grid), and will include information on the following:

- Raw data files and associated field notes and logbook entries
- Processed DGM data per grid or survey area in Geosoft Database (*.GDB) format
- Final target list per grid or survey area in *.GDB and/or spreadsheet formats
- Geosoft Map (Packed) per grid or survey area (*.MAP and *.PDF format)
- Dynamic Data Processing Checklist detailing the following:
  - Survey date
  - Standard quality control checks performance
    - Latency/Lag correction
    - Coverage
    - Background response
    - Leveling Filter
    - Gridding Filter
    - Target Threshold
  - Associated Function Test filename
  - Associate IVS Test filename(s)
  - Area subset (grid ID)
- QC Checklist (per data delivery package)
- Updated Project Database

5.3 QC CHECKLIST FOR DGM DATA PROCESSING

TEAM INFORMATION		
Deliverable:	**Location:**	**Date:**
Data Processor:		
Data Included:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	This SOP	Have personnel read and signed the workers' statement?				
2	This SOP, WS#22	Were all function test data present, processed and did the tests pass the MQOs?				
3	This SOP, WS#22	Were all the IVS test data present, processed and did the tests pass the MQOs?				
4	This SOP, WS#22	Were invalid data (e.g. GPS fit quality, flatlined responses) identified and rejected?				
5	This SOP, WS#22	Were gaps in data coverage due to down-line and across line sampling identified and accounted for (obstructions)?				
6	This SOP	Were all data processing routines and parameters, including the leveling and target selection methods, appropriate and documented in the data processing checklist?				

FINDINGS

Item	Comments

Signatures:

Data Processor:		Date:	
QC Geophysicist (indicating form reviewed):		Date:	

5.4 DYNAMIC DATA PROCESSING CHECKLIST

		FILENAMES:			
Site:		Raw:			
Location:		Converted:			
Contractor:		Processed:			
Sector:		Grid:			
Grid:		Target List:			
Processor(s):		Target Map:			
			Y	N	N/A
Preprocessing					
1. Coordinate Conversion:					
Projected Coordinate System:					
2. Removal of Drift and Leveling					
Record Corrections:					
3. Latency, Lag and Offset					
Record Corrections:					
Processing					
4. Initial Gridding					
Record Parameters:					
5. Digital Grid Filtering and Enhancement ☐ Low Pass ☐ High Pass ☐ Non-Linear ☐ 3x3 Convolution ☐ Median filter ☐ Dipole response filter ☐Other ______________________________					
6. Threshold Selection value: _________					
7. DGM target Selection Number of targets: _____________________					

TETRA TECH

UXO SOP for MEC AVOIDANCE

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct Munitions and Explosives of Concern (MEC) avoidance operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Technical Operations and Explosives Safety. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director, Technical Operations & Explosives Safety Patrick Tatman	P. Tatman	Date:	6/23/2020

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read UXO SOP – MEC Avoidance and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

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1.0 PURPOSE AND SCOPE

The purpose of this Standard Operating Procedure (SOP) is to provide procedures and technical guidance for the MEC Avoidance at designated munitions response sites. These operations include:

- Civil survey operations to establish boundary lines, control points, grids, and transects;
- Vegetation Clearance/Removal operations
- Soil Sampling
- Escort
- Construction Support

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials that may be required to implement this activity.

2.1 PERSONNEL

The following individuals or vendors may be involved in Munitions and Explosive Concern (MEC) Avoidance activities:

- Subcontractors (Surveyors, Construction workers, Soil Sampling, etc.)
- Unexploded Ordnance (UXO) Personnel
- Visitors or other site personnel

2.2 EQUIPMENT

- Personal protective equipment outlined in the Activity Hazard Analysis (AHA) (gloves, safety glasses, etc.)
- Hand-held geophysical instruments
- Hand-held Global Positioning System (GPS) Unit
- Computers/Tablets
- Cameras
- Utility or Passenger Vehicles
- First-aid gear
- Fire extinguisher

3.0 PROCEDURES AND GUIDELINES

3.1 EQUIPMENT SET-UP

3.1.1 Receipt Onsite

Materials or equipment received at the site will be inspected for serviceability and against purchase order requirements. Photos will be taken and filed with the daily quality control reports or the Quality Receiving Inspection Report (QRIR).

Hand-held geophysical sensors will be tested and, if applicable, search programs uploaded and verified in the test strip for functionality per the operator's manual.

Hand-held or other Global positioning systems for use during MEC Avoidance will be checked for correct project and coordinate upload.

Cameras will have video cards and batteries checked.

Utility vehicles or passenger vehicles will be inspected for damage and verified as operational. Photos of vehicles will be taken and given to the site safety officer.

3.1.2 Daily Prior to Operations

Electronic equipment will be tested prior to beginning operations each day and the results recorded in the team logbook or on forms. All tests will be reported to the lead onsite quality representative for inclusion in the daily report.

GPS devices will be checked against know points before use to ensure accuracy during use.

Hand-held geophysical sensors will be checked in an established test strip or against a metal piece on the surface before beginning daily operations.

UTVs or passenger vehicles will be inspected daily for damage and operability. Inspection forms will be submitted to the site safety officer weekly.

3.2 OPERATIONS

3.2.1 General Safety

Intrusive anomaly investigation is not authorized during MEC avoidance activities. Avoidance for intrusive construction activities such as grading and trenching will only be conducted on projects with a documented low MEC probability based on past use and historical evidence.

MEC avoidance activities will not be conducted until the required training and proper equipment checks have been completed, documented, and the appropriate exclusion zone (EZ) is established, marked, and secured.

The appropriate authorities will mark all utilities before intrusive operations.

Avoidance activities at any given location onsite may be conducted by a single individual trained as a UXO Technician I, provided a second UXO Technician and reliable communications between UXO Technician has been established in case of emergency.

The appropriate supervisor will be notified immediately of all MEC or suspected MEC finds.

Non-UXO personnel must always be escorted by UXO-trained personnel, after receiving 3R training, in areas potentially containing MEC.

If MEC is encountered that presents an immediate threat to life or property, it will be marked and secured until turned over to EOD or the appropriate local authorities.

UXO personnel must remain onsite at all times when non-UXO personnel are conducting intrusive operations.

Do not touch or disturb MEC; mark their location with a red pin flag or surveyors' tape and avoid them.

Do not expose electrically fired munitions to radio, cell phone, or satellite phone transmissions within 25-ft. (7.6-m).

Do not collect souvenirs.

Do not smoke except in designated areas.

Prohibit non-essential personnel from encroaching upon the site.

Suspend all operations immediately upon approach of an electrical storm (within 10-miles).

3.2.2 Survey of Access Lanes and Work Sites

UXO technician must conduct a surface and subsurface survey for anomalies on the access path both to and from the worksite before any type of activities commence, including foot and vehicular traffic. The surface area checked should be at least twice the width of the largest vehicle to be used. The UXO technician will also complete a surface and subsurface survey of the proposed work site, as listed in the work plan. The work site will be a minimum dimension in all directions equal to twice the length of the longest vehicle or equipment to be used unless stated in the work plan. These boundaries will be clearly marked using survey flagging or pin flags.

The UXO Technician will use the appropriate magnetometer to clear the areas listed above. Subsurface anomalies will be marked with proper pin flags and will be avoided. If MEC is located, the UXO technician will halt escorted personnel in place, mark the item, and notify the appropriate supervisor for further instruction.

3.2.3 Avoidance for Sampling Activities

A survey of all access lanes, worksites, and buffer zones in accordance with 7.5.1 must be completed before conducting sampling activities. UXO technicians equipped with appropriate magnetometer will clear all sampling sites and observe all sampling activities. If anomalies are detected, they will be marked, avoided, and a new sampling location was chosen. If MEC is located, the UXO technician will halt sampling activities, mark the item, and notify the appropriate supervisor, who will then notify the proper authorities.

3.2.4 Avoidance for Civil Survey Operations

A UXO technician must survey access lanes ahead of the surveyor when locating specific survey points. Once the surveyor has found the survey point, the area must be checked for anomalies with the magnetometer before placing a grid stake or pin. If an anomaly is located, the pin placement will be moved to another area. If MEC is found, the UXO technician will mark the item and notify the appropriate supervisor.

3.2.5 Escort Duties

A UXO trained person will escort all non-UXO trained personnel as necessary to support project operations. The UXO Escort will lead the group and visually and, if needed, utilize a hand-held instrument to detect surface contacts in vegetated areas.

3.2.6 Discovery Of Anomalies/Items Other Than MEC

Material other than munitions may be located during the MEC avoidance operations, including metal debris, underground utilities, chemicals, and other hazards.

Metal debris located during MEC avoidance will be clearly marked with surveyors' tape, paint, or another identifiable item and left in place unless stated in the contract or presents a safety hazard.

Suppose there are any indications that a near-surface utility line is present (such as a signal from the locator or discovery of marking tape). In that case, all activities will cease, and the appropriate supervisor will be notified. The work area should be relocated to another site, if possible.

Locating industrial chemicals is a possibility during MEC avoidance operations. If any evidence of chemical contamination is detected (stained soil, chemical odors, powders, or other substances resembling chemicals), all activities will cease. The appropriate supervisor will make the required notifications as per the work plan.

Suppose sealed drums or other suspect materials or conditions indicate a potential health or safety hazard are encountered during the investigation. In that case, all activities will cease, and the appropriate supervisor will make the required notification as per the work plan.

4.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 INPUT DATA REQUIRED

The data input in order to perform MEC avoidance is varied depending on what task is being performed.

4.2 OUTPUT DATA

The primary output from this SOP are areas ready for civil survey, soil sampling data is collected, or areas are identified for surface operations.

5.0 QUALITY CONTROL

Quality Control (QC) for this SOP will be achieved through visual checks of the definable feature of work (DFW), completion of the QC Checklist for MEC Avoidance (Section 5.3), and performance metrics identified in the plans are met. The checklist will be filled out and signed by the onsite quality lead or designee upon completing the area or grid.

5.1 MEASUREMENT QUALITY OBJECTIVES

The Measurement Quality Objectives (MQOs) for MEC Avoidance are presented in the project plans, with results documented in the team logbook.

5.2 REPORTING

Input to the project MEC/Material Potentially Posing an Explosive Hazard (MPPEH) Accountability Log is the only reporting output from this SOP.

5.3 QC CHECKLIST FOR MEC AVOIDANCE

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	UXO SOP X	Have personnel read and signed the workers' statement?				
2	UXO SOP X	Has the equipment been checked out, and is it documented correctly?				
3	UXO SOP X	Are daily position checks within specified tolerances if the GPS is used?				
4	UXO SOP X	Have the appropriate MQOs been achieved for MEC Avoidance?				
5						

FINDINGS

Item	Comments

Signature:

UXOQCS or Designee: ______________________ **Date:** ____________

TETRA TECH

UXO SOP for Vegetation Clearance/Removal

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct vegetation clearance/removal operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Technical Operations and Explosives Safety. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director, Technical Operations & Explosives Safety Patrick Tatman	P. Tatman	Date:	6/23/2020

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read this UXO SOP – Vegetation Clearance/Removal and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

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1.0 PURPOSE AND SCOPE

The purpose of this Standard Operating Procedure (SOP) is to provide procedures and technical guidance for the vegetation clearance/removal at designated munitions response sites. These operations include:

- Vegetation clearance of boundary lines, control points, grids and transects;
- Manual and mechanical vegetation clearance/removal operations

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials that may be required to implement this activity.

2.1 PERSONNEL

The following individuals or vendors may be involved in vegetation clearance/removal activities or be in the area during these operations:

- Vegetation Clearance/Removal Subcontractors
- Surveyors
- Site Geophysicist
- Unexploded Ordnance (UXO) Technicians
- UXO Quality Control Specialist (UXOQCS)

2.2 EQUIPMENT

- Hand brush clearing tools
- Mechanical brush clearing equipment (chainsaws, skid steers, hydro axes, etc.)
- Personal protective equipment outlined in the Activity Hazard Analysis (AHA)/Job Safety Analysis (JSA)
- Hand-held geophysical instruments
- Hand-held Global Positioning System (GPS) Unit
- Computers/Tablets
- Cameras
- Utility or Passenger Vehicles
- First-aid Kit
- Fire extinguisher
- Refueling equipment

3.0 PROCEDURES AND GUIDELINES

3.1 EQUIPMENT SET-UP

3.1.1 Receipt onsite:

Materials or equipment received at the site will be inspected for serviceability and against purchase order requirements. Photos will be taken and filed with the daily quality control report or the Quality Receiving Inspection Report (QRIR).

GPS units or GPS enabled tablets will be loaded with the coordinates specific to the project. Upon receipt at the site, receipt inspections will verify all electronic equipment is operational and that coordinate systems and layers are loaded for the project.

Hand-held geophysical sensors will be tested and, if applicable, search programs uploaded and verified in the test strip for functionality per the operator’s manual.

Cameras will have video cards and batteries checked.

Utility vehicles, passenger vehicles, or mechanized brush clearing equipment will be inspected for damage and verified as operational. Photos of vehicles/equipment will be taken and given to the site safety officer.

3.1.2 Daily Prior to Operations:

Electronic equipment will be tested prior to beginning operations each day of use and the results recorded in the team logbook or on forms. All tests will be reported to the lead onsite quality representative for inclusion on the daily quality control report.

GPS devices will be checked against know points before use to ensure accuracy during use.

Hand-held geophysical sensors will be checked in an established test strip or against a piece of metal on the surface before beginning daily operations.

Mechanized or power equipment will be checked out before use, following owners’ operations manuals and documented on forms or in a logbook.

Utility terrain vehicles (UTVs)/passenger vehicles will be inspected daily for damage and operability. Inspection forms will be submitted to the site safety representative weekly.

3.2 OPERATIONS

3.2.1 General Safety

Surface sweeps will be performed before vegetation clearance/removal operations if Munitions and Explosives of Concern (MEC) is known to exist on the surface. UXO Escorts may be used in place of surface sweeps if the UXO escort surveys the grid or area if MEC is not confirmed on the surface.

Vegetation will be removed as limited by the contract. All vegetation at or below the allowed removal size will be chipped, mulched, shredded, or cut down and removed from the area operations will be conducted.

The measurement to determine if a tree is allowed to be removed will be measured from a height of 4-feet above the ground surface. All trees exceeding the allowed removal size will not be removed, and all practical measures to limit damage will be taken by vegetation removal personnel.

When powered equipment is in use, a Safety observer not engaged with brush cutting activities will be designated.

Observe safety precautions/warnings found in the operator's manual/manufacturer's publications.

Maintain 6 inches of ground clearance during vegetation cutting operations.

Maintain exclusion zone site control.

Non-UXO personnel must always be escorted by UXO-trained personnel in areas potentially containing MEC.

Avoidance activities at any given location onsite may be conducted by a single individual trained as a UXO Technician I, provided a second UXO Technician or the Senior UXO Supervisor (SUXOS) is readily available and reliable communications between UXO Technician has been established in case of emergency.

Observe MEC safety precautions for items encountered or suspected.

Extreme caution must be used when any vegetation removal equipment, powered or otherwise, is in use. Personnel observing manual brush clearing operations will stand outside of the debris throwing distance for that equipment. For mechanized brush clearing equipment, the safe distance identified in the operations manual will be observed.

Onsite mobile refueling operations will only be conducted when equipment is shut down. Additionally, the task will have the appropriate spill prevention and containment controls in place, along with the required fire extinguisher for that task.

The appropriate supervisor will be notified immediately of all MEC or suspected MEC finds.

Non-UXO personnel must be escorted by UXO-trained personnel at all times in areas potentially containing MEC.

If MEC is encountered that presents an immediate threat to life or property, it will be marked and secured until turned over to Explosive Ordnance Disposal (EOD) or the appropriate local authorities.

Do not touch or disturb MEC; mark their location with a red pin flag or surveyors' tape or other means and avoid them.

Do not expose electrically fired munitions to radio, cell phone or satellite phone transmissions within 25-ft. (7.6-m).

Do not collect souvenirs.

Do not smoke except in designated areas.

Prohibit non-essential personnel from encroaching upon the site.

Suspend all operations immediately upon the approach of an electrical storm as defined within AHA/JSA

In areas where vegetation removal is needed, UXO Technicians will first conduct a hand-held instrument-assisted surface sweep of the area to mark any surface material potentially presenting an explosives hazard (MPPEH), will remove any surface debris and identify other hazards that might damage equipment or injure personnel. Hazards will be marked with the flagging, paint, pin flag to ensure the vegetation team can clearly see the hazard. Team personnel will be briefed on location and type of hazardous features before commencing the vegetation removal.

If the purpose of the project is to gather data to determine area contamination density, the number of contacts removed will be recorded in logbooks or forms and reported to the SUXOS, Site Geo, or designee.

Team personnel are to ensure that 6 inches of ground clearance is maintained during removal operations. Those areas marked as hazards are to be avoided. The manner in which operations are accomplished will follow safe work practices and procedures. If MPPEH/MEC is located, the UXO technician will halt operations, mark the item, and notify the SUXOS and UXOSO.

Upon completion of the unit of production (grid, transect, or grouping of grids), the UXO person assigned to the vegetation clearance/removal operation will notify the SUXOS or Lead Site Manager by the end of the production day. The Site Geophysicist and UXOQCS or designee will inspect the area for compliance with the contract and requirements in the plan. Inspections will be documented on the daily quality control report and the project database updated.

4.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 INPUT DATA REQUIRED

The data input to perform vegetation clearance/removal is the Geographic Information System (GIS) or project layout data loaded into the GPS or tablet system being utilized.

4.2 OUTPUT DATA

The primary output from this SOP are areas ready for civil survey, surface clearance (if not previously performed), blind seeding, and preparations for further geophysical or intrusive activities.

5.0 QUALITY CONTROL

Quality Control (QC)for this SOP will be achieved through inspection of the area or grids; completion of the QC Checklist for vegetation clearance/removal (Section 5.3) and performance metrics identified in the plans are met. The checklist will be filled out and signed by the Site Geophysicist, and onsite quality lead upon completion of the area or grid.

5.1 MEASUREMENT QUALITY OBJECTIVES

The Measurement Quality Objectives (MQOs) for vegetation clearance/removal are presented in the project plans. Results will be documented in the project GIS tracking system and daily quality control reports.

5.2 REPORTING

The project GIS tracking system will contain all vegetation clearance/removal status. Control documentation checks (coordinate readings) will be recorded in team logbooks. The UXOQCS will verify the completion of the checks and proper documentation on the frequency specified in the plans. The check will be documented on the daily quality control report when performed. For any work performed by a land surveyor subcontractor, a surveyor’s report will be generated by the subcontractor upon completion of the work.

5.3 QC CHECKLIST FOR VEGETATION CLEARANCE

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	UXO SOP	Have personnel read and signed the workers' statement?				
2	UXO SOP	Has the equipment been checked out, and is it documented correctly?				
3	UXO SOP	Are daily position checks within specified tolerances if the GPS is used?				
4	UXO SOP	Have the appropriate MQOs been achieved for vegetation clearance?				
5	UXO SOP	Has the Site Geophysicist or UXOQCS conducted a visual walkthrough of the area to ensure the work is acceptable?				
6	UXO SOP	Has the GIS Tracking system been updated?				

FINDINGS

Item	Comments

Item	Comments

Signature:

UXOQCS or Designee: ______________________ **Date:** ____________

UXO SOP for Surface Sweep/Clearance Operation

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct Surface Sweep or Clearance Operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Technical Operations and Explosives Safety. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director, Technical Operations & Explosives Safety Patrick Tatman	P. Tatman	Date:	6/23/2020

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read UXO SOP – Surface Sweep/Clearance Operations and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

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1.0 PURPOSE AND SCOPE

The purpose of this Standard Operating Procedure (SOP) is to provide procedures and technical guidance for the Surface Sweep/Clearance Operations at designated munitions response sites. This SOP does not cover escort duties for Construction Support, Soil Sampling, or Surveyor operations. These operations include:

- Surface Sweep/Clearance
- Construction Support (access)

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials that may be required to implement this activity.

2.1 PERSONNEL

The following individuals or vendors may be involved in Surface Sweep/Clearance activities:

- Unexploded Ordnance (UXO) Sweep Personnel
- Sampling Technicians
- Professional Licensed Surveyors
- Construction Workers
- UXO Personnel

2.2 EQUIPMENT

- Personal protective equipment outlined in the Activity Hazard Analysis (AHA)/Job Safety Analysis (JSA)
- Hand-held geophysical instruments
- Global Positioning System (GPS) units
- Computers/Tablets
- Cameras
- Marking flags or ribbon
- Utility or Passenger Vehicles
- First-aid Kit
- Fire extinguisher

3.0 PROCEDURES AND GUIDELINES

All training on equipment will be either formal or on-the-job training (OJT). This training will be documented by site personnel and subject to review for accuracy and completeness. The UXO Quality Control Specialist (UXOQCS) will verify and document that all personnel assigned to surface sweep/clearance teams have received training on the equipment, Accident Prevention Plan/Site-Specific Health and Safety Plan (APP/SSHP), AHA/JSA, environmental requirements, and as dictated in the Work Plan.

The Senior UXO Supervisor (SUXOS), UXO Safety Officer (UXOSO), and UXO Team Leader (TL) will review the site terrain and determine the best approach for sweep/clearance operations. Although not expected, all inaccessible locations will be documented in the field logbook.

3.1 EQUIPMENT SET-UP

3.1.1 Receipt Onsite

Materials or equipment received at the site will be inspected for serviceability and against purchase order requirements or operations manuals. Photos will be taken and filed with the daily quality control reports or the quality receipt inspection report (QRIR) or equivalent record.

Hand-held geophysical sensors will be tested and, if applicable, search programs uploaded and verified in the test strip for functionality per the operator's manual.

Hand-held or other Global positioning systems for use during Surface Sweep/Clearance will be checked for correct project and coordinate upload.

Cameras will have video cards and batteries checked.

Utility/passenger vehicles and heavy equipment will be inspected for damage and verified as operational. Photos of vehicles will be taken and filed, as stated above.

3.1.2 Daily Prior To Use

Electronic equipment will be tested prior to beginning operations each day and the results recorded in the team logbook or on forms. All tests will be reported to the lead on-site quality representative for inclusion in the daily report.

GPS devices will be checked against know points before use to ensure accuracy during use.

Hand-held geophysical sensors will be checked in an established test strip or against a piece of metal on the surface before beginning daily operations.

Personal Protection Equipment (PPE) will be inspected before use.

First-aid kits and fire extinguishers will be inspected weekly.

Utility terrain vehicles (UTVs) or passenger vehicles will be inspected daily for damage and operability. Inspection forms will be submitted to the site safety officer weekly.

3.2 OPERATIONS

3.2.1 General Safety

The most pertinent rules for handling Munitions and Explosive Concern (MEC) are summarized below:

- Assume munitions contain a live charge until determined otherwise.
- Avoid inhalation of and skin contact with smoke, fumes, and vapors of explosives and related hazardous materials.
- Consider munitions that have been exposed to fire or detonation as extremely hazardous. Chemical and physical changes may have occurred to the contents, which can render them much more sensitive than their original state (e.g., changes to the condition of the fuze or explosives).
- Make every effort to identify the munitions. Carefully examine the munition for markings and other identifying features such as shape, size, and external fittings. Do not move the suspected munition until it is identified and confirmed to be safe to move by the SUXOS and UXOSO.
- Plan for, provide, and know the measures to be taken in the event of an accident.
- Provide a designated emergency vehicle in the area in case of an accident or an emergency.
- Do not handle, use, or remain near explosives during the approach or progress (within 10-miles) of an electrical storm. All personnel will shelter as identified in the Accident Prevention Plan (APP) or as directed by the UXOSO.
- Only allow essential personnel to be present near the munitions.
- Always base operations on minimum exposure consistent with efficient operations.
- Do not rely on the color-coding of MEC for positive identification of contents. Munitions having non-existent, incomplete, or improper color codes may be present.
- Avoid the area forward of the ammunition’s nose until it can be determined that the item is not a shape-charge or high-explosive anti-tank round. The explosive jet can be fatal to great distances forward of the item’s longitudinal axis. Assume any shape-charge munitions contain a piezoelectric fuzing system until the fuzing is otherwise identified. Piezoelectric fuzes are extremely sensitive, can fire at the slightest physical change, and may remain hazardous for an indefinite period.
- Approach an unfired rocket motor from the side. Ignition will create a moving projectile hazard and hot exhaust. Do not allow electrically fired rocket motors within 25 feet of any exposed electronic transmitting equipment or antenna leads.

3.2.2 Daily Briefing

After arriving at the worksite, the SUXOS will conduct a tailgate operations/safety meeting at the work location. The UXOSO will brief the teams on potential hazards in the area and the operations performed during the shift, and review the AHA/JSA for the task. The SUXOS will assign selected worksites to each of the UXO teams for surface sweep/clearance operations.

The TL will ensure hand-held instruments, GPS, communications equipment, safety gear, or other non-construction equipment is function checked and serviceable before beginning field operations. The checks will be documented in team logs or on forms.

3.2.3 Surface Sweep/Clearance

All analog geophysical sensor visual surface sweep/clearance operations will be performed under the direct supervision of a Qualified UXO Technician III or higher. The UXO team will consist of one UXO Technician III, two UXO Technician IIs, and four UXO TIs or UXO Sweep personnel (UXOSP). A standard team will not exceed seven personnel, but if large areas require surface sweep/clearance as many as 22 personnel can perform this activity. If the area to be swept is large, two additional UXO Technician IIs and up to twelve UXO sweep personnel may be added to the basic team (for a total of twenty-two personnel).

- The UXO team members will be spaced approximately 5–ft (1.5-m) apart. At the direction of the UXO Technician III, will move through the grid/area, making sure the hand-held instruments do not interfere with one another as the technicians traverse the area to be swept. Hand-Held instruments meeting the detection performance metrics will be used to detect any surface debris that may be obscured by brush or heavy grasses.
- If UXO Sweep personnel are utilized, the UXO Sweep person will visually look at a contact once the hand-held instrument indicates a target is present. They will notify a UXO Tech II or higher to make the identification. At no time will UXO Sweep personnel touch with their instrument or hands any contact.
- IF UXO Personnel are used to conduct sweep/clearance operations, the UXO Technician will make a tentative identification to determine if the contact is MPPEH or Non-munitions-related debris (NMRD) [note, the identification of any debris discovered by a UXO Technician I must be confirmed by a fully qualified UXO Technician (defined as a UXOTII or above)]. The UXO Technician II will inspect the contact to verify if it is MPPEH, munitions debris (MD), range-related debris (RDD), or NMRD. All MEC/MPPEH will be left in place and marked as identified in the Explosive Safety Submission (ESS) or Explosives Siting Plan (ESP).
- As the team moves forward, the team member at the edge of the grid will use the grid stakes (or other visual marking) as one clearance lane boundary. The team member on the opposite end of the line will mark the limit of the cleared lane with pin flags, ribbon, cone, or other marking mechanism. These markers become the guide for the turnaround and define the limits of the previously cleared lane.
- This procedure is continued until the grid or area is completely cleared.
- The UXO Technician II and III will follow behind the sweep line depending on team configuration (seven or 22 personnel), ensuring that proper spacing is maintained, will inspect and verify the identification of the flagged MEC/MPPEH, and record data on the type, nomenclature, and location of the items as required.

Upon completion of the grid clearance all MD, RDD, and NMRD will be 100% inspected by a UXO Technician II and a UXO Technician III before it is removed from the grid or area to ensure it is free of explosive hazards. If MEC is found, it will be left in place, clearly marked, and the UXO Technician III will notify the SUXOS for further instructions. The UXO Technician III will also notify the SUXOS when MPPEH (not able to be 100% inspected) is found and request further instructions.

The team leader will photograph all MEC or MPPEH and record as much information as possible in the Team Leader's logbook or in the personal digital assistant (PDA). Recorded data includes nomenclature (if known), type (projectile, mortar, rocket, etc.), size, physical condition, fuzed or unfuzed, and fuze type by function (point detonating, mechanical time, etc.), condition (fired or unfired, armed or unarmed), filler if known, and global positioning system (GPS) coordinates.

The SUXOS and UXOSO are the only personnel who are authorized to make them acceptable to move determination for MEC or suspected MPPEH.

3.2.4 Collection Points

Collection points allow for temporary accumulation of recovered MEC/MPPEH that are acceptable to move to another area for storage or destruction. The net explosive weight, location, and separation distances between the collection point will be identified in the explosive safety documents. No MEC/MPPEH will be transported from one munitions response site to another.

3.2.5 Field Communication

Hand-held radios will be used for any required communications between the UXO teams and the site office/site management personnel. The site office will relay all required communication to other on-site personnel using established radio links or by telephone/cell phone. Applicable telephone numbers can be found in the APP/SSHP and will be posted in the site office and placed in all vehicles. If necessary, a radio base station or repeaters will be used to ensure reliable communications across the site.

3.3 MPPEH CHARACTERIZATION

- The first person who discovers the MPPEH will conduct the initial classification (MEC, MD, RDD, NMRD). If the person is a UXO Tech I, he will have a second person UXO Tech II or higher verify the classification. UXO Sweep personnel will never touch or move MPPEH until directed by a UXO Tech II or higher.
- The UXO Tech III (UXO TL) will inspect all MD, RDD, and NMRD before leaving the clearance area (i.e., grid, transect
- The UXO TL will determine whether the MPPEH, once visible, is MEC and notify the SUXOS and UXOSO. MPPEH that is not inspectable will be treated as MEC, as discussed in the Work Plan.
- The SUXOS will make the final identification of any suspected MEC.
- The SUXOS and UXOSO will make a joint decision on the acceptable to move determination. The two must be in agreement with the decision, and it will be documented.
- If an MEC/MPPEH is determined by the SUXOS and UXOSO to be unsafe to move, it will be blow in place (BIP) or may be moved remotely after all appropriate precautions have been taken. MEC will not be left unsecured in the field at any time. Notifications to the client, Ordnance and Explosives Safety Specialist or equivalent and PM will be made as outlined in the Work Plan.
- Protective works will be implemented as described in the explosive safety documents for BIPs
- If MEC is not intact upon discovery (i.e., exposed high explosive [HE] or filler), this will be noted on the Investigation Data Sheet & MEC Accountability Log. If the MEC/MPPEH is judged to be safe to transport, it will be placed in a container to prevent further loss of the filler and will be destroyed by detonation at a point identified in the ESS or ESP. Any HE or filler found on/in the soil will be marked with a digital global positioning system (DGPS) coordinate and logged in the TL's logbook and reported to the SUXOS and PM.
- Any suspected hazardous material (not munitions-related related) identified will be assessed on a case-by-case basis by the SUXOS and PM in consultation with the client. Hazardous material will be suspected to be hazardous if it emits a chemical odor, has caused soil staining, or is contained in a drum or other container commonly used (or marked) for storage of hazardous materials. If any doubt, materials will be reported for further investigation.

3.4 MEC/MPPEH AND MDAS

MPPEH identified as MEC [i.e., UXO, discarded military munitions (DMM), recovered bulk explosive, or Munitions Constituents (MC)] will be disposed of via detonation in-situ or relocated to a collection point. MEC/MPPEH will dispose of individually or as part of a consolidated shot, the day they are found, using a same-day donor explosives delivery service or guarded until disposal can be conducted. MEC Management and Disposal SOP addresses how MEC/MPPEH is transported.

MEC/MPPEH will be tracked/documented from discovery to final disposal in an accountability log.

Materials that cannot be certified and verified as inert (either following demolition disposal or otherwise) will have demolition activities performed on them again. MEC/MPPEH certified as explosive-free (materials documented as safe [MDAS]) will be managed and recycled as scrap metal following the MPPEH and MDAS Management SOP.

4.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 INPUT DATA REQUIRED

No data other than the Geographic Information System (GIS) files are required to perform surface sweep/clearance operations.

4.2 OUTPUT DATA

The primary output from this SOP is the MEC/MPPEH, MD, RDD, and NMRD quantities that are recovered during the operation and its location and identifying information.

5.0 QUALITY CONTROL

Quality Control (QC) for this SOP will be achieved through three-phase of control of the definable features of work (DFW), completion of the QC Checklist for Surface Sweep/Clearance Operation (Section 5.3), and performance metrics identified in the plans are met. The checklist will be filled out and signed by the on-site quality lead or designee upon completion of unit of production.

When surface sweep/clearance using hand-held instruments is the remedy, coverage seeds placement and measurement quality objectives (MQOs) developed by the project team will be followed. EM200-1-15 does not recognize a surface clearance or sweep as a final remedy.

5.1 MEASUREMENT QUALITY OBJECTIVES

The MQOs for Surface Sweep/Clearance Operations are presented in the project plans. Results will be documented in the daily quality control report.

5.2 REPORTING

Input to the project MEC/MPPEH Accountability Log and disposal records are the only reporting output from this SOP.

5.3 QC CHECKLIST FOR SOIL SURFACE SWEEP/CLEARANCE

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	**UXO SOP**	Have personnel read and signed the workers' statement?				
2	**UXO SOP**	Has the equipment been checked out, and is it documented correctly?				
3	**UXO SOP**	Have the appropriate MQOs been achieved for Surface Sweep/Clearance?				
4	**UXO SOP**	Were all seeds (if instituted) placed and recovered?				

FINDINGS

Item	Comments

Signature:

UXOQCS or Designee: ______________________ **Date:** ____________

TETRA TECH

UXO SOP for Intrusive Investigation

RECORD OF DEVELOPMENT, REVIEW, VALIDATION AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct Intrusive Investigation Operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Technical Operations and Explosives Safety. SOPs will be reviewed annually.

Director Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	4/24/2020
Director, Technical Operations & Explosives Safety Patrick Tatman	P. Tatman	Date:	6/23/2020

Review Date	Reviewer	Next Review
11/9/2020	Added new paragraph 3.2.3.1, Mag and Flag/Eugene Mikell	As required

WORKER'S STATEMENT

I have read UXO SOP – Intrusive Investigation Clearance Operations and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

TABLE OF CONTENTS

1.0 PURPOSE AND SCOPE

The purpose of this Standard Operating Procedure (SOP) is to provide procedures and technical guidance for the Intrusive Investigation Operations to include surface clearance at designated munitions response sites. These operations include:

- Surface Clearance
- Mag and Flag Operations
- Mag and Dig Operations
- Target Investigations as a result of geophysical data collection

All training on equipment or software will be either formal or on-the-job training (OJT). This training will be documented by site personnel and subject to review for accuracy and completeness. The Unexploded Ordnance (UXO) Quality Control Specialist (UXOQCS) will verify training is complete and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials that may be required to implement this activity.

2.1 PERSONNEL

The following individuals or vendors may be involved in Surface Sweep/Clearance activities:

- Geophysical Personnel
- UXO Personnel

2.2 EQUIPMENT

- Personal protective equipment outlined in the Activity Hazard Analysis (AHA)/Job Safety Analysis (JSA)
- Geophysical or metal-detector instruments
- Global positioning system (GPS) or real-time surveying (RTS) positioning units
- Computers/Tablets
- Cameras
- Marking flags or ribbon
- Utility or Passenger Vehicles
- First-aid kit
- Fire extinguisher

3.0 PROCEDURES AND GUIDELINES

The Senior UXO Supervisor (SUXOS), UXO Safety Officer (UXOSO), and UXO Team Leader (TL) will review the site terrain and determine the best approach for intrusive investigation operations. Any inaccessible locations will be documented in the field logbook.

3.1 EQUIPMENT SET-UP

Materials or equipment received at the site will be inspected for serviceability and against purchase order requirements or operations manuals. Photos will be taken and filed with the daily quality control reports, the quality receipt inspection report (QRIR) or equivalent record.

Analog metal detector sensors will be assembled with fully charged batteries and tested for functionality at an Instrument Test Strip (ITS) prepared under the direction of the UXOQCS. The test strips will include a collection of Industry Standard Objects (ISO) buried at depths and orientations defined in the Quality Assurance Project Plan (QAPP) or equivalent planning document. This will simulate the size and depth of the targets expected at the project site. Sensors will be tested at the ITS prior to beginning operations each day and the results recorded in the team logbook or on forms. All tests will be reported to the UXOQCS for inclusion in the daily report.

Geophysical sensors (EM61) will be assembled and operated in accordance with the appropriate SOPs. GPS or RTS positioning systems will be assembled and operated in accordance with the appropriate civil survey SOP. This includes daily equipment checks and data recordings as appropriate to their use in support of Intrusive Investigations.

Cameras will have video cards and batteries checked.

All tests will be reported to the UXOQCS for inclusion in the daily report.

3.2 OPERATIONS

3.2.1 General Safety

The most pertinent rules for handling munitions and explosives of concern (MEC) are summarized below:

- Assume munitions contain a live charge until determined otherwise.
- Avoid inhalation of and skin contact with smoke, fumes, and vapors of explosives and related hazardous materials.
- Consider munitions that have been exposed to fire or detonation as extremely hazardous. Chemical and physical changes may have occurred to the contents, which can render them much more sensitive than their original state (e.g., changes to the condition of the fuze or explosives).
- Make every effort to identify the munitions. Carefully examine the munition for markings and other identifying features such as shape, size, and external fittings. Do not move the suspected munition until it is identified and confirmed safe to move by the SUXOS and UXOSO.
- Plan for, provide, and know the measures to be taken in the event of an accident.
- Provide a designated emergency vehicle in the area in case of an accident or an emergency.

- Do not handle, use, or remain near explosives during the approach or progress (within 10-miles) of an electrical storm. All personnel will shelter as identified in the Accident Prevention Plan (APP) or as directed by the UXOSO.
- Only allow essential personnel to be present near the munitions.
- Always base operations on minimum exposure consistent with efficient operations.
- Do not rely on the color-coding of MEC for positive identification of contents. Munitions having non-existent, incomplete, or improper color codes may be present.
- Avoid the area forward of the ammunition's nose until it can be determined that the item is not a shape-charge or high-explosive anti-tank round. The explosive jet can be fatal to great distances forward of the item's longitudinal axis. Assume any shape-charge munitions contain a piezoelectric fuzing system until the fuzing is otherwise identified. Piezoelectric fuzes are extremely sensitive, can fire at the slightest physical change, and may remain hazardous for an indefinite period.
- Approach an unfired rocket motor from the side. Ignition will create a moving projectile hazard and hot exhaust. Do not allow electrically fired rocket motors within 25 feet of any exposed electronic transmitting equipment or antenna leads.

3.2.2 Daily Briefing

After arriving at the worksite, the SUXOS or designee will conduct a tailgate operations/safety meeting at the work location. The UXOSO or designee will brief the teams on potential hazards in the area and operations conducted during the shift and review the AHA/JSA for the task. The SUXOS will assign selected worksites to each of the UXO teams for intrusive investigation.

The TL will ensure hand-held instruments, GPS, communications equipment, safety gear or other equipment is function checked and serviceable before beginning field operations. The checks will be documented in team logs or on forms.

3.2.3 Intrusive Operations

3.2.3.1 Mag and Flag Operations

The general process for mag and flag operations are:

- The government will be afforded time prior to analog operations for seeding.
- The TL will take a photograph of the area to be cleared once the ropes are setup. This photograph will serve as evidence in proper setup
- The TL will assign lanes to each team member. The TL will document the person assigned to each lane, the start time, stop time, and distance of each lane or transect worked by team member. This information can be recorded on grid sheets or the team logbook.
- For mag and flag operations, lay ropes, lines, or any means to establish a search area within the grid or transect. It will be the TLs discretion to determine the width of the search lanes based on the anomaly density.
- Guide on the lines while walking forward slowly down the search lane sweeping the head of the analog sensor smoothly from side to side;
- Ensure the sensor head exceeds the width of the search lane;

- A wide head electromagnetic analog sensor requires an overlap of one-half the width of the head to perform an effective search. The sensor head must be parallel to the ground surface. Keep the head close to the ground;
- A small head magnetic sensor such as a Schonstedt, requires a sweep spacing of six inches or less depending on the smallest munitions anticipated at the site;
- The sensor head must be kept at a constant height throughout the sweep;
- Each pass across a search lane should take 2-3 seconds;
- Mark and document the location for every anomaly detected that is consistent with the smallest munition anticipated at the site;
- Do not be deceived by a dull or low volume signal from a sensor. Deep targets do not necessarily produce a loud or sharp signal;
- Continue the process until the assigned area/lane is complete.
- TLs will verify lane or grid sheets/personal digital assistant (PDA) are filled out correctly, are complete, and correct.

3.2.3.2 Mag and Dig Operations

The general intrusive investigation procedures for mag and dig operations are:

- For mag and dig operations, lay ropes, lines, or any means to establish a search area within the grid or transect. It will be the TLs discretion to determine the width of the search lanes based on the anomaly density.
- Guide on the lines while walking forward slowly down the search lane sweeping the head of the analog sensor smoothly from side to side;
- Ensure the sensor head exceeds the width of the search lane to slightly overlap the adjacent lane;
- A wide head electromagnetic analog sensor requires an overlap of one-half the width of the head to perform an effective search. The sensor head must be parallel to the ground surface. Keep the head close to the ground;
- A small head magnetic sensor such as a Schonstedt, requires a sweep spacing of six inches or less depending on the smallest munitions anticipated at the site;
- The sensor head must be kept at a constant height throughout the sweep;
- Each pass across a search lane should take 2-3 seconds;
- Investigate every anomaly detected that is consistent with the smallest munition anticipated at the site;
- Do not be deceived by a dull or low volume signal from a sensor. Deep targets do not necessarily produce a loud or sharp signal;
- Define the extent of the anomaly using the analog sensor;
- Technicians may use a non-sparking probe if soil conditions permit;
- Using a shovel, trowel or other suitable tool, remove soil in small amounts from the side of the anomaly and work inward toward the anomaly;
- Once the anomaly is uncovered characterize and recover it as described in this SOP;
- Recheck the excavation with the analog sensor and continue clearing the anomaly if necessary;

- When restarting the sweeping activity, back up a foot and begin sweeping this should ensure that no residual target is present in the excavation;
- Backfill any excavation after completing documentation unless otherwise instructed; and
- Continue the process until the assigned area/lane is complete.
- TLs will verify dig sheets/personal digital assistant (PDA) are filled out correctly, are complete, correct, standardized nomenclature is used, and no-finds are listed. MEC requires positive identification on the dig sheet. Gross weight of material documented as safe (MDAS) per grid is documented separately. Location and depth of item is recorded.
- Blind seed items (BSIs) must be recovered and correctly identified/documented.

3.2.3.3 DGM Target Investigation

The specific intrusive investigation procedures for digital geophysical mapping (DGM) target investigations are:

- The selected targets from the DGM data are marked with non-metallic flags using the appropriate positioning system;
- Each target flag will be investigated to the radius and depth defined in the work plan by passing the analog sensor over the surface of the ground and then investigating all contacts identified within the search radius. The search radius may be extended by the geophysical data processor and noted in the dig sheet.
- After prosecution of the target to the extent required, the EM61 or analog metal detector will be used to verify the remaining signature is less than the threshold criteria selected for the project. Once complete the flag should be bent to indicate a completed target.

Upon completion of the target clearance, all munitions debris (MD), radiological dispersal devices (RDD) and non-munition related debris (NMRD) will be 100% inspected by a UXO Technician II and a UXO Technician III before it is removed from the grid to ensure it is free of explosive hazards. If MEC/ material potentially presenting an explosive hazard (MPPEH) is found it will be left in-place, clearly marked, and the UXO Technician III will notify the SUXOS and UXOSO.

The TL will photograph all MEC/MPPEH and record as much information as possible in the Team Leader's logbook or in the PDA. Recorded data includes nomenclature (if known), type (projectile, mortar, rocket, etc.), size, physical condition, fuzed or unfuzed and fuze type by function (point detonating, mechanical time, etc.), condition (fired or unfired, armed or unarmed), filler if known, GPS coordinates.

All MD, RDD, and NMRD will be brought to the central consolidation point for SUXOS and UXOQCS or government representative inspection. See SOP for MPPEH and MDAS Management.

All project records will be returned to the SUXOS or project data manager at the end of the day

3.2.4 Collection Points

Collection points allow for temporary accumulation of recovered MEC/MPPEH that are acceptable to move to another area for storage or destruction. The net explosive weight, location, and separation distances between the collection point will be identified in the explosive safety documents. No MEC/MPPEH will be transported from one munitions response site to another.

3.2.5 Field Communication

When feasible, handheld radios will be used for any required communications between the UXO teams and the site office/site management personnel. The site office will relay all required communication to other on-site personnel using established radio links or by telephone/cell phone. Applicable telephone numbers can be found in the APP/SSHP. Additionally, these will be posted in the site office and placed in all site vehicles. If necessary, a radio base station or repeaters will be used to ensure reliable communications across the site.

3.3 MPPEH CHARACTERIZATION

Refer to the specific SOP for full details on MPPEH characterization.

- The first person who discovers the MPPEH will conduct the initial classification (MEC, MD, RDD, NMRD). If the person is a UXO Tech I he will have a UXO Tech II or higher verify the classification. UXO Sweep personnel will never touch or move MPPEH until directed by a UXO Tech II or higher.
- The UXO Tech III (UXO TL) will inspect all MD, RDD, and NMRD before leaving the clearance area (i.e., grid, transect
- The UXO TL will determine whether the MPPEH, once visible, is MEC and notify the SUXOS and UXOSO. MPPEH that is not inspectable will be treated as MEC, as discussed in the Work Plan.
- The SUXOS will make the final identification of any suspected MEC.
- The SUXOS and UXOSO will make a joint decision on the acceptable to move determination. The two must be in agreement of the decision and it will be documented.
- If an MEC/MPPEH is determined by the SUXOS and UXOSO to be unsafe to move, it will be blow in place (BIP) or may be moved remotely after all appropriate precautions have been taken. MEC will not be left unsecured in the field at any time. Notifications to the client, Ordnance and Explosives Safety Specialist or equivalent and PM will be made as outlined in the Work Plan.
- Protective works will be implemented as described in the explosive safety documents for BIPs
- If MEC is not intact upon discovery (i.e., exposed high explosive [HE] or filler), this will be noted on the Investigation Data Sheet & MEC Accountability Log. If the MEC/MPPEH is judged to be safe to transport, it will be placed in a container to prevent further loss of the filler and will be destroyed by detonation at a point identified in the Explosive Safety Plan (ESS) or Explosives Safety Plan (ESP). Any HE or filler found on/in the soil will be marked with a digital global positioning system (DGPS) coordinate and logged in the TL's logbook and reported to the SUXOS and Project Manager (PM).
- Any suspected hazardous material (not munitions-related related) identified will be assessed on a case-by-case basis by the SUXOS and PM in consultation with client. A hazardous material will be suspected to be hazardous if it emits a chemical odor, has caused soil staining, or is contained in a drum or other container commonly used (or marked) for storage of hazardous materials. If any doubt, materials will be reported for further investigation.

3.4 MEC/MPPEH and MDAS

Refer to the specific SOP for full details on MEC/MPPEH and MDAS disposal.

MPPEH identified as MEC [i.e., UXO, discarded military munitions (DMM), recovered bulk explosive, or Munitions Constituents (MC)] will be disposed of via detonation in-situ or relocated to a collection point. MEC/MPPEH will disposed of individually or as part of a consolidated shot, the day they are found, using a same-day donor explosives delivery service or guarded until disposal is able to be conducted. MEC Management and Disposal SOP addresses how MEC/MPPEH is transported.

MEC/MPPEH will be tracked/documented from discovery to final disposal in an accountability log.

Materials that cannot be certified and verified as inert (either following demolition disposal or otherwise) will have demolition activities performed on them again. MEC/MPPEH certified as explosive-free (materials documented as safe) will be managed and recycled as scrap metal in accordance with the MPPEH and MDAS Management SOP.

4.0 DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 INPUT DATA REQUIRED

No data other than sensor user manuals and target location Geographic Information Systems (GIS) files are required to perform intrusive operations.

4.2 OUTPUT DATA

The primary output from this SOP is the quantities and locations of MEC/MPPEH and the amounts of MD, RDD, and NMRD recovered that are recovered. Secondary outputs include equipment inspection records and daily quality reports.

5.0 QUALITY CONTROL

QC for this SOP will be achieved through three-phase of control of the Definable Feature of Work (DFW), completion of the QC Checklist for Intrusive Investigation Operation (Section 5.3), and performance metrics identified in the plans are met. The checklist will be filled out and signed by the onsite quality lead or designee upon completion of unit of production.

5.1 MEASUREMENT QUALITY OBJECTIVES

The Measurement Quality Objectives (MQOs) for Intrusive Investigation Operation are presented in the project plans. Results will be documented in the daily quality control report.

5.2 REPORTING

Input to the project MEC/MPPEH Accountability Log and disposal records are the only reporting output from this SOP.

5.3 QC CHECKLIST FOR INTRUSIVE INVESTIGATIONS

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	UXO SOP	Have personnel read and signed the workers' statement?				
2	UXO SOP	Has the equipment been checked out and is it documented correctly?				
3	UXO SOP	Have all intrusive results been fully and appropriately documented?				
4	UXO SOP	Have the appropriate MQOs been achieved for Intrusive Investigation?				
5	UXO SOP	Were all seeds (if instituted) recovered?				

FINDINGS

Item	Comments

Signature:

UXOQCS or Designee: ______________________ Date: ______________

TETRA TECH

UXO SOP MPPEH and MDAS Management and Disposal

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct MPPEH and MDAS management and disposal operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Technical Operations and Explosives Safety. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director, Technical Operations & Explosives Safety Patrick Tatman	P. Tatman	Date:	6/23/2020

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read UXO SOP – MPPEH and MDAS Management and Disposal and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

TABLE OF CONTENTS

1.0 PURPOSE AND SCOPE

The purpose of this standard operating procedure (SOP) is to provide procedures and technical guidance for material potentially presenting an explosive hazard (MPPEH) inspection, management, safety, security and chain of custody (CoC) certification during munitions response activities. This applies to all Tetra Tech Unexploded Ordnance (UXO) Technicians involved in the inspection and management process for certifying MPPEH as material documented as safe (MDAS) before transfer within or release from U.S. Department of Defense (DOD) control.

This SOP is not a stand-alone document and should be used together with the Quality Assurance Project Plan (QAPP) or equivalent planning documents, other Tetra Tech SOPs, applicable Federal, State, local regulations, and contract restrictions and guidance.

All training on equipment or software will be either formal or on-the-job training (OJT). Training will be documented by site personnel and subject to review for accuracy and completeness. The UXO Quality Control Specialist (UXOQCS) will verify training is completed and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 PERSONNEL

The following individuals may be involved in MPPEH and MDAS Management and Disposal activities:

- Senior Unexploded Ordnance Supervisor (SUXOS)
- UXOQCS
- Unexploded Ordnance Safety Officer (UXOSO)
- UXO Technicians, Levels III, II, and I
- Government or third-party Quality Assurance personnel

2.2 EQUIPMENT

- MDAS containers (e.g., 55-gallon drums, 20yd roll-off, etc.)
- Unique Numbered Seals
- Expray Kit
- Logbook and/or PDA for recording data
- Bottled water
- Camera
- Communications equipment
- First-aid kit
- Level D personal protective equipment (PPE)
- Fire extinguisher

3.0 PROCEDURES AND GUIDELINES

3.1 UXO TECHNICIAN RESPONSIBILITIES AND PROCEDURES

The objective of the following procedures is to ensure that an inspection of the exterior and interior surfaces of all recovered MPPEH is safely conducted to ensure these items do not present an explosive hazard and are not transferred from DOD or Tetra Tech custody.

3.1.1 Unexploded Ordnance Sweep Personnel (UXOSP)

Will only mark suspected MPPEH and will not be allowed to perform any assessment of a suspect MPPEH to determine its status.

3.1.2 UXO Technician I

Can tentatively identify a located material as MPPEH confirmation by a UXO Technician II or III.

3.1.3 UXO Technician II

Will perform a 100 percent inspection of each piece of MPPEH as it is recovered and determine the following:

a. Is the MPPEH MEC, munitions debris (MD), range-related debris (RRD) or is non-munition related debris (NMRD)?

b. Does the MPPEH contain explosives hazards or other dangerous fillers?

c. Does the MPPEH/MEC require detonation?

d. Does the MPPEH/MEC require demilitarization or venting to expose dangerous fillers of cavities not inspectable?

e. Does the MPPEH require removal of batteries, mercury seals, or switches; the draining of engine fluids, illuminating dials, and other visible liquid hazardous, toxic, or radiological waste (HTRW) materials?

Will segregate material MPPEH requiring demilitarization or venting procedures from those items ready for certification.

Will process any MPPEH found to contain explosives hazards or other dangerous fillers following applicable UXO SOP – MEC Management and Disposal.

3.1.4 UXO Technician III:

Will perform a 100 percent re-inspection of all reclassified MPPEH to determine if free of explosives hazards or other dangerous fillers and engine fluids, illuminating dials, and other visible liquid HTRW materials.

Will supervise detonation of MEC/MPPEH found to contain explosive hazards or other dangerous fillers and venting/demil procedures.

Will supervise the consolidation of inspected MPPEH for containerization and sealing. MD and RRD or NMRD will be segregated.

3.1.5 UXO Quality Control Specialist (UXOQCS)

Will conduct daily audits of the procedures used by UXO teams and individuals for processing MPPEH.

Will perform and document random sampling (by pieces, volume, or area) of all MPPEH collected from the various teams to ensure no MD, RRD, or NMRD contains and explosive hazard, engine fluids, illuminating dials, and other visible liquid HTRW.

The UXOQCS will sign as the verifier on the DD Form 1348-1 in the absence of a government representative.

3.1.6 UXO Site Safety Officer (UXOSO)

Will ensure the specific procedures and responsibilities for processing MPPEH for certification as MD or RRD specified in the work plan are being followed.

Will ensure all procedures for processing MPPEH are being performed safely and consistent with applicable regulations.

3.1.7 SUXOS:

Will be responsible for ensuring work and Quality Control (QC) plans specify the procedures and responsibilities for processing MPPEH for final disposition as MD or RRD.

Will ensure a Requisition and Turn-in Document DD Form 1348–1A is completed for all MD and RRD to be transferred for final disposition.

Will perform a final 100 percent re-inspection of all recovered MPPEH to certify that they are free of explosives hazards or other dangerous fillers and engine fluids, illuminating dials, and other visible liquid HTRW material necessary to complete the DD Form 1348–1A.

Will be responsible for ensuring that inspected debris is secured in a closed, labeled, and sealed container and documented as follows:

a. The container will be closed and clearly labeled on the outside with the following information: The first container will be labeled with a unique identification that will start with the applicable DOD component/Installation Name/Tetra Tech/0001/Seal's unique identification and continue sequentially.

b. The container will be closed in such a manner that a seal must be broken to open the container. A seal will bear the same unique identification number as the container, or the container will be clearly marked with the seal's identification if different from the container.

c. Tetra Tech will provide a documented description of the container with the following information for each container: contents, weight of the container, location where munitions or RRD was obtained, name of the contractor, names of certifying and verifying individuals, unique container identification, and seal identification, if required.

Will establish a secure location for the collection, processing, and storage of MD, RRD, and NMRD until transferred off-site.

All acceptable to move MEC or MPPEH will be stored in a magazine or secured until disposal.

3.2 MD CERTIFICATION AND CONTAINERIZATION

MPPEH procedures will be per DOD Instruction 4140.62, EM 385-1-97 or OP-5. All MPPEH will be assessed and its explosive safety status determined and documented before transfer within the DOD or release from DOD control. Before release to the public, MPPEH will be documented by personnel who are authorized in writing and technically qualified to certify or verify MDAS after a 100 percent inspection, and an independent 100 percent re-inspection to ensure that it is safe from an explosive perspective. The following certification and verification procedures will be followed for material suspected or determined as MPPEH:

- The SUXOS will certify that the debris is free of explosives hazards.
- The UXOQCS or similarly trained individual in the absence of a government representative will verify that the debris is free of explosive hazards.

- DD Form 1348–1A Issue Release/Receipt Document will be used as the certification/verification documentation. The DD Form 1348–1A must clearly show the names and contact numbers of the SUXOS and the UXOQCS, similarly trained UXO-qualified individual or Government representative and will be completed with the following information:

  Block 2: Site Address

  Block 3: Address where the MDAS will be shipped to

  Block 5: Document date

  Block 8: Cargo type (MDAS or NMRD – non-munitions related debris)

  Block 9: Mandatory Entry - Enter "U" if Unclassified material. For more Controlled Inventory Item Codes (CIIC) see DOD 4100.39-M, Volume 10, Chapter 4, Table 61.

  Block 10: Actual quantity received. Entered by Receiver

  Block 11: Number of items for this unit. Enter "1" if only one container is listed on the form.

  Block 12: Enter the weight of the container listed on the form

  Block 15: Mandatory Entry – Enter "0" for No Shelf-life. For more codes see DOD 4100.39-M Volume 10, Chapter 4, Table 50

  Block 16: Leave blank for the transport company

  Block 17: Basic material content such as Material Documented as Safe or Non-Munitions Related Debris with the type of metal (steel or mixed)

  Block 18: Type of container

  Block 19: Number of containers that make up the shipment

  Block 20: Total weight of all containers that make up the shipment

  Block 22: Signature of receiver

  Block 23: Date received

  Block 24:

  - Site Name
  - Site Location
  - Company name
  - Contract Number

  Block 25: Container number - DOD component/Installation Name/Tetra Tech/0001/Seal's unique identification

Block 26:

- The following certification/verification will be entered on each DD Form 1348–1A for MD or RRD transferred within or release from DOD control and will be signed by the SUXOS and the UXOQCS, a similarly trained UXO-qualified individual or Government representative. This statement will be used on any ranges where range related debris is to be processed along with MD:

  "This certifies that the material listed has been 100 percent properly inspected and, to the best of our knowledge and belief, are free of explosive hazards, engine fluids, illuminating dials, and other visible liquid HTRW materials."

- The following certification/verification will be entered on each DD Form 1348–1A for turnover of MD and will be signed by the SUXOS and the UXOQCS, similarly trained UXO-qualified individual or Government representative where only munitions debris is being processed:

  "This certifies and verifies that the material listed has been 100 percent inspected and, to the best of our knowledge and belief, are inert and/or free of explosives or related materials."

Block 27: Signature Block for both the SUXOS and UXOQCS containing:

- Certified by: SUXOS Name / Verified by: UXOQCS Name or other verifier
  Tetra Tech (OU Name Here), Munitions Response Services
  Applicable OU Address
  Home Office: XXX-XXX-XXXX
  SUXOS phone number / UXOQCS phone number or other verifier
  Signature of SUXOS / Signature of UXOQCS or other verifier

Upon receipt of the material identified on the DD Form 1348–1A, the PM is responsible for ensuring the following blocks are completed by the qualified recycler:

- Block 10: Quantity of material receive;
- Block 22: Signature; and
- Block 23: Date.

3.3 MAINTAINING CHAIN OF CUSTODY AND FINAL DISPOSITION

Tetra Tech will arrange for maintaining the chain of custody and final disposition of the certified and verified materials. The certified and verified material will be released only to an organization that will:

A. Upon receiving the unopened labeled containers, each with its uniquely identified and unbroken seal ensuring a continued chained of custody, and after reviewing and concurring with all the provided supporting documentation, the receiving vendor will sign for having received and agreeing with the provided documentation that the sealed containers contained no explosive hazards upon receipt. This will be signed on company letterhead that states the contents of these sealed containers will not be sold, traded, or otherwise given to another party until the contents have been smelted and are only identifiable by their basic content.

B. ***Send notification and supporting documentation to the sealed container-generating contractor documenting the contents of the sealed containers have been smelted and are now only identifiable by their basic content.***

C. ***If the chain of custody is broken, the affected shipment must undergo a 100 percent inspection, a second 100 percent re-inspection, and be documented to verify its explosives safety status.***

MDAS is no longer considered MPPEH as long as the chain of custody remains intact. A legible copy of the inspection, re-inspection, and documentation must accompany the material through final disposition and be maintained thereafter for three years.

4.0 QUALITY CONTROL

The MPPEH and MDAS Management and Disposal operations will meet the QC metrics outlined within the QAPP or equivalent planning document and the Compliance Checklist in this SOP.

The UXOQCS will verify the quality of the task through the three-phase of control and document the results as described in the QAPP or equivalent planning documents. Any tasks the UXOQCS determines not to meet the QC metrics will be considered deficient or non-conforming. If a deficiency or nonconformance occurs, the UXOQCS will prepare a Deficiency Report or Nonconformance Report.

4.1 QC CHECKLIST: MPPEH/MDAS MANAGEMENT AND DISPOSAL

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

Item	Ref.	Inspection Points	Yes	No	N/A	Comments
1	SOP	Have all personnel read and signed the workers' statement?				
2	SOP	Do all personnel performing this DFW meet the minimum qualifications required?				
3	SOP	Have all personnel performing this DFW been trained on this SOP, and is it documented?				
4	SOP	Have the teams been provided maps of the overall project site and evacuation routes?				
5	SOP	Are all equipment and materials required to perform the DFW inspected, available on-site, and is it documented?				
6	SOP	Was each received container marked as MPPEH or MDAS, sealed and contained in a cleared area?				
7	SOP	Is the PPE serviceable and worn properly?				

FINDINGS

Item	Comments

Conducted By: ______________________ **Reviewed By:** ______________________

TETRA TECH

UXO SOP for MEC Management and Disposal

RECORD OF DEVELOPMENT, REVIEW, VALIDATION, AND APPROVAL

This Standard Operating Procedure (SOP) contains the procedures by which Tetra Tech, Inc will conduct MEC Management and Disposal operations for munitions response projects. Any changes or deviations will be included in the project plans and approved by the Director of Technical Operations and Explosives Safety. SOPs will be reviewed annually.

Director, Health, Safety, & Environmental Jim Streib, CSP, SMS, CQA, CHST		Date:	
Director, Technical Operations & Explosives Safety Patrick Tatman		Date:	6/23/2020

Review Date	Reviewer	Next Review

WORKER'S STATEMENT

I have read UXO SOP MEC Management and Disposal and received the training necessary to demonstrate my capability to perform the procedures addressed in this SOP. If I identify a hazard not addressed in this SOP or encounter an operation I cannot perform in accordance with this SOP, I will stop the process and notify my immediate supervisor.

Worker's Name	Date	Supervisor's Name	Date

TABLE OF CONTENTS

1.0 PURPOSE AND SCOPE

This Standard Operating Procedures (SOP) provides Munitions and Explosive Concern (MEC) management and basic explosive demolition procedures for the treatment of MEC and material potentially presenting material potentially posing an explosive hazard (MPPEH) found during the MEC activities on Munitions Response Site (MRSs). These procedures will be conducted in accordance with the Quality Assurance Project Plan (QAPP) or equivalent planning documents.

This SOP provides the detailed information needed to safely configure, conduct demolition procedures, and perform post demolition inspection and area restoration. These operations include:

- Documenting the recovery, accountability, and management of MEC/MPPEH
- Conducting disposal operations involving MEC/MPPEH
- Post disposal operations

All training on equipment or software will be either formal or on-the-job training (OJT). Training will be documented by site personnel and subject to review for accuracy and completeness. The Unexploded Ordnance (UXO) Quality Control Specialist (UXOQCS) will verify training is completed and documented.

2.0 PERSONNEL, EQUIPMENT, AND MATERIALS

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 PERSONNEL REQUIREMENTS

Explosive demolition operations require specific organizational roles and personnel assignments, specifically:

- Senior Unexploded Ordnance Supervisor (SUXOS), to oversee all demolition operations.
- Demolition Supervisor (DS), an Unexploded Ordnance (UXO) Technician Level III or above, designated by the SUXOS. The DS is responsible for planning, directing, and executing all demolition operations. The SUXOS may perform duties of the DS based on the project manning.
- Unexploded Ordnance Safety Officer (UXOSO), ensures that all demolition operations are performed safely and following the approved site-specific plans.
- Two Unexploded Ordnance Technicians Level II or I, designated to assist the DS.

2.2 EQUIPMENT

The Demolition teams conducting MEC management and disposal tasks will be equipped with the following:

- Analog Geophysical Sensor
- Disposal equipment
- Donor explosives
- Logbook and/or personal digital assistant (PDA) for recording data
- Camera

3.0 PROCEDURES AND GUIDELINES

3.1 MEC/MPPEH MANAGEMENT

When MEC and MPPEH are discovered, they are inspected and positively identified using a three-tiered inspection process while the munitions are left in place.

1. Inspected first by the UXO technician discovering the munition(s) to determine if it is MEC or MPPEH,
2. Second by a UXO Tech II to independently classify the munitions(s), and
3. Third by the UXO Tech III, Team Leader.

For MEC/MPPEH, the SUXOS and UXOSO must assess and agree that the risk associated with the movement of MEC or suspected munition is acceptable and necessary. They will document the decision in writing. If necessary, the Director of Technical Operations and Explosives Safety will be consulted and concur with the decision to move the ordnance. Based on knowledge of the site, this may be accomplished before field operations beginning.

If MEC/MPPEH are determined by the SUXOS and UXOSO to be unacceptable to move, they will be conspicuously marked, secured, and scheduled for Blow-in-Place (BIP) treatment by a demolition team.

All MEC shall be secured or guarded by a UXO technician or approved security personnel until demolition operations.

All MEC will be photographed, and as much information as possible will recorded on the dig sheet or PDA. Recorded data to include nomenclature (if known), type (projectile, mortar, rocket, mine, etc.), size, physical condition, fuzed or unfuzed, fuze type by function (e.g., point detonating, mechanical time, etc.), condition (e.g., fired or unfired, armed or unarmed), filler if known, Global Positioning System (GPS) coordinates (if different from the relocated position) and depth.

3.2 NOTIFICATIONS

The SUXOS will ensure that the agencies responsible for emergency response are notified as far in advance as possible that demolition activities will be taking place. The notifications should address scheduling, evacuations, road closures, exclusion zones (EZs), and any other required support. Table 1 provides a list of emergency telephone numbers and contacts.

Table 1: Emergency Contact Numbers

Contact	Phone Number
Fire Department	
EMS	
Police	
FAA	
Base Operations	
Anyone else not listed….	

3.3 EXCLUSION ZONES, ENGINEERING CONTROLS, AND ROAD CLOSURES

Engineering controls should be employed whenever possible to minimize the damage from demolition operations. These controls may consist of sandbags, ecology blocks, trenching, buttressing, taping of glass, mounding, flooding and/or venting to reduce the effects of detonations.

The SUXOS will ensure EZ barricades are set up with signs at all access roads and marked appropriately: Danger, UXO Remediation Project in Progress, DO NOT ENTER, and list contact information on the barricade sign.

3.4 WEATHER AND ENVIRONMENTAL CONSIDERATIONS

Before commencing demolition operations, the SUXOS or UXOSO will obtain a local weather report.

Demolition operations will not be conducted if electrical storms are within 10 miles of the demolition site or during severe weather conditions that would impact safety.

The SUXOS and UXOSO will decide on whether wind speed and visibility will hamper the safe execution of demolition operations.

3.5 FIRE SUPPORT

The telephone number of the responding fire departments will be posted in plain sight at the site office and the disposal site.

The Fire Department nearest the disposal site location will be notified of disposal operations each day.

When the fire hazard is high due to dry conditions, disposal operations will not be conducted unless mobile fire-fighting equipment is standing by and the fire department is capable of responding within five (5) minutes.

Fire extinguishers, portable water tanks, and shovels will be on-site to fight small fires. Evacuate the area if the fire approaches ordnance or explosives. Do not fight grass fires in areas where there may be ordnance or kick-outs.

Conduct a fire risk assessment before conducting disposal operations to consider the type of ordnance to be disposed of, environmental conditions on the site, and appropriate preventative measures to be employed before initiation of explosive procedures.

Consider preventative measures to include: Movement of the MEC to a prepared site, if possible, ground preparation to include scraping and vegetation removal, wetting of the site just before the commencement of operations, and tamping of the shot with sand, or water.

3.6 DEMOLITION OPERATIONS

3.6.1 Demolition Briefing

The DS will brief all personnel involved in range operations in the following areas:

- General Safety Precautions
- Type of MEC or MPPEH being destroyed
- Type, placement, and quantity of demolition material being used

- Method of initiation (electric or Nonel)
- Team assignments
- Equipment being used (e.g., Remote Firing Device [RFD], galvanometer, blasting machine, firing wire, etc.)
- Misfire procedures
- Post-shot cleanup of range procedures
- Emergency procedures

3.6.2 Preparing Donor Charges for Initiation

One Pound Pentolite Booster

1. Insert the 80-grain detonating cord into the detonator well. Insert all the way through the first hole and back through the second hole, then tie an overhand knot to secure it.
2. When using more than one booster, insert the detonating cord through each of the booster's detonator wells and secure to keep it from sliding along the detonating cord.
3. Place the booster on the MEC/material documented as an explosive hazard (MDEH) using tape or other suitable material to prevent it from moving.

Jet Perforator

1. Using tape or detonating cord clips secure the detonating cord to the jet perforator.
2. Place the jet perforator on the MEC/MPPEH using tape or other suitable material to prevent it from moving.

Binary Explosives

1. Obtain part A and part B.
2. Mix per manufacturer requirements and the site where the operation will be conducted.
3. Place on item in same manner as booster and as discussed during demolition briefing.

3.6.3 Initiation Set-ups

The UXOSO will act as a safety observer during demolition set-ups and will depart the range/demolition area before the demo team priming the donor charge. He/she will maintain communications with the team, the SUXOS, and Site Field Office at all times.

A maximum of 2 people will prime the shot. All others will be located outside the EZ.

Electric Blasting Cap

- Prior to making a connection with the electric blasting cap, the firing circuit will be continuity tested.
- All parts of the firing circuit will be kept insulated from the ground or other conductors such as bare wires, rails, pipes, or other paths of stray current.
- The shunt will not be removed from the wires until the individual performing the operation has been grounded. Electric blasting caps will be connected to the firing circuit before connection to the main initiation charge.
- Electric blasting caps of different manufacturers or types will not be used in the same system.
- The electric blasting caps will be tested for continuity with a galvanometer at least 50-ft (15.2-m) downwind from any explosives before connecting them to the firing circuit. After the testing is completed, the lead

wires will be short-circuited by twisting the bare ends of the wires together. The wires will remain shunted until ready to connect to the firing circuit.

- The electrical lead wires of electric blasting caps, detonators, or other electro-explosive devices should not be pulled; detonation may occur.
- The legs should be unrolled so that the cap is as far as possible from the operator and pointing away from him before testing.
- The blasting cap will be placed in a hole, behind a barricade, or under a sandbag before removing the shunt and testing for continuity. The cap should not point toward other personnel or explosives. Always test at the extent of lead wires with ones back towards the blasting cap.
- Only authorized and serviceable testing equipment will be used.
- The remote receiver will not be connected to the firing wires until all pre-firing tests have been completed, and all preparations have been made to fire the charge.

Nonel Blasting Cap

- No testing required
- Blasting cap should be placed in a hole, behind a barricade, or under a sandbag before priming.
- The blasting cap should not point towards other personnel or explosives.

Nonel Lead Line Splicing

- Care should be taken to keep moisture from the cut end of the shock tube.
- The DS or designated UXO Technician will perform the following procedures to cut and splice the shock tube.
- Minimize the number of splices in a shock tube line to as few as possible.
- Lead Line splicing procedure as follows:
    1. Use a sharp knife or razor blade to squarely cut (at a 90-degree angle) approximately 12 inches from a new roll or the cut-off end of a partial roll.
    2. Loosely tie the two-shock tube ends to be spliced together. Leave at least 2 inches free at the end of each shock tube beyond the knot.
    3. Pull the shock tube lightly to tighten the knot, but not so tight as to significantly deform the shock tube in the knot.
    4. Use only the splicing tubes provided to make splices. Taping the two cut ends of the shock tubes together does not make a reliable splice.
    5. Push one of the free shock tubes, to be spliced, firmly into one of the pre-cut splicing tubes at least 1/4 inch.
    6. Push the other shock tube end firmly into the other end of the splicing tube at least 1/4 inch. Attempt to push the two ends up against each other or get as close as possible.

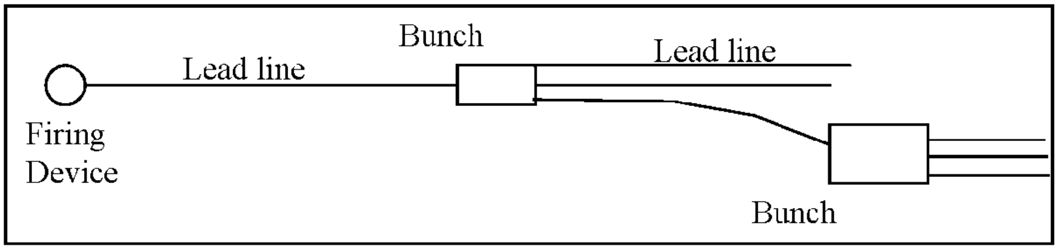
Nonel Lead Line Preparation

The DS or designated UXO Technician will perform the following procedures to set up the lead line.

1. Layout the required length of lead line from the demolition area back to the firing point.
2. Attach an EZTL 30 Bunch Block (or equivalent method) to the lead line at the demolition site using the supplied splicing tube.
3. Secure the bunch block or immobilize with sandbags.
4. Run additional lead line(s) from the bunch block to the MEC/MPPEH (see Figure 3-1).

Note: Only attach a maximum of six additional leads per bunch block. Use additional bunch blocks, if necessary.

Figure 3-1 Nonel Lead Line Setup



3.6.4 Initiation Systems

The firing system will use RFD with Nonel or electric blasting caps. As a back-up to the RFD, the Scorpion Electronic Blasting Machine with electric caps or Nonel will be used.

Remote Firing Device Preparation

1. Perform system pre-operational test and set up using the operator's manual. Remove key from controller unit until ready to fire.
2. Place the remote near the detonation site with the antenna in the vertical position. If using electric caps, the remote should be within 100 feet of the shot. Using the unit blast shield, sandbags, or natural cover to protect the remote.
3. Ensure the remote indicates a READY condition for the selected initiation method (green READY LED on steady, red ARMED LEG off).
4. If using Nonel, connect the shock tube to the igniter tip. The tube should be wrapped around through holes in the tip's molded casing to keep it from falling out. Prime the shot and return to the safe area.
5. If using electric caps, cut off a length of firing wire that will reach between the remote and the charges (100' or less).
6. Conduct a continuity check of the firing wire with a galvanometer. Shunt the free ends of the wire to prevent an electric charge from building up in the firing wire.
7. Test each electric blasting cap 50 feet downwind of other explosives with a galvanometer.
8. Place blasting caps in a hole, behind a barricade or under a sandbag before removing the shunt and testing for continuity.
9. Fully extend the leg wires and ensure the cap is pointing away from the person conducting the continuity test.
10. Secure the leg wires to prevent the cap from moving during the test.
11. Use only a special silver-chloride dry cell battery in the testing galvanometer. Other type batteries may provide sufficient voltage to fire the blasting cap.
12. Upon completion of testing, re-shunt the leg wires. The wires will remain shunted until ready to connect to the firing circuit.
13. For dual priming connect blasting caps in a parallel circuit to the extension wires.
14. Test the circuit with the Galvanometer, and then connect extension wires to the remote.
15. Retrieve caps from barricade, prime shot, and return to safe area.

Scorpion Electronic Blasting Machine Preparation

1. Perform pre-operational check as per instructions on blasting machine.
2. Layout firing wire or Nonel.
3. Conduct a continuity check of the firing wire with a galvanometer. Shunt the free ends of the wire to prevent an electric charge from building up in the firing wire.
4. Test each blasting cap with a galvanometer 50 feet downward of other explosives.
5. Place blasting caps in a hole, behind a barricade or under a sandbag before removing the shunt and testing for continuity.
6. Fully extend the leg wires and ensure the cap is pointing away from the person conducting the continuity test.
7. Secure the leg wires to prevent the cap from moving during the test.
8. Use only a special silver-chloride dry cell battery in the testing galvanometer. Other type batteries may provide sufficient voltage to fire the blasting cap.
9. Upon completion of testing, re-shunt the leg wires. The wires will remain shunted until ready to connect to the firing circuit.
10. For dual priming connect blasting caps in a parallel circuit to the firing wire.
11. Retrieve caps from barricade, prime shot, and return to safe area.

Initiation Sequence

The SUXOS or DS will ensure that the actions taken before initiating a demolition shot are completed as follows.

1. Ensure all required notifications have been made.
2. Set up EZ and post guards at the barricades.
3. Visually inspect EZ and surrounding area for unauthorized personnel.
4. **Five-minute warning**. The DS will give the five-minute warning on the radio, followed by a one-minute series of long blasts on the air-horn.
5. **One-minute warning**. The DS will give the one-minute warning on the radio, followed by a one-minute series of short blasts on the air-horn before the shot. At this time, the arming of the RFD or Blasting Machine will occur.
6. Before initiating the shot, the DS will give three loud "*Fire in the Hole!*" warnings and then give the “fire” command on the radio.

Firing the Remote Firing Device

1. Install the key and engage the "POWER" switch on the controller to the right until the BATTERY LED illuminates.
2. Momentarily depress the controller STATUS button. The yellow TRANSMIT LED will flash for approximately one second. At the end of this time, a green READY LED will come on steady, indicating that the remote is on and in the standby mode. The steady green LED also means the remote is within range of the controller.
3. Push the ARM/DISARM switch to the left and hold for one second. The red ARMED LED will flash for approximately 18 seconds then come on steady. The remote is now armed.
4. The SUXOS or DS gives three loud "Fire-in-the-Hole" warnings.
5. Then the SUXOS gives permission to fire the shot.
6. Lift the safety cover on the FIRE switch and push the FIRE switch forward.

Firing the Scorpion Electronic Blasting Machine

1. Connect the firing leads to the terminal posts of the blasting machine.
2. For Nonel plug in the shock tube adapter and attach Nonel.
3. SUXOS or DS gives three loud "Fire-in-the-Hole" warnings.
4. Then the SUXOS gives permission to fire the shot.
5. Degrees and hold CHARGE button (keep depressed throughout sequence).
6. Press DETONATE button when green ready light comes on. For non-electric shots hold DETONATE button down for one second and release.

3.6.5 Misfires

If a misfire does occur, it must be cleared with extreme caution. The responsible technician will investigate and correct the situation using the steps outlined below.

Misfire Procedures for the Remote Firing Device

1. Make three successive attempts to fire.
2. Turn off the controller and remove the key.
3. Wait 1 hour from the last initiation attempt.
4. After the wait time has elapsed, the SUXOS or DS and one other UXO technician will proceed downrange to inspect the firing system.
5. Disconnecting from RFD:
   - 5.1 If Nonel was used, do not remove the caps from the charge. Disconnect Nonel from the igniter tip on the remote firing device.
   - 5.2 If electric caps were used, remove the old blasting caps from charge and disconnect from extension wires. Shunt cap leg wires.
6. Set up new firing system.

Misfire Procedures for the Scorpion Electronic Blasting Machine

1. Make three successive attempts to fire.
2. If using firing wire and still unsuccessful disconnect wires and check continuity.
3. If continuity is good, reconnect to blasting machine and make three more attempts to fire.
4. If still unsuccessful check connections of firing wires to terminals and make three more attempts to fire.
5. Change blasting machine after third unsuccessful attempt.
6. If unsuccessful with new blasting machine disconnect and shunt firing leads.
7. If using Nonel disconnect from blasting machine.
8. Wait 1 hour from the last initiation attempt.
9. After the wait time has elapsed, the SUXOS or DS and one other UXO technician will proceed downrange to inspect the firing system.
10. Clearing the primed shot:
    - 10.1 If electric caps were used, remove the old blasting caps from charge and disconnect from firing wire. Shunt cap leg wires.
    - 10.2 If detonating cord was used cut detonating cord between cap and charge, disconnect cap from fire wire. Shunt cap leg wires.
    - 10.3 If Nonel was used, do not remove the caps from the charge. Place a new, primed explosive charge next to the misfired charge.
11. Set up new firing system.

3.6.6 Post Demolition Procedures

1. Wait the designated wait times specified by the SOP. A minimum of 5 minutes after a single shot or after a series of shots that can be counted. A minimum of 30 minutes after multiple shots that could not be counted.
2. The SUXOS or DS and one other UXO technician will return to the detonation site and check the results of the shot. If the procedure was successful, the demo supervisor will call in additional personnel to clean up the site. UXO personnel will conduct a visual sweep of the detonation site and the immediate area to gather fragments and explosive residue if present.
   - 2.1 Metal fragments will be examined to ensure complete consumption of explosive material.
   - 2.2 Explosive residue will be collected and detonated.
   - 2.3 Intact MEC items will be disposed of if they fail to detonate.
3. After the area is swept and cleared, the SUXOS or DS will notify the remaining personnel over the radio that the "All Clear" is given.
4. Backfill hole, as necessary.
5. Recover all equipment.

3.7 DOCUMENTATION

Forms and checklists should be generated and/or modified to meet site-specific requirements. The forms provided in this SOP may be used, or alternate forms containing the same information may be used. The SUXOS will make this determination. For disposal operations, the SUXOS or the UXO DS will, as a minimum, complete the following.

- General Safety Precautions
- Disposal Operations Checklist
- Explosive Disposal Log

4.0 QUALITY CONTROL

The MEC Management and Disposal operations will meet the quality control (QC) performance objectives identified in the QAPP or equivalent planning document and the attached quality control inspection checklist.

The QC team will verify the quality of the task through the three phases of the control process and document the results as described in the QAPP or equivalent planning document. Any tasks the QC team determines do not meet the quality control metrics, will be considered deficient or non-conforming. If a deficiency or nonconformance occurs, the UXOQCS will prepare a Deficiency Report or Nonconformance Report.

ATTACHMENTS

ATTACHMENT 1

DEMOLITION EQUIPMENT CHECKLIST

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DEMOLITION EQUIPMENT CHECKLIST

Equipment List

Equipment	Quantity	Comments
Explosive Vehicle(s)		
Personnel Vehicle(s)		
Digital Camera		
Air Horn		
Hand-held Radios		
Cellular Telephone(s)		
Remote Firing Device		
White XLT all-metals detector		
Shovel, round point, long handle		
Shovel, round point, short handle		
Blasting Machine		
Tape, duct		
Tape, measuring, 50- or 100-meter		
Tape, electricians, plastic		
Toolbox, general hand tools		
Galvanometer		
IME-22 container		
Knife		
Initiating explosives		
Donor explosives		
Fire Extinguishers, 20B:C		
Wheel Chocks		

Checklist Verification

Disposal Supervisor Signature:	Date:

ATTACHMENT 2

HEALTH AND SAFETY EQUIPMENT CHECKLIST

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HEALTH AND SAFETY EQUIPMENT CHECKLIST

Equipment List

Equipment	Quantity	Comments
Air Horn, emergency		
Burn Blanket		
Burn Kit		
Emergency Eye Wash		
Hand-held Radio and Satellite Phone		
Lightning Detector		
Fire Extinguisher, 20-pound ABC		
Bloodborne Pathogen Kit		
First Aid Kit		
Gloves, leather		
Goggles		
Face Shield(s)		
Fire Retardant Gloves		
Fire Retardant Apron(s)		
Rain Suit(s)		
Safety Vest(s)		
Stretcher		
Water, 5-gal bottle (emergency shower)		
Water, drinking -- 1 liter per person		

Checklist Verification

Disposal Supervisor Signature:	Date:

ATTACHMENT 3

GENERAL SAFETY PRECAUTIONS

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GENERAL SAFETY PRECAUTIONS

1. Carry blasting caps in approved containers and keep them out of the direct rays of the sun. Keep the caps located at least 25 feet from other explosives until they are needed for priming.
2. Do not work with electric blasting caps or other electro-explosive devices while wearing clothing prone to producing static electricity such as nylon, silk, synthetic hair, etc.
3. Do not use explosives or accessory equipment that is obviously deteriorated or damaged. They may cause premature detonation or fail completely.
4. Always point the explosive end of blasting caps, detonators, and explosive devices away from the body during handling.
5. Use only standard blasting caps of at least the equivalent of a commercial No. 8 blasting cap.
6. Use electric blasting caps of the same manufacturer for each demolition shot involving more than one cap.
7. Do not use improvised methods for initiating blasting caps.
8. Do not bury blasting caps. Use detonating cord to transmit the explosive wave from the blasting caps, on the surface, to a buried/tamped explosive charge. Buried blasting caps are subject to unobserved pressures and movement, which could lead to premature firing or misfires.
9. Test electric-blasting caps for continuity at least 50 feet from any other explosives before connecting them to the firing circuit. Upon completion of testing, the lead wires will be shunted by twisting the bare ends of the wires together. The wires will remain shunted until ready to be connected to the firing circuit.
10. In the event of a misfire when disposing of explosives by detonation, do not approach the disposal site for at least 60 minutes after the expected detonation time, when firing electrically.
11. Items with lugs, strong backs, tail-booms, base plates, etc., should be oriented away from personnel locations.
12. Consideration should be given to tamping the UXO to control fragments if the situation warrants. Fragments will be minimized not only to protect personnel but also property, such as buildings, trees, etc.
13. Avoid inhaling the smoke, dust, or fumes of burning pyrotechnic or incendiary materials. The smoke, dust, and fumes from many of these materials are irritating and/or toxic if inhaled.
14. Do not use water on incendiary fires. Water may induce a violent reaction or be completely ineffective, depending on the mixture.
15. Anticipate a high order detonation when burning pyrotechnic or incendiary-loaded MEC. Safety measures for personnel and property must be based upon this possibility.
16. Inert ordnance will not be disposed of, or sold for scrap, until the internal fillers have been exposed and unconfined. The heat generated during a reclamation operation can cause the inert filler, moisture, or air to expand and burst the sealed casings. Venting or exposure may be accomplished in any way necessary to preclude rupture due to pressure from being confined. All requirements of the UXO Procedure for the Management and Disposition of MPPEH will be met before releasing any inert ordnance material.
17. Maintain minimum safe distances between electromagnetic-radiating sources and electro-explosive devices (IAW EODB/TM-TO 60A-1-1-12).
18. Do not conduct blasting or demolition operations during an electrical, dust, sand, or snowstorm severe enough to produce atmospheric static electrical charges, or when such a storm is nearby (within 6 miles). Under such conditions, all operations will be suspended or terminated, cap and lead wires shunted, and personnel removed from the demolition area. Demolition operations will also be terminated if visibility becomes less than 600 feet.
19. Loose initiating explosives: lead azide, mercury fulminate, lead styphnate, and tetracene, these explosives manifest extreme sensitivity to friction, heat, and impact. Extra precautions are required when handling

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these types of explosives. Keep initiating explosives in a water-wet condition at all times until ready for final preparation for detonation. The sensitivity of these explosives is significantly increased when dry.

20. Exercise extreme care when handling and preparing high explosives for detonation. They are subject to detonation by heat, shock, or friction.
21. Do not pack bomb fuze wells with explosives unless it can be positively confirmed that the fuze well does not contain any fuze components.
22. Photo flash bombs must be handled with the same care as black powder-filled munitions.
23. MEC containing white phosphorous will not be detonated into the ground. White phosphorous munitions will be counter-charged on the bottom centerline (CCBC) when possible.
24. A search of the detonation site, after the demo operation, will be conducted to assure complete disposal was accomplished.
25. Do not abandon any explosives.
26. Do not leave explosives, empty cartridges, boxes, liners, or other materials used in the packing of explosives lying around where children, unauthorized persons or livestock can get at them.
27. Do not allow any wood, paper, or other materials used in packing explosives to be burned in a stove, fireplace, or other confined space, or be re-used for any other purpose. Such materials will be destroyed by burning at an isolated location out of doors, with no one allowed within 100 feet of the burning operation.
28. Do not fight fires involving explosive material. Evacuate all personnel to a safe location and secure the area.
29. Know and observe international, federal, state, and local laws/regulations that apply to the transportation, storage, and use of explosives.
30. Do not permit metal, except approved metal truck bodies, to contact explosive containers.
31. Do not transport metal, flammable, or corrosive substances with explosives.
32. Do not allow smoking, or the presence of unauthorized personnel, in vehicles transporting explosives.
33. Carefully load and unload explosives from vehicles. Never throw or drop explosives from the vehicle.
34. Assure the load is blocked and braced to prevent it from movement and displacement.
35. Do not drive vehicles containing explosives over public highways until all permits and certifications have been obtained from the state enforcement agencies.
36. All routes must be approved in writing before transporting explosive materials over public highways.
37. Licensed commercial carriers will conduct the shipment of explosive materials over public highways unless Tetra Tech UXO personnel have been specifically licensed and certified to make the shipment.
38. Never leave a vehicle that is loaded with explosives unattended.
39. Do not store blasting caps, detonators, or other items containing initiating explosives in the same box, container, or magazine with other explosives.
40. Store explosive materials in military or ATF-approved magazines only. Ensure the magazines used for the storage comply with quantity distance requirements, for the class of explosive material they contain. Reference documents include: NAVSEA OP-5, TM 9-1300-206, AMCR 385-100, ATF - Explosives Law and Regulation, ATF P 5400.7, and 49 CFR.
41. Do not store spark-producing metal/tools in an explosive magazine.
42. Do not permit smoking, matches, or any source of fire or flame within 100 feet of an explosive magazine.
43. Do not allow leaves, grass, brush, or debris to accumulate within 50 feet of an explosive magazine.
44. Do not permit the discharge of firearms within 300 feet of an explosive magazine.

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45. Do not use any alkaline material such as lye, washing soda, or soap to remove TNT exudate. Alkaline materials will react with TNT to render it more sensitive.
46. Do not permit smoking, matches, or other sources of fire or flame within 100 feet of an area in which explosives are being handled.
47. Do not expose explosives or devices containing explosive to prolonged exposure to direct sunlight. Such exposure can increase sensitivity and deterioration.
48. Ensure all unused explosives are returned to their proper containers, and the container closed after use.
49. Do not carry explosives or explosive components in pockets or on the body.
50. Do not strike, tamper with, or attempt to remove or investigate the contents of an electric/non-electric blasting cap, detonator, or other explosive initiating device. A detonation may occur.
51. Do not pull on the electrical lead wires of electric blasting caps, detonators, or their electro-explosive devices. A detonation may occur.
52. Do not attempt to remove an unfired or misfired primer or blasting cap from a base coupling. There is a high risk of an explosion.
53. Do not allow unauthorized or unnecessary personnel to be present when explosives are being handled.
54. Do not use pull rings or safety pins to lift or handle explosive devices.

ATTACHMENT 4

DISPOSAL OPERATIONS CHECKLIST

TETRA TECH

DISPOSAL OPERATIONS CHECKLIST

FUNCTION	DATE/TIME	SIGNATURE
SUXOS		
Assign Disposal Team		
Brief Disposal Team Review emergency procedures Discuss MEC/MPPEH to be disposed Describe Disposal procedures and method		
Inspect Range/Exclusion Zone upon completion of operations		
Disposal Supervisor		
Assign demolition task to team members		
Verify Not Later Than (NLT) disposal time includes wait time for misfire procedures		
Verify roads are closed		
Verify Exclusion Zone boundaries in place		
Complete health and safety and equipment checklists		
Ensure Field Site Office has completed the verification checklist Responsible activity Medical Facility Fire Department Security/Police Department		
Disposal Supervisor tailgate safety brief: Designate emergency vehicles Designate emergency evacuation route Review emergency response procedures		
Verify daily equipment inspection		
Verify detonators are separated from explosives		
Verify area has been evacuated		
Verify engineering controls are correct		
Notify Field Site Office that operations are commencing		
Start disposal activities		
Inspect shot after designated wait time		
Collect all metal fragments for later disposal		
QC check performed		
QA check (if required)		
Tetra Tech to notify upon completion: Client Responsible Activity Medical Facility Fire Department Security/Police Department		
Complete MEC/MPPEH Accountability Log and record data in Explosive Disposal Log		
Demolition Supervisor signature:		Date:

ATTACHMENT 5

EXPLOSIVE DISPOSAL LOG

TETRA TECH

EXPLOSIVE DISPOSAL LOG

Project Information

Project Name: ______________________ Start Time: ______________

Project Location: Stop Time:

MEC Disposed of This Date (List items and quantity of each item)

QTY	NOMENCLATURE	GRID	MEC	MDAS	DATE LOCATED	DATE DISPOSAL

Donor Explosive Used (List types and quantity)

QTY	TYPE
	ELECTRIC DETONATORS
	DETONATNG CORD
	COMMERCIAL SHAPED CHARGES

Remarks

Approval

Demolition Supervisor (Signature):

Print Name ______________________

Date:

ATTACHMENT 6

QUALITY CONTROL INSPECTION CHECKLIST

MEC MANAGEMENT AND DISPOSAL

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Contract #:		
Task Order #:		

QC CHECKLIST POINTS

ITEM	REF.	INSPECTION POINT	YES	NO	N/A	COMMENTS
1	**Workers' Statement**	Have all MEC Management and Disposal Team Members read this SOP?				
2	**QAPP**	Have assigned disposal team members received training on and demonstrated proficiency with the RFD?				
3	**SOP**	Did all personnel attending the morning safety/operational briefing sign-in?				
4	**SOP**	Did the Team Leader conduct and document the Tailgate Safety Briefing before beginning operations?				
5	**SOP**	Did all recovered MPPEH undergo the three-tiered inspection process?				
6	**SOP**	Did the SUXOS and UXOSO assess all MEC and agree that the risk associated with movement is acceptable or not?				
7	**SOP**	Was the decision to move MEC documented in writing before movement or transporting the items to the storage magazines for temporary storage?				
8	**SOP**	Were MPPEH items further classified as or MDAS, as appropriate?				
9	**SOP**	Were all MEC items photographed?				
10	**SOP**	Did the Demolitions Supervisor conduct and document the demolitions briefing?				
11	**SOP**	Was the EZ established and observed?				
12	**SOP**	Was the demolition sequence observed?				
13	**SOP**	Were donor charges properly prepared?				
14	**SOP**	Were post-demolition operations conducted?				

FINDINGS

Item	Comments

Conducted By: ______________________ **Reviewed By:** ______________________

APPENDIX C

Munition with the Greatest Fragmentation Distance

Fragmentation Data Review Form

Database Revision Date 6/5/2020

Category:	Surface-Launched HE Rounds
Munition:	37 mm Mk II
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Projectile
Munition Case Classification:	Extremely Heavy Cased

DODIC:	
Date Record Created:	9/21/2004
Record Created By:	MMC
Last Date Record Updated:	5/3/2018
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	0.053
Diameter (in):	1.4500
Cylindrical Case Weight (lb):	0.49264
Maximum Fragment Weight (Intentional) (lb):	0.0305
Design Fragment Weight (95%) (Unintentional) (lb):	0.0213
Critical Fragment Velocity (fps):	3309

Sandbag and Water Mitigation Options

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	0.053
Kinetic Energy 10^6 (lb-ft²/s²):	0.1352

Single Sandbag Mitigation

Required Wall & Roof Thickness (in)	12
Expected Max. Throw Distance (ft):	25
Minimum Separation Distance (ft):	25

Double Sandbag Mitigation

Required Wall & Roof Thickness (in)	24
Expected Max. Throw Distance (ft):	10
Minimum Separation Distance (ft):	12.5

Water Mitigation

Minimum Separation Distance (ft):	200/200
Water Containment System:	5 gal carboys/ inflatable pool

Note: Use Sandbag and Water Mitigation in accordance with all applicable documents and guidance. If a donor charge larger than 32 grams is utilized, the above mitigation options are no longer applicable. Subject matter experts may be contacted to develop site specific mitigation options.

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	90
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	982
MFD-V [Maximum Fragment Distance, Vertical] (ft):	756

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	0.053
3.5 psi, K18 Distance (ft):	7
2.3 psi; K24 Distance (ft):	9
1.2 psi, K40 Distance (ft):	15
0.0655 psi, K328 Distance (ft):	123

"NOTE: Values shown within this section only address overpressure hazards and do not account for applicable distance values for fragments and debris as required per DoD 6055.09-M."

Minimum Thickness to Prevent Perforation (in)

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	2.97	1.95
Mild Steel:	0.57	0.37
Hard Steel:	0.46	0.30
Aluminum:	1.18	0.79
LEXAN:	4.24	3.25
Plexi-glass:	2.76	1.94
Bullet Resist Glass:	2.23	1.51

Item Notes