

**US Army Corps
of Engineers®**

ENGINEERING AND DESIGN

EM 1110-1-4009
23 June 2000

ORDNANCE AND EXPLOSIVES RESPONSE

ENGINEER MANUAL

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	Engineering and Design ORDNANCE AND EXPLOSIVES RESPONSE	
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CEMP-RA

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

EM 1110-1-4009

Manual
No. 1110-1-4009

23 June 2000

Engineering and Design
ORDNANCE AND EXPLOSIVES

1. Purpose. This manual provides the U.S. Army Corps of Engineers (USACE) personnel with the procedures to be used to perform engineering and design activities for all phases of Ordnance and Explosives (OE) response actions.
2. Applicability. This manual applies to all Headquarters, USACE (HQUSACE) elements and all USACE commands having responsibility for performing OE response activities.
3. Distribution Statement. Approved for public release; distribution is unlimited.
4. References. Required and related references are at Appendix A.
5. Explanation of Abbreviations and Terms. Abbreviations/acronyms and special terms used in this manual are explained in the glossary.

FOR THE COMMANDER:

1 Appendix
(See Table of Contents)


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CEMP-RA

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CHAPTER 1 INTRODUCTION

1-1. Introduction.

a. USACE conducts OE response actions consistent with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the National Oil and Hazardous Substance Pollution Contingency Plan (NCP). While USACE prefers to use Engineering Evaluation/Cost Analyses (EE/CA) to evaluate OE sites, other types of investigations may be implemented at particular sites. Regardless of the type of investigation implemented, the guidance provided in this EM applies to all USACE OE response actions.

b. This EM guides a project team through the engineering and design requirements that should be addressed while planning an OE response project. This EM is subdivided into chapters representing the major components of an OE project that require project team consideration. Following each chapter, checklists are provided to assist the project team in assuring that all necessary items have been considered.

c. The engineering considerations presented in this EM primarily address the actions taken to reduce the safety risks to human health and the environment from OE. For additional information on the procedures for USACE personnel to follow when planning and executing an OE response action, contact the OE MCX.

1-2. Project Team Members.

a. The project team responsible for the OE project design process is normally composed of the following members:

(1) Design Center Point of Contact. The Design Center Point of Contact (POC) is the single POC responsible for coordination between the Project Manager (PM), the project team and the OE Mandatory Center of Expertise (MCX). The Design Center POC is responsible for the overall interdisciplinary coordination, definition and development of project requirements.

(2) OE Safety Specialist. The OE Safety Specialist is located within the USACE element executing the OE response project. The functions of the OE Safety Specialist include:

(a) Provide on-site safety support for OE activities.

(b) Verify unexploded ordnance (UXO) qualifications of contractor employees.

(c) Advise the contractor on safety procedures.

(d) Coordinate exclusion zone activities with and advise the PM, Design Center POC, and the OE Safety Manager in the OE Design Center.

- (e) Facilitate military Explosive Ordnance Disposal (EOD) response, when needed.
- (f) Provide technical OE safety support to USACE districts and contractors.
- (g) Conduct government quality assurance inspections of completed work.

(h) If located at a district, the OE Safety Specialist will assist with the review of Statements of Work (SOW), Work Plans, Site Safety and Health Plans (SSHP) and, if required, Explosives Safety Submissions (ESS). If located at an OE Design Center, the OE Safety Specialist will assist with the execution and approval of SOWs, Work Plans, SSHPs and ESSs (if required).

(3) Project Engineers. The project engineers are responsible for the technical aspects of the design and execution of OE projects in their respective areas of expertise.

b. The project team members are responsible for executing the functions discussed in this document. For additional information on the roles and responsibilities of USACE personnel during an OE response project, refer to Engineer Regulation (ER) 1110-1-8153, OE Response.

1-3. Safety. Safety is a critical component of all USACE activities and operations. Not all safety requirements for OE response projects are addressed in this document, but are discussed in detail in other USACE guidance documents. The OE MCX may also be contacted for assistance.

1-4. Data Quality Objectives.

a. Data Quality Objectives (DQO) are qualitative and quantitative statements developed to clarify study objectives, define the type of data needed, and specify the tolerable levels of potential decision errors. DQOs are used as the basis for establishing the type, quality and quantity of data needed to support the decisions that will be made.

b. While planning the engineering and design elements of an OE response project, the project team should develop DQOs. Where applicable, this document provides guidance on the DQOs that are relevant to a specific task of an OE response project. For additional information on the development and application of DQOs, contact the OE MCX.

CHAPTER 2 PROJECT PLANNING

2-1. Introduction.

a. This chapter presents guidance for the project team on government planning activities for OE projects. The purpose of government planning is to develop a strategy for each project that will ensure the achievement of project goals in a manner that is safe, timely, and cost-effective. Topics discussed in this chapter include the SOW, cost estimate, and project schedule.

b. Government planning activities require input from many different disciplines and should therefore be prepared in a manner that fully involves all affected disciplines. Quality excellence is achieved in government planning activities through the conscientious and cooperative efforts of each project team member.

2-2. Statement of Work. A SOW should be prepared for each project, whether it will be completed as a delivery order/task order to a contractor or as a work effort for an Army element.

a. Performance Objectives. The SOW identifies the specific work requirements for a particular project. The project team's performance objective is to develop a SOW that will serve as the basis for:

- (1) Developing a cost estimate either for budgetary purposes or for use in contract negotiations;
- (2) Defining clear, achievable, and contractually enforceable project requirements;
- (3) Obtaining successful project performance; and
- (4) Ensuring fair and effective administration of a contract or delivery order/task order.

b. Preparation.

(1) The project team is responsible for preparation of SOWs for site visits, EE/CAs, Removal Actions, UXO Support, and Time Critical Removal Actions (TCRAs) in coordination with the PM. The Design Center POC should ensure that the PM and all members of the project team are included in the preparation of the SOW. The OE MCX may be consulted to provide the appropriate statements or paragraphs concerning background and authority for the work described in the SOW.

(2) When preparing the SOW, the project team should consult the Inventory Project Report (INPR), Archives Search Report (ASR), previous investigation reports, and information gathered

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during the site visit (see Chapter 4 of this manual) for site-specific information. Attachment 2-1 is a checklist to aid in the preparation of the SOW.

c. Contents. The contents of a SOW depend on the type of OE project, the type of OE response action, and site-specific requirements. The following topics should generally be included in a SOW:

- (1) General responsibilities;
- (2) Project description;
- (3) Scope of services;
- (4) Schedule and deliverables;
- (5) Reviews and conferences;
- (6) Technical criteria and standards, including government-furnished information;
- (7) Administrative instructions;
- (8) General provisions; and
- (9) References.

d. SOW for Project Phases. The project team may need to develop a SOW for specific phases of a project. Project team considerations for site visit, EE/CA, and Removal Action SOWs are discussed below. More detailed information on SOW preparation is provided in subsequent chapters of this manual.

(1) SOW for Site Visit. A site visit may be required prior to the initiation of or as the first task of an OE project. Site visits are discussed in more detail in Chapter 4 of this manual.

(2) SOW for EE/CA Reconnaissance (RECON). Once funds have been received and following an evaluation of the site-specific data gathered during the Preliminary Assessment of Eligibility (PAE) and Site Inspection (SI) phases, the project team may decide to implement the optional RECON task. RECON is discussed in Chapter 6 of this manual. If the RECON task will be implemented, the project team will prepare a RECON SOW. Typical tasks included in a RECON SOW are:

- (a) Work Plan and Abbreviated Site Safety and Health Plan (ASSHP) (see Chapter 3);
- (b) Analysis of the ASR;

- (c) Spatial analysis (aerial survey);
- (d) Ground reconnaissance;
- (e) Technology evaluation; and
- (f) Analysis report/data archive.

(3) SOW for EE/CA. Once funds have been received, the project team may begin preparation of the SOW for the EE/CA phase. The SOW may not be awarded until the Approval Memorandum has been signed. If the EE/CA RECON task is implemented, the project team may use the results to modify/refine the EE/CA SOW or make a decision to move directly to the removal action without further study. Typical tasks included in an EE/CA SOW are:

- (a) Records review and land restriction assessment;
- (b) Work Plan, including SSHP and Institutional Analysis Plan (see Chapter 3);
- (c) Site preparation;
- (d) Site characterization (see Chapters 7 and 8);
- (e) Safety and public risk evaluation (see Chapters 10 and 11);
- (f) Preparation of the EE/CA report;
- (g) Preparation of the Action Memorandum; and
- (h) Community relations.

(4) SOW for Removal Action. Once funds have been received, the project team may begin preparation of the SOW for the Removal Action. The SOW may not be awarded until the Action Memorandum has been signed. It should comply with the approved Action Memorandum. Typical tasks included in an OE Removal Action SOW include:

- (a) Site visit (see Chapter 4);
- (b) Work Plan development (see Chapter 3);
- (c) Location surveying and mapping (see Chapters 8 and 9);
- (d) Site preparation (see Chapter 7);

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- (e) Geophysical investigation prove-out (see Chapter 7);
- (f) Geophysical investigations (see Chapter 7);
- (g) Anomaly reacquisition (see Chapter 7);
- (h) Clearance action;
- (i) Institutional control activities and recurring reviews;
- (j) Turn-in; and
- (k) Preparation of the site-specific removal report.

e. Review and Approval. The Design Center POC should ensure that the SOW is in compliance with the signed Approval Memorandum (EE/CAs) or Action Memorandum (Removal Actions). The Design Center POC should direct SOWs to the appropriate personnel, including the PM and appropriate members of the project team, for review. Review comments should be provided in writing to the Design Center POC. Following review and approval in accordance with ER 1110-1-8153, the Design Center POC should submit the final SOW to the Contracting Officer (CO). The PM should provide the final SOW to the customer and stakeholders for review.

2-3. Cost Estimating.

a. General.

(1) Once the SOW is approved, a cost estimate should be prepared by personnel having expertise in the type of work involved on the project. The cost estimator should develop the estimate based on a detailed analysis of the SOW, assuming reasonable economy and efficiency, and modern and effective methods.

(2) In developing cost estimates, whether for budgets or contractor procurement purposes, a number of tools are available. Cost engineering offices at each district have cost estimating software, databases, and documents available to use in developing cost estimates at various phases. The recommended USACE software programs are Remedial Action Cost Engineering and Requirements System (RACER) 99 for parametric estimating and Micro Computer Aided Cost Engineering System (MCACES) Gold Version 5.3, MCACES for Windows, or Excel™ or LOTUS 123™ spreadsheets for detailed estimating.

b. Performance Objectives. The project team's performance objective is to prepare a cost estimate that is complete and of sufficient detail such that it can be used to:

- (1) Obtain program funding; or
- (2) Negotiate the award of a contract at a price that is fair and reasonable to the government.

c. Project Team Considerations and Cost Estimating Checklist.

(1) The project team should first identify the purpose of the cost estimate. If the purpose of the cost estimate is to obtain program funding, then a rough order of magnitude estimate may be prepared. If the purpose of the cost estimate is to award a contract, then a detailed cost estimate is required.

(2) Once the intended use of the estimate is identified, the cost estimator should consider the phase of the project and the following items which will impact project cost (this list is not intended to be all inclusive):

- (a) Size of areas of concern;
- (b) Site risk;
- (c) Type of ordnance;
- (d) Soil type;
- (e) Topography;
- (f) Vegetation type;
- (g) Ordnance density;
- (h) Required depth of clearance;
- (i) Amount of scrap;
- (j) Special environmental and safety concerns (e.g., presence of Chemical Warfare Materiel [CWM], requirements for engineering controls, sampling and analysis requirements such as air monitoring, etc.);
- (k) Production rates;
- (l) In-house or contracted;
- (m) Percent of property to be investigated;

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- (n) Surveying methods (e.g., mag and flag, geophysical);
- (o) Data format requirements (i.e., digital or non-digital);
- (p) Personal Protective Equipment (PPE) level required;
- (q) Type of operation to be performed (e.g., search only or search and recovery);
- (r) Number and type of UXO technicians required;
- (s) Equipment and vehicles required (e.g., magnetometer, towed array, earth moving machinery, recovery vehicles);
- (t) Expected time duration;
- (u) Access restrictions;
- (v) Political considerations; and
- (w) Start date.

(3) This information may be derived from historical reports (e.g., the INPR and ASR) and previous investigations at the site. This information should also be compiled in the SOW, from which the estimate will be developed. Attachment 2-2 is a checklist that may be used by the cost estimator to aid in preparing a cost estimate for an OE project.

2-4. Project Schedule. The project schedule should be included in the SOW. The Design Center POC should develop the project schedule in cooperation with the PM. The project team should provide the Design Center POC with estimates for the duration of each task required in the SOW. These estimates should be used by the PM to establish dates for project deliverables and the overall project schedule. The project team should provide agreement or comments on the schedule established by the PM.

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ATTACHMENT 2-1
STATEMENT OF WORK PREPARATION CHECKLIST

Project Name: _____
 Project Location: _____
 Design Center POC: _____
 Preparer's Name and Title: _____
 Date of Preparation: _____

	Y	N	N/A
<u>All SOWs:</u>			
1. Has the authorization and funding been received for SOW preparation?	_____	_____	_____
2. Has the Design Center POC held a pre-scoping meeting with the project team to discuss project requirements and to determine required resources?	_____	_____	_____
3. Have project requirements been identified through interfacing with the PM?	_____	_____	_____
4. Do the personnel responsible for preparing the SOW have a detailed knowledge of the project history, site conditions, characteristics of UXO anticipated and of geophysical methods?	_____	_____	_____
5. Has existing site information been provided to the project team (may include ASR, previous site investigation reports, information from site visits, information from district contractors that have worked on the site in the past, etc.)?	_____	_____	_____
6. Have the requirements for the site visit been met (i.e., right of entry, ASSHP, etc. - see Chapter 4 of this manual)?	_____	_____	_____
7. Have federal, state and local regulatory requirements been identified in the SOW?	_____	_____	_____

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	Y	N	N/A
8. Has an appropriate schedule has been included in the SOW?	_____	_____	_____
9. Has the OE MCX reviewed the SOW?	_____	_____	_____
10. Are the following general included in the SOW:			
• General responsibilities of the contractor?	_____	_____	_____
• Project description?	_____	_____	_____
• Scope of services?	_____	_____	_____
• Schedule and deliverables?	_____	_____	_____
• Reviews and conferences?	_____	_____	_____
• Technical criteria and standards, including government furnished information?	_____	_____	_____
• Administrative instructions?	_____	_____	_____
• General provisions?	_____	_____	_____
• References?	_____	_____	_____
11. Have review comments been obtained from appropriate personnel, including PM and project team members, in accordance with ER 1110-1-8153?	_____	_____	_____
12. Has the SOW been approved in accordance with ER 1110-1-8153 and submitted final SOW to the Contracting Officer?	_____	_____	_____
13. Was an external review of the SOW performed?	_____	_____	_____
14. If the SOW is prepared for a removal action, did it clearly identify if the contractor is responsible for the preparation of an ESS?	_____	_____	_____

	Y	N	N/A
<u>SOW for EE/CA RECON</u>			
1. Have the following tasks, as applicable, been included in the EE/CA RECON SOW: (See Chapter 6 of this manual for additional information)			
• Work Plan and ASSHP (see Chapter 3 of this manual)?	_____	_____	_____
• Analysis of the ASR?	_____	_____	_____
• Spatial Analysis (aerial survey)?	_____	_____	_____
• Ground reconnaissance?	_____	_____	_____
• Technology evaluation?	_____	_____	_____
• Analysis report/data archive?	_____	_____	_____
<u>SOW for EE/CA</u>			
1. Have the following typical tasks, as applicable, been included in the EE/CA SOW:			
• Records review and land restriction assessment?	_____	_____	_____
• Project Work Plan, including SSHP and Institutional Analysis Plan (see Chapter 3 of this manual)?	_____	_____	_____
• Site preparation?	_____	_____	_____
• Site characterization (see Chapters 7 and 8 of this manual)?	_____	_____	_____
• Safety and public risk evaluation (see Chapters 10 and 11 of this manual)?	_____	_____	_____
• Preparation of the EE/CA report?	_____	_____	_____
• Preparation of the Action Memorandum?	_____	_____	_____
• Community relations?	_____	_____	_____
2. Is the SOW in compliance with the Approval Memorandum?	_____	_____	_____

	Y	N	N/A
<u>SOW for Removal Action</u>			
1. Have the following typical tasks, as applicable, been included in a Removal Action SOW:			
• Site visit (see Chapter 4 of this manual)?	_____	_____	_____
• Work Plan development (see Chapter 3 of this manual)?	_____	_____	_____
• Location surveying and mapping (see Chapters 8 and 9 of this manual)?	_____	_____	_____
• Site preparation (see Chapter 7 of this manual)?	_____	_____	_____
• Geophysical investigation prove-out (see Chapter 7 of this manual)?	_____	_____	_____
• Geophysical investigation (see Chapters 7 of this manual)?	_____	_____	_____
• Anomaly reacquisition (see Chapter 7 of this manual)?	_____	_____	_____
• Clearance action?	_____	_____	_____
• Institutional control activities and recurring reviews?	_____	_____	_____
• Scrap turn-in?	_____	_____	_____
• Preparation of site-specific removal report?	_____	_____	_____
2. Is the SOW in compliance with the Action Memorandum?	_____	_____	_____

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ATTACHMENT 2-2 COST ESTIMATE PREPARATION CHECKLIST

Project Name: _____
 Project Location: _____
 Design Center POC: _____
 Preparer's Name and Title: _____
 Date of Preparation: _____

	Y	N	N/A
<u>Prior to beginning work on cost estimate</u>			
1. Is the cost estimate being prepared for internal budgetary purposes (i.e., to obtain program funding)? If yes, a rough order of magnitude estimate may be prepared.	_____	_____	_____
2. Is the cost estimate being prepared for contract procurement (i.e., for use in contract negotiations)? If yes, a detailed cost estimate is required.	_____	_____	_____
3. Has the SOW been developed and approved?	_____	_____	_____
4. Have the phase of the project and the following items which will impact project cost (this list is not intended to be all inclusive) been considered:			
• Size of areas of concern?	_____	_____	_____
• Site risk?	_____	_____	_____
• Type of ordnance?	_____	_____	_____
• Soil type?	_____	_____	_____
• Topography?	_____	_____	_____
• Vegetation type?	_____	_____	_____
• Ordnance density?	_____	_____	_____
• Required depth of clearance?	_____	_____	_____
• Amount of scrap?	_____	_____	_____

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	Y	N	N/A
• Special environmental and safety concerns (e.g., presence of CWM, requirements for engineering controls, sampling and analysis requirements such as air monitoring, etc.)?	_____	_____	_____
• Production rates?	_____	_____	_____
• In-house or contracted?	_____	_____	_____
• Percent of property to be investigated?	_____	_____	_____
• Surveying methods?	_____	_____	_____
• Data format requirements (i.e., digital or non-digital)?	_____	_____	_____
• PPE level required?	_____	_____	_____
• Type of operation to be performed (e.g., search only or search and recovery)?	_____	_____	_____
• Number and type of UXO technicians required?	_____	_____	_____
• Equipment and vehicles required (e.g., magnetometer, towed array, earth moving machinery, recovery vehicles)?	_____	_____	_____
• Expected time duration?	_____	_____	_____
• Access restrictions?	_____	_____	_____
• Political considerations?	_____	_____	_____
• Start date?	_____	_____	_____

CHAPTER 3 SITE VISIT

3-1. Introduction.

a. This chapter describes the elements that should be addressed by the project team when planning and conducting a site visit. The purpose of the site visit is to:

- (1) Gather current information on site conditions;
 - (2) Fill any data gaps; and
 - (3) Make more informed decisions about project requirements.
- b. All site visits will be conducted using avoidance techniques.

3-2. Performance Objectives. The project team should consider the following performance objectives when planning and executing the site visit:

- a. Identify specific elements which should be discussed in the SOW;
- b. Identify stakeholder requirements;
- c. Identify and review existing information on past activities at the site including site-specific reports, aerial photos, maps and geospatial data and systems information;
- d. Coordinate with local and/or state entities to discuss data sharing if data gaps have been identified;
- e. Determine the appropriate type of response action for the site or sections of the site;
- f. Determine the appropriate type of contractor (service or Architect-Engineer [A-E]) for the response action, if not previously determined;
- g. Perform sector prioritization, if possible; and
- h. Identify factors influencing the cost estimate and project schedule.

3-3. Types of Site Visits. Depending on the project, a government and/or a contractor site visit may be conducted.

a. Government Site Visit. A government site visit is conducted prior to developing the SOW and typically includes only government personnel. However, if the contractor has been

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identified at the time of the initial government site visit, the PM may invite contractor personnel to attend.

b. Contractor Site Visit. A contractor site visit is conducted to allow contractor personnel to gather pertinent site information for use in preparing the cost estimate and project planning documents. The contractor site visit may take place under two scenarios:

(1) Contractor personnel may be invited to accompany the government team during the initial site visit; or

(2) The government may coordinate a second site visit with contractor personnel. During this site visit, the government team would accompany the contractor attendees.

c. EP 1110-1-18 describes government and contractor site visits in further detail. Attachment 3-1 provides a checklist to assist the project team with planning a site visit.

3-4. Site Visit Attendees. The project team should ensure that the appropriate personnel are represented at the site visit. The personnel requirements for the government and contractor site visits are discussed below.

a. Government Site Visit Attendees.

(1) The primary attendees for the government site visit include:

(a) PM;

(b) Design Center POC;

(c) OE Safety Specialist;

(d) Project engineers; and

(e) Cost estimator.

(2) If the prospective contractor is known at the time of the government site visit, then contractor personnel may also be invited to attend.

b. Contractor Site Visit Attendees. The contractor's site visit team should be composed of no more than three personnel. One contractor participant will be the PM and one will be a qualified Senior UXO Supervisor. The contractor personnel should be qualified in accordance with the current USACE Personnel Work Standards, which are located on the OE MCX website at <http://www.hnd.usace.army.mil/oew>. The government project team will accompany contractor personnel on the contractor site visit.

3-5. Site Visit Requirements. The project team should ensure that the following requirements for the site visit are fulfilled.

a. Site-Specific Reports. Prior to the site visit, the project team should review existing site information and identify data gaps. Sources of site data available to the project team include:

- (1) ASR;
- (2) Previous site investigation reports; and
- (3) Information from previous district contractors that have worked on the site.

b. Site Visit SOW. Once a contractor is selected, the Design Center may authorize the site visit as either a purchase order or as the first task of an incrementally funded contract/task order. In either case, the contractor will be issued a site visit SOW prior to the actual site visit. Sample SOWs for both the stand-alone site visit and the site visit included as a task in a larger task order are found on the OE MCX website at <http://www.hnd.usace.army.mil/oew>.

c. Right-of-Entry. As applicable, the PM is responsible for contacting the property owner/operator to determine the need for and to arrange for the preparation of a right-of-entry.

d. ASSHP. Since the site visit is conducted in avoidance mode (i.e., intrusive work is not permitted), an ASSHP is sufficient for site visits. EP 1110-1-18 discusses the ASSHP in further detail.

e. Training. Site visit participants are not required to have Hazardous Waste Operations and Emergency Response (HAZWOPER) training.

3-6. Site Visit Information. During the site visit, the project team should ensure that information needed to prepare the SOW, cost estimate, and planning documents is gathered. The project team, in conjunction with the other attendees, should obtain information on:

- a. Site topography, soil type and vegetation;
- b. Preliminary identification of environmental concerns and environmental resources data (e.g., wetlands, endangered species, archaeological and cultural resources);
- c. Accessibility to the site;
- d. Utility locations;
- e. Potential locations for staging areas, offices, etc.;

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- f. Clear distances to inhabited buildings;
- g. Location of and coordination with the nearest hospital and fire station;
- h. Coordination with local airport and Federal Aviation Administration;
- i. Coordination with local police/sheriff/military police to assess security and fencing requirements for explosives storage magazines;
- j. Location for support zone and explosives storage magazines;
- k. Logistical coordination for lodging, equipment and vehicle rental, office space, explosives dealers, etc.; and
- l. Coordination with Range Control, Defense Reutilization Management Office, Ammunition Supply Point, and Post Provost Marshall, if applicable.

ATTACHMENT 3-1
SITE VISIT REVIEW CHECKLIST

Project Name: _____
 Project Location: _____
 Design Center POC: _____
 Preparer's Name and Title: _____
 Date of Preparation: _____

	Y	N	N/A
<u>General</u>			
1. Will the initial site visit be a:			
• Government site visit?	_____	_____	_____
• Contractor site visit?	_____	_____	_____
• Combined government and contractor site visit?	_____	_____	_____
<u>Government Site Visit Attendees</u>			
1. Are the following personnel, at a minimum, attending the government site visit:			
• PM?	_____	_____	_____
• Design Center POC?	_____	_____	_____
• OE Safety Specialist?	_____	_____	_____
<u>Contractor Site Visit Attendees</u>			
1. Are the following personnel, at a minimum, attending the government site visit:			
• Contractor PM?	_____	_____	_____
• Senior UXO Supervisor?	_____	_____	_____
• PM (government)?	_____	_____	_____
• Design Center POC?	_____	_____	_____
• OE Safety Specialist?	_____	_____	_____
2. Has the project team ensured that no more than three contractor personnel are attending the site visit?	_____	_____	_____

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	Y	N	N/A
3. Has the project team confirmed that the contractor personnel are qualified in accordance with USACE Personnel Work Standards?	_____	_____	_____

Site Visit Requirements. Prior to the site visit, the project team should ensure that the following requirements are fulfilled:

- | | | | |
|---|-------|-------|-------|
| • Have site-specific reports been reviewed? | _____ | _____ | _____ |
| • Have any data gaps in the existing site data been identified? | _____ | _____ | _____ |
| • Has the PM issued a site visit SOW to the contractor? | _____ | _____ | _____ |
| • Has the PM obtained Rights-of-Entry, if applicable? | _____ | _____ | _____ |

ASSHP. Has the project team ensured that an ASSHP has been prepared and approved prior to the site visit?

_____	_____	_____
-------	-------	-------

CHAPTER 4 WORK PLANS

4-1. Introduction.

a. This chapter presents guidance for the project team regarding the preparation and review of EE/CA and Removal Action Work Plans. The purpose of developing Work Plans is to ensure that project goals will be achieved in a safe, timely, and cost-effective manner.

b. A Work Plan is required for all OE response projects. The contractor following the site visit will prepare the Work Plan, which is the basis for all contractor activities during the execution of the OE response action.

4-2. Performance Objectives. The project team should ensure that the Work Plan addresses the following:

- a. Project requirements in accordance with the SOW;
- b. Stakeholder requirements; and
- c. The approach, methods and operational procedures to be employed at the project site.

4-3. Work Plan Review. The contractor will submit the draft Work Plan to the PM and the Design Center POC for review and comment. Each project should be assessed individually to determine which specific areas of expertise should be involved in the review and approval process. As a minimum, the draft Work Plan should be reviewed by the:

- a. PM;
- b. Design Center POC;
- c. Project engineers;
- d. OE Safety Specialists;
- e. Industrial hygienist; and
- f. Cost engineers.

4-4. Work Plan Contents. The project team should ensure that the following components, as applicable, have been adequately presented in the Work Plan. Not all requirements will be applicable to all projects. It is the responsibility of the entity preparing the Work Plan to determine inapplicable requirements, or requirements not in this outline that should be included in the Work Plan. These should be identified in the SOW or discussed in the government meeting.

Attachment 4-1 presents a checklist of general requirements for the Work Plan. Additional details on Work Plan requirements are provided in subsequent chapters of this manual.

a. EE/CA RECON Work Plan. The EE/CA RECON is an optional task within the EE/CA phase. If the project team has determined that the RECON task should be implemented for a specific project, a RECON Work Plan and ASSHP should be prepared. Chapter 6 of this manual provides additional details on the RECON task. The contents of the EE/CA RECON Work Plan are:

(1) Chapter 1 – Introduction. This chapter should include a brief description of the project authorization, purpose and scope.

(2) Chapter 2 – Analysis of ASR. This chapter should discuss how the information provided in the ASR will be supplemented with additional information and how the ASR data will be converted into a spatially coincident digital format. The resulting digital format should allow the historical and site information to be used throughout the project.

(3) Chapter 3 – Spatial Analysis (Aerial Survey). This chapter should describe the procedures that will be used to perform a detailed analysis of spatial data to assist in making decisions regarding predicted areas of interest at the site. If an aerial survey is considered necessary, this chapter should describe the procedures for either conducting the survey or obtaining a recent survey from a local air survey company.

(4) Chapter 4 – Ground Reconnaissance. This chapter should discuss the procedures that will be used to conduct a ground reconnaissance to verify the results of the spatial analysis.

(5) Chapter 5 – Technology Evaluation. This chapter should present the procedures that will be used to evaluate various OE detection instruments using a test grid.

(6) Chapter 6 – Analysis Report and Data Archive. This chapter should describe the preparation of the analysis report documenting the results of the RECON task as well as the procedures for establishing a data archive.

b. EE/CA Work Plan. The contents of the EE/CA Work Plan are:

(1) Chapter 1 - Introduction. This chapter should include a brief description of the project authorization, purpose and scope.

(2) Chapter 2 - Site Description. This chapter should discuss the site characteristics, including location, physical description, and history; a summary of previous investigations; and an initial summary of OE risk.

(3) Chapter 3 - Project Management. This chapter should include a discussion of the following project features: objectives, organization, personnel, communication and reporting,

deliverables, schedule, public relations support, subcontractor management procedures, and field operation management procedures.

(4) Chapter 4 – Overall Approach of the EE/CA. This chapter should include a discussion of the preliminary removal action goals, identification of data quality objectives, required data, data reduction and evaluation, data incorporation into EE/CA reports, OE exposure analysis, alternatives identification and analysis (including institutional control options), EE/CA report, EE/CA Approval Memorandum, EE/CA completion and close-out, use of TCRAs during the EE/CA process, and follow-on activities.

(5) Chapter 5 - Site Layout and Control. This chapter should provide a map; zone delineation; and procedures for on/off-site communications, site access controls, and security (physical and procedural). If applicable, this chapter should discuss exclusion, contamination reduction and support zones for each work site in accordance with the requirements of 29 CFR 1910.

(6) Chapter 6 - Site Characterization. This chapter should include a description of how the site will be investigated. This chapter should describe the goals, methods, procedures and personnel used for field sampling and data gathering activities. The topics that should be specifically addressed in this chapter are listed below and discussed in more detail in Chapters 7 and 8.

- (a) Use of statistical sampling tools;
- (b) OE sampling grid locations;
- (c) Geophysical investigation procedures;
- (d) Surveying and mapping procedures;
- (e) Risk characterization and analysis procedures;
- (e) Institutional analysis procedures;
- (f) Geographic Information System (GIS) requirements; and
- (g) Data management and data backup procedures.

(7) Chapter 7 - OE Planning and Operations. This chapter should describe how OE operations would be planned and implemented utilizing appropriately qualified personnel, equipment and procedures. No substitute experience or qualifications will be accepted for personnel requirements. This chapter should specifically address the following:

- (a) Operations in OE areas;

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- (b) OE accountability and records management;
- (c) OE identification;
- (d) OE removal;
- (e) OE transportation;
- (f) OE storage;
- (g) OE disposal procedures;
- (h) OE disposal range, if used;
- (i) OE personnel and qualifications; and
- (j) Disposal alternatives.

(8) Chapter 8 - Explosives Management Plan. This chapter should describe how demolition explosives would be managed, planned and implemented during OE operations utilizing appropriately qualified personnel, equipment and procedures. This chapter should also describe management of recovered OE.

(9) Chapter 9 - Environmental Protection Plan. This chapter should provide details of the approach, methods, and operational procedures to be employed to perform all delivery tasks in compliance with environmental regulations at a project site. Additional information on the Environmental Protection Plan is provided in Chapter 5 of this manual.

(10) Chapter 10 - Quality Control Plan. This chapter should discuss quality control procedures for the project. Additional information on the contents of the Quality Control Plan is provided in Chapter 12 of this manual.

(11) Chapter 11 – SSHP. This chapter should discuss the health and safety procedures that will be implemented at the site.

(12) Other items. The Work Plan will also include references and appendices as required.

c. Removal Action Work Plan. The contents of the Removal Action Work Plan are:

(1) Chapter 1 – Introduction. This chapter should provide information on the site location, site history, topography, climate and other general information deemed appropriate.

(2) Chapter 2 – Technical Management Plan. This chapter should document the approach and procedures to be used to execute the tasks included in the SOW. Data management and data backup procedures should be included.

(3) Chapter 3 – Explosives Management Plan. This chapter should provide a description of the procedures and materials to be used for the management of explosives at the site. This should include procedures for acquisition, receipt, storage, security, transportation and inventory of explosives.

(4) Chapter 4 - Explosives Siting Plan. This chapter should describe the safety criteria for siting explosives operations at the site. This should include a description of explosives storage magazines including the Net Explosive Weight (NEW) and Quantity-Distance (Q-D) criteria, OE areas including separation distances, and planned or established demolitions areas. These explosives operations should be identified on a site map. The Explosives Siting Plan should also address footprint areas for blow-in-place, collection points, and in-grid consolidated shots, although these footprint areas do not need to be shown on the site map. When a project requires an ESS, the data from the Explosives Siting Plan will be incorporated into the Q-D section of the ESS. Additional detail is provided in paragraph 11-9 of this manual.

(5) Chapter 5 - Geophysical Investigation Plan. This chapter should describe the requirements for all geophysical activities that will occur during the project. Additional information on the contents of this plan is provided in paragraph 7-11 of this manual.

(6) Chapter 6 - SSHP. This chapter should discuss the safety and health program that will be implemented at the site. The SSHP should be prepared in accordance with Occupational Safety and Health Administration (OSHA) and USACE requirements. The project team should refer to safety guidance documents for specific requirements.

(7) Chapter 7 – Location Surveys and Mapping Plan. This chapter should document the site-specific survey, mapping, aerial photography and GIS requirements for the project. Additional details on this chapter are provided in paragraph 8-5 of this manual.

(8) Chapter 8 – Work, Data, and Cost Management Plan. This chapter should describe how the work will be managed and accomplished, and how costs will be controlled.

(9) Chapter 9 - Property Management Plan. This chapter should detail procedures for the management of government property in accordance with Federal Acquisition Regulation (FAR) Part 45.5 and its supplements.

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(10) Chapter 10 – Sampling and Analysis Plan. This chapter should describe site-specific procedures, equipment and methods to be used for the collection, preservation, analysis, shipment, quality assurance (QA)/quality control (QC) and reporting for soil, sludge, sediment, ash and/or water samples. This plan should also identify the laboratory that will be used, the number and locations of samples, and the rationale used to design the sampling approach.

(11) Chapter 11 – Quality Control Plan. This chapter should document the approach and procedures to be used to ensure quality throughout the execution of project. Additional details on the Quality Control Plan are provided in paragraph 12-6 of this manual.

(12) Chapter 12 – Environmental Protection Plan. This chapter should describe the procedures and methods to be implemented during site activities to minimize pollution, protect and conserve natural resources, restore damage, and control noise and dust within reasonable limits. Additional information on the Environmental Protection Plan is provided in paragraph 5-7 of this manual.

(13) Chapter 13 – Investigative Derived Waste Plan. This chapter should describe how investigative derived waste (IDW) will be handled on the work site. Issues that should be addressed include requirements for containerization, sampling and analysis, disposal, manifesting and storage time limits.

(14) Chapter 14 – Appendices. The Removal Action Work Plan should include the following documents as appendices:

- (a) SOW;
- (b) Site Maps;
- (c) Local POCs;
- (d) Contractor's QC log form;
- (e) Contractor's safety meeting attendance log form;
- (f) Contractor's site visitors log form;
- (g) Contractor's safety inspections log form; and
- (h) Contractor's daily report of OE operations form.

4-5. Work Plan Approval. The Work Plan approval process is applicable to the RECON Work Plan, EE/CA Work Plan, and Removal Action Work Plan. Following the review of the draft Work Plan, the project team should provide comments to the Design Center POC for incorporation into the final Work Plan. Following the final approval of the Work Plan from the project team and CO,

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a Notice-to-Proceed may be issued. If any proposed changes occur to the approved Work Plan, the project team should review them prior to implementation. If the project team approves changes, the modifications should be forwarded to the CO for approval. The CO will then issue the modification to the contractor.

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ATTACHMENT 4-1
WORK PLAN REVIEW CHECKLIST

Project Name: _____
Project Location: _____
Design Center POC: _____
Reviewer's Name and Title: _____
Date of Review: _____

	Y	N	N/A
<u>General</u>			
1. Have the following project team members, at a minimum, reviewed the Work Plan:			
• PM?	_____	_____	_____
• Design Center POC?	_____	_____	_____
• OE Safety Specialist?	_____	_____	_____
• Project engineers in relevant subject matter areas?	_____	_____	_____
• Industrial hygienist?	_____	_____	_____
• Cost Engineer?	_____	_____	_____
2. Is the Work Plan in compliance with the project SOW?	_____	_____	_____
3. Is the Work Plan in compliance with contract requirements?	_____	_____	_____

EE/CA RECON Work Plan

The project team should ensure that the RECON Work Plan has been prepared in accordance with the SOW and contract specifications. The RECON Work Plan will generally include the following chapters:

1. **Chapter 1 - Introduction.** Are the following topics discussed in this chapter:
 - Project authorization? _____

	Y	N	N/A
• Project purpose?	_____	_____	_____
• Project scope?	_____	_____	_____
2. Chapter 2 - Analysis of ASR. Are the following topics discussed in this chapter:			
• Procedures for supplementing the existing ASR data?	_____	_____	_____
• Procedures for converting the ASR data into a spatially coincident digital format that will allow the information to be used throughout the project?	_____	_____	_____
3. Chapter 3 - Spatial Analysis (Aerial Survey). Are the following topics discussed in this chapter:			
• Procedures for completing a detailed analysis of spatial data in order to differentiate potentially contaminated areas from contaminated areas?	_____	_____	_____
• If necessary, procedures for completing an aerial survey of the site or obtaining a recent aerial survey from a local air survey company?	_____	_____	_____
4. Chapter 4 - Ground Reconnaissance. Are the following topics discussed in this chapter:			
• Procedures for verifying the results of the spatial analysis in the field?	_____	_____	_____
• Obtaining a ROE?	_____	_____	_____
5. Chapter 5 - Technology Evaluation. Is the following topic discussed in this chapter:			
• Procedures evaluating various OE detection instruments using a test grid? (See Chapter 7 of this manual for additional detail.)	_____	_____	_____
6. Chapter 6 - Analysis Report and Data Archive. Are the following topics discussed in this chapter:			
• Procedures for reporting the RECON results?	_____	_____	_____
• Procedures for archiving the RECON data?	_____	_____	_____

	Y	N	N/A
<u>EE/CA Work Plan</u>			
The project team should ensure that the EE/CA Work Plan has been prepared in accordance with the SOW and contract specifications. The EE/CA Work Plan will generally include the following chapters:			
1. Chapter 1 - Introduction. Are the following topics discussed in this chapter:			
• Project authorization?	_____	_____	_____
• Project purpose?	_____	_____	_____
• Project scope?	_____	_____	_____
2. Chapter 2 - Site Description. Are the following topics discussed in this chapter?			
• Site characteristics including location, physical description and history?	_____	_____	_____
• Summary of previous site investigations?	_____	_____	_____
• Initial summary of OE risk at the site?	_____	_____	_____
3. Chapter 3 - Project Management. Are the following topics discussed in this chapter:			
• Project organization?	_____	_____	_____
• Project organization?	_____	_____	_____
• Project personnel?	_____	_____	_____
• Project communication and reporting?	_____	_____	_____
• Deliverables?	_____	_____	_____
• Schedule?	_____	_____	_____
• Public relations support?	_____	_____	_____
• Subcontractor management procedures?	_____	_____	_____
• Field operation management procedures?	_____	_____	_____

	Y	N	N/A
4. Chapter 4 - EE/CA Approach. Are the following topics discussed in this chapter:			
• Preliminary removal action goals?	_____	_____	_____
• Data quality objectives?	_____	_____	_____
• Required data?	_____	_____	_____
• Data reduction and evaluation?	_____	_____	_____
• Data incorporation into the EE/CA report?	_____	_____	_____
• OE exposure analysis?	_____	_____	_____
• Alternatives identification and analysis?	_____	_____	_____
• EE/CA report?	_____	_____	_____
• EE/CA approval memorandum?	_____	_____	_____
• EE/CA completion and close-out?	_____	_____	_____
• Use of TCRA during EE/CA process?	_____	_____	_____
• Follow-on activities?	_____	_____	_____
5. Chapter 5 - Site Layout and Control. Are the following topics included in this chapter:			
• Is a site map provided?	_____	_____	_____
• Are zones delineated?	_____	_____	_____
• Are procedures for on/off site communications discussed?	_____	_____	_____
• Are procedures for site access control discussed?	_____	_____	_____
• Are security procedures discussed?	_____	_____	_____
6. Chapter 6 - Site Characterization. Are the following topics included in this chapter:			
• Site characterization goals?	_____	_____	_____
• Site characterization procedures and methods?	_____	_____	_____
• Personnel requirements?	_____	_____	_____

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	Y	N	N/A
• OE sampling grid locations?	_____	_____	_____
• Surveying and mapping procedures?	_____	_____	_____
• Geophysical investigation procedures?	_____	_____	_____
• Data management and data backup procedures?	_____	_____	_____
• Risk characterization procedures?	_____	_____	_____
• Institutional analysis?	_____	_____	_____
• GIS requirements?	_____	_____	_____
7. Chapter 7 – OE Planning and Operations. Does this chapter discuss the planning and implementation of the following:			
• Operations in OE area?	_____	_____	_____
• OE accountability and record management?	_____	_____	_____
• OE identification?	_____	_____	_____
• OE removal?	_____	_____	_____
• OE transportation?	_____	_____	_____
• OE storage?	_____	_____	_____
• OE disposal procedures?	_____	_____	_____
• OE disposal range, if used?	_____	_____	_____
• OE disposal alternatives:	_____	_____	_____
• OE personnel and qualifications?	_____	_____	_____
• Is this chapter in accordance with CEHND 1105-3-14?	_____	_____	_____
8. Chapter 8 - Explosives Management Plan.			
• Does this chapter describe how demolition explosives will be managed, planned and implemented during OE operations?	_____	_____	_____

	Y	N	N/A
9. Chapter 9 - Environmental Protection Plan.			
Does this chapter provide details on the approach, methods and operational procedures employed to ensure all tasks are performed in compliance with environmental regulations at the site? (See Chapter 5 for additional review criteria.)	_____	_____	_____
10. Chapter 10 - Quality Control			
Does this chapter adequately discuss quality control procedures for the OE project? (See Chapter 12 of this manual.)	_____	_____	_____
11. Chapter 11 - Site Safety and Health Plan.			
Does this chapter adequately discuss the health and safety procedures to be implemented at the site? (See safety guidance documents for specific criteria.)	_____	_____	_____
12. Other items.			
- Does the Work Plan include any additional information required in the SOW? - Does the Work Plan include appropriate references and appendices?	_____	_____	_____

Removal Action Work Plan

The project team should ensure that the Removal Action Work Plan has been prepared in accordance with the SOW and contract specifications. The Removal Action Work Plan will generally include the following chapters:

1. Chapter 1 - Introduction. Are the following topics discussed in this chapter:

- | | | | |
|--------------------|-------|-------|-------|
| • Site location? | _____ | _____ | _____ |
| • Site history? | _____ | _____ | _____ |
| • Site topography? | _____ | _____ | _____ |
| • Climate? | _____ | _____ | _____ |

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	Y	N	N/A
• Other appropriate information?	_____	_____	_____
2. Chapter 2 - Technical Management Plan. Are the following topics discussed in this chapter:			
• Approach to be used to execute the tasks included in the SOW?	_____	_____	_____
• Procedures to be used to execute the tasks included in the SOW?	_____	_____	_____
• Data management and data backup procedures?	_____	_____	_____
3. Chapter 3 - Explosives Management Plan. Are the following topics discussed in this chapter:			
• Acquisition of explosives, including source?	_____	_____	_____
• Type of explosives to be used?	_____	_____	_____
• Quantity of explosives to be used?	_____	_____	_____
• Procedures for receipt of explosives?	_____	_____	_____
• Procedures for resolving discrepancies in quantities shipped and quantities received?	_____	_____	_____
• Establishment of explosive storage facilities?	_____	_____	_____
• Physical security of explosive storage facilities?	_____	_____	_____
• Transportation procedures from storage to disposal locations on-site?	_____	_____	_____
• Requirements for on-site transport vehicles?	_____	_____	_____
• Names of personnel authorized to receive, issue, transport and use explosives?	_____	_____	_____
• Inventory procedures?	_____	_____	_____
• Procedures for issuance of explosives on-site?	_____	_____	_____
• Procedures for daily return to storage of unused explosives?	_____	_____	_____
• Procedures for disposal of unused explosives at the end of site activities?	_____	_____	_____

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	Y	N	N/A
Compliance with FAR 45.5, local and state laws and regulations, ATFP 5400.7, DOD 6055.9-STD, DOT regulations and AR 190-11?	_____	_____	_____
4. Chapter 4 - Explosives Siting Plan. Are the following topics discussed in this chapter:			
Type of explosive storage magazines to be used?	_____	_____	_____
NEW and hazard division to be stored in each magazine?	_____	_____	_____
Use of Q-D criteria to site magazines?	_____	_____	_____
Design criteria for engineering controls to be used to mitigate exposures to public when required Q-D criteria cannot be met?	_____	_____	_____
Determination of appropriate safe separation distances for the public during intrusive operations?	_____	_____	_____
Determination of planned or established demolition areas?	_____	_____	_____
Footprint areas for blow-in-place operations using the criteria for established demolition areas?	_____	_____	_____
Footprint areas for collection areas based on the same public separation distances as the Most Probable Munition (MPM)?	_____	_____	_____
Footprint areas for in-grid consolidated shots using the criteria for established demolition areas?	_____	_____	_____
Site map(s) showing Q-D arcs for public separation distances and personnel safe separation distances for planned or established demolition areas?	_____	_____	_____

	Y	N	N/A
5. Chapter 5 – Geophysical Investigation Plan.			
Does this chapter adequately discuss the requirements for project geophysical activities? (See chapter 7 of this manual for additional review criteria.)	_____	_____	_____
6. Chapter 6 - Site Safety and Health Plan.			
Does this chapter adequately discuss the health and safety procedures to be implemented at the site? (See safety guidance documents for specific criteria.)	_____	_____	_____
7. Chapter 7 - Location Surveys and Mapping Plan.			
Are the following topics discussed in this chapter?			
Survey requirements/procedures as specified in SOW/contract?	_____	_____	_____
Mapping requirements/procedures as specified in SOW/contract?	_____	_____	_____
Aerial photography requirements/procedures as specified in SOW/contract?	_____	_____	_____
GIS requirements as specified in SOW/contract?	_____	_____	_____
8. Chapter 8 - Work, Data and Cost Management Plan.			
Are the following topics discussed in this chapter?			
Description of the project management approach for all tasks including controls to ensure timely performance and use of correct procedures?	_____	_____	_____
Schedule including milestones for deliverables, chronology of tasks, number of working days between milestones, and associated costs and human resources required?	_____	_____	_____
Description of cost control and tracking methodology to be used?	_____	_____	_____
List of recurring deliverables to be submitted which relate to work, data and cost management?	_____	_____	_____

	Y	N	N/A
9. Chapter 9 - Property Management Plan. Are the following topics discussed in this chapter?			
• Description and quantity of materials to be used?	_____	_____	_____
• Source and estimated rental/acquisition costs of all materials?	_____	_____	_____
• Documentation of the contractor's process to acquire 3 quotes for each item and a comparison of rental versus purchase cost for each item?	_____	_____	_____
• Basis of selection to be used by the contractor to recommend the source for leased vehicles?	_____	_____	_____
• List of consumable supplies and personal property that are included in the Contractor's overhead rate?	_____	_____	_____
• Proposed storage plan, including the method of separation of government property from contractor property?	_____	_____	_____
• Ultimate disposal plan covering salvage, turnover to the government, or other disposition of material upon contract termination?	_____	_____	_____
• Plan for submitting a property tracking log report which lists all contractor acquired property that is directly charged to the project?	_____	_____	_____
• Procedures for notifying the Contracting Officer of loss, damage, or destruction of accountable government property?	_____	_____	_____
10. Chapter 10 - Sampling and Analysis Plan. Are the following topics discussed in this chapter?			
• Procedures, equipment and methods for:			
– Collection and preservation of samples?	_____	_____	_____
– Field and Laboratory analyses?	_____	_____	_____
– Sample shipment?	_____	_____	_____
– QA/QC?	_____	_____	_____

	Y	N	N/A
Contaminants of concern and associated detection limits?	_____	_____	_____
Number and locations of samples, including QA/QC samples?	_____	_____	_____
Data reporting methods?	_____	_____	_____
Identification of analytical laboratory and copies of the appropriate validations/certifications?	_____	_____	_____
11. Chapter 11 - Quality Control Plan.			
Does this chapter adequately discuss quality control procedures for the OE project? (See Chapter 12 of this manual for specific review criteria.)	_____	_____	_____
12. Chapter 12 – Environmental Protection Plan.			
Does this chapter adequately describe procedures to minimize pollution, protect and conserve natural resources, restore damage, and control noise and dust within reasonable limits? (See Chapter 5 manual for specific review criteria.)	_____	_____	_____
13. Chapter 13 - Investigative Derived Waste Plan. Are the following topics discussed in this chapter:			
Handling of IDW at the site?	_____	_____	_____
Type of containerization, if required?	_____	_____	_____
Description of the sampling and analytical strategy utilized?	_____	_____	_____
List of acceptable disposal facilities?	_____	_____	_____
Description of site storage and security?	_____	_____	_____
Description of transportation requirements and procedures?	_____	_____	_____
Description of manifesting requirements and procedures?	_____	_____	_____
Description of storage time limits?	_____	_____	_____

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	Y	N	N/A
Is regulatory acceptance of the IDW Plan required? If so, has regulatory acceptance been received?	_____	_____	_____
14. Appendices. Are the following documents included as appendices to the Work Plan:			
SOW?	_____	_____	_____
Site maps?	_____	_____	_____
Local points of contact?	_____	_____	_____
Resumes for key personnel and personnel filling core labor categories, EOD school graduation certificates if applicable?	_____	_____	_____
- Contractor forms for collecting the following data: - Quality Control Log? - Safety Meeting Attendance Log? - Site Visitors Log? - Safety Inspections Log? - Daily Report of OE Operations?	_____	_____	_____
	_____	_____	_____

CHAPTER 5 REGULATORY COMPLIANCE

5-1. Introduction. This chapter presents guidance on regulatory compliance issues the project team should consider during an OE response project.

5-2. Performance Objectives. The project team's performance objectives for regulatory compliance on OE projects are to:

- a. Execute OE projects in accordance with federal, state and local regulatory requirements; and
- b. Develop planning documents adequately addressing environmental considerations.

5-3. OE Response Regulatory Authorities. The OE response process at Formerly Used Defense Sites (FUDS) is consistent with the CERCLA and the NCP. The determination of the governing laws and regulations for any specific OE project will be made by the District Office of Counsel in consultation with counsel supporting the OE MCX for FUDS, or the appropriate legal representative of the sponsoring agency for work performed by USACE under a different program or authority (e.g., Base Realignment and Closure [BRAC], Installation Restoration Program [IRP], or Work for Others). EP 1110-1-18 provides an overview of the legal authorities governing OE response actions.

5-4. Applicable or Relevant and Appropriate Requirements. The project team should consider applicable or relevant and appropriate requirements (ARARs) under federal or state laws to the extent practicable considering the urgency of the situation and the scope of the response. Therefore, ARARs should be considered prior to selecting the most suitable OE response for a particular site. EP 1110-1-18 provides additional information regarding ARARs on OE response actions.

5-5. Environmental Considerations. EP 1110-1-18 provides a discussion of environmental considerations that should be addressed by the project team before and during an OE response action. Summary tables of environmental laws and regulations as well as DOD Directives, Instructions and Regulations relevant to OE response actions are also provided.

5-6. Environmental Survey. Prior to the start of on-site activities, an environmental survey will be conducted jointly by the contractor and the CO/CO Representative (COR) or other government personnel. The purpose of the environmental survey is to identify any wetlands, endangered and protected species or habitats, and cultural or historical resource areas. The contractor will prepare an Environmental Report including a layout plan which shows the current condition of trees, shrubs and grassy areas immediately adjacent to the site work areas, storage

areas, and access routes. Both the contractor and CO will sign this report prior to the start of on-site activities upon mutual agreement as to its accuracy and completeness.

5-7. Environmental Protection Plan. The project team should review the Environmental Protection Plan (EPP) included as part of the Work Plan. The EPP should provide details of the approach, methods, and operational procedures to be employed at a project site to minimize pollution, protect and conserve natural resources, restore damage and control noise and dust within reasonable limits.

a. Contents. The project team should ensure that the EPP contains the elements described in the following paragraphs. Attachment 5-1 is an EPP review checklist.

(1) A list of potential ARARs should be provided as well as an initial determination as to their actual applicability to the project. The procedure by which ARARs will be identified and complied with during field investigation activities should be described. The EPP should also note that evaluation of ARARs is an iterative process to be performed throughout the life of the project, particularly when evaluating and recommending an appropriate removal response.

(2) The EPP should detail the identification and location of, as well as provide procedures to protect and/or mitigate the impact to, the following:

- (a) Endangered or protected species;
- (b) Cultural or historical resources;
- (c) Wetlands;
- (d) Water resources;
- (e) Coastal zones;
- (f) Trees and shrubs that will be removed within the project site; and
- (g) Existing waste disposal sites within the project site.

(3) The EPP should discuss the environmental protection strategy which describes the potential for occurrence of adverse impacts and the protective, avoidance or mitigative actions the contractor will take in the following areas:

- (a) Land areas affected by the work;
- (b) Work site;
- (c) Storage areas;

- (d) Temporary facilities;
 - (e) Access routes;
 - (f) Trees and shrubs protection and restoration;
 - (g) Water resources - control of water used on-site, control of run-on water, and control of run-off water and sediment;
 - (h) Waste disposal - uncontaminated waste, contaminated waste, packaging, labeling, storage and disposal, manifesting and transportation, compliance with 40 CFR 262, subpart b, compliance with Department of Transportation (DOT) shipping regulations;
 - (i) Burning;
 - (j) Dust and emission control;
 - (k) Spill control and prevention;
 - (l) Decontamination and disposal of equipment; and
 - (m) Minimization of areas of disturbance.
- (3) The EPP should also include procedures for post-activity cleanup.

b. Environmental Documentation. The contractor may be required to prepare environmental documentation prior to any field work for Non-Time Critical Removal Actions (NTCRAs). The environmental documentation should conform to the requirements of Army Regulation (AR) 200-2, Environmental Effects of Army Actions. The environmental documentation may be in the form of a Record of Environmental Consideration, Environmental Assessment, Environmental Impact Statement, or EE/CA. The CO will determine the type of environmental documentation required at each site.

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ATTACHMENT 5-1
ENVIRONMENTAL PROTECTION PLAN REVIEW CHECKLIST

Project Name: _____
 Project Location: _____
 Design Center POC: _____
 Reviewer's Name and Title: _____
 Date of Review: _____

Y N N/A

Review of the Environmental Protection Plan

The project team should ensure that the Environmental Protection Plan, a chapter to the Work Plan, has been prepared in accordance with the SOW and contract specifications. The project team should ensure that the following items are discussed in the EPP:

- | | | | |
|--|-------|-------|-------|
| 1. Is a list of potential ARARs provided? | _____ | _____ | _____ |
| 2. Is an initial determination provided as to the actual applicability of these ARARs to the project? | _____ | _____ | _____ |
| 3. Is the procedure by which ARARs will be identified and complied with during field investigation activities described? | _____ | _____ | _____ |
| 4. Does the EPP note that evaluation of ARARs is an iterative process to be performed throughout the life of the project? | _____ | _____ | _____ |
| 5. Does the EPP detail the identification and location of, as well as provide procedures and methods to protect and/or mitigate the impacts to, the following: | | | |
| • Endangered or protected species? | _____ | _____ | _____ |
| • Cultural or historical resources? | _____ | _____ | _____ |
| • Wetlands? | _____ | _____ | _____ |
| • Water resources? | _____ | _____ | _____ |
| • Coastal zones? | _____ | _____ | _____ |

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	Y	N	N/A
• Trees and shrubs that will be removed within the project site?	_____	_____	_____
• Existing waste disposal sites within the project site?	_____	_____	_____
6. Does the EPP include a description of the joint environmental survey conducted prior to the start of any on-site work by the contractor and CO/COR or other government personnel?	_____	_____	_____
7. Does the EPP include an environmental protection strategy describing the potential for occurrence of adverse impacts and the protective or avoidance actions the contractor will take in the following areas:			
• Land areas affected by the work?	_____	_____	_____
• Work site?	_____	_____	_____
• Storage areas?	_____	_____	_____
• Temporary facilities?	_____	_____	_____
• Access routes?	_____	_____	_____
• Trees and shrubs protection and restoration?	_____	_____	_____
• Water resources:			
– Control of water used on-site?	_____	_____	_____
– Control of run-on water?	_____	_____	_____
– Control of run-off water and sediment?	_____	_____	_____
• Waste disposal:			
– Uncontaminated waste?	_____	_____	_____
– Contaminated waste?	_____	_____	_____
– Packaging, labeling?	_____	_____	_____
– Storage and disposal?	_____	_____	_____
– Manifesting and transportation?	_____	_____	_____
– Compliance with 40 CFR 262, subpart b?	_____	_____	_____
– Compliance with DOT shipping regulations?	_____	_____	_____

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	Y	N	N/A
• Burning?	_____	_____	_____
• Dust and emission control?	_____	_____	_____
• Spill control and prevention?	_____	_____	_____
• Decontamination and disposal of equipment?	_____	_____	_____
• Minimization of areas of disturbance?	_____	_____	_____
8. Does the EPP describe procedures for post-activity clean-up?	_____	_____	_____
9. Does the EPP include a requirement for the appropriate environmental documentation as specified in the SOW by the CO?	_____	_____	_____

CHAPTER 6 SITE RECONNAISSANCE

6-1. Introduction.

a. This chapter discusses the elements of an OE response Site Reconnaissance (RECON) tasking that should be addressed by the project team. The RECON tasking is an optional element within the EE/CA phase of the OE response process. If implemented, RECON is the first task of the EE/CA phase. The purpose of the RECON tasking is to:

(1) Build upon site-specific data gathered during the PAE and SI phases in an effort to save costs associated with the EE/CA investigation;

(2) Provide detailed information that can be used by the project team to refine the SOW and cost estimate for the subsequent EE/CA investigation; and

(3) Identify any areas of concern with imminent OE hazards requiring implementation of a TCRA.

b. Based on the adequacy of existing site information for development of a definitive EE/CA SOW, the project team should include RECON in the project schedule. The government may complete the RECON task and supply the result to the EE/CA contractor as Government Furnished Information or the RECON task may be conducted by the EE/CA contractor as an independent task.

6-2. Data Quality Objectives.

a. The project team should consider data quality objectives for each of the following areas during the preparation of the RECON SOW.

(1) Geospatial Data and Geospatial Data Systems (GD&S). The project team should develop project-specific GD&S requirements for inclusion in the SOW for each OE project in accordance with Chapter 9, "Geospatial Data and Systems". GD&S requirements should include site-specific standards for the format, transfer, and storage of all geospatial data. Factors influencing formulation of data standards include:

(a) Compatibility with current OE MCX and district hardware and software platforms;

(b) Existing digital data and geo-spatial referenced mapping; and

(c) Usability by all parties of concern, including stakeholders.

(2) Spatial Data Reference System. Unless otherwise specified, all horizontal control will be based on either the English or metric system and reference to the North American Datum of 1983 (NAD83) and the State Plane Grid System for the project location. Vertical control, if required, will also be based on either the English or metric system and referenced to the North American Datum of 1988 (NAVD88).

(3) Base Mapping. Aerial photography provides a cost-effective means of developing a base map for an OE response project. The process of developing historic site use and characterization requires a level of detail that is generally well within the normal resolving power of aerial photography collected under normal conditions. Resolution values of one meter or less are desired for identification of features and boundaries between former as well as current land uses.

(4) Composite Data Modeling. Geographic positioning of interpreted features from one time frame or photography scale to another should be carefully monitored. A good-quality scale-compatible base map will serve to minimize this problem. Enlargements of orthophotography and other scale-controlled photography for map production should not exceed an upper scale limit of twice the original scale. Enlargements greater than two times require some degree of field verification of resulting solutions.

(5) Scale and Resolution. The original data scale and resolution or detection properties of the data should be clearly identified with each data set in order to ensure that no misleading detail is implied.

(6) Imaging/Remote Sensing. Airborne geophysical surveys for gross characterization of potential OE contaminated sites are advancing technology procedures. The nature, scope, and cost of these methods dictate that specialized contractors should provide these services, if utilized. The airborne geophysical contractor should have experience, equipment, and documented results from prior airborne services.

(7) Probability of Detection (Pd). The project team developing the SOW should determine the minimum criteria and level of confidence the contractor should meet to have an acceptable Pd performance for any airborne geophysical mapping.

(8) Horizontal Accuracy. The project team should state in the SOW the horizontal accuracy required for any geophysical mapping and reacquisition of data. The horizontal accuracy statements should address the minimum percentile(s) of all identified point targets that should lie within defined radii of their surveyed surface position.

(9) Spatial Analysis/Stratification. Correlated geospatial data should be used by the project team to assist in making informed decisions on delineation of area of concern footprints. A reduction in the area of concern footprints could result from using spatial analysis and stratification to differentiate probable levels of UXO contamination ("Footprint Reduction").

Ground-borne site characterization efforts can then be cost-effectively allocated to those portions of the site containing the greatest levels of concern. Therefore, the project team should develop minimum acceptable validation criteria for the correlation between derived solutions and actual conditions. Portions with lower levels of concern may be excluded from further OE response actions or designated as areas requiring limited confirmation sampling during the EE/CA phase.

(10) Quality Control. A number of quality control parameters should be evaluated on each geospatial data set in order to ensure that the whole RECON effort assembled for a site is of equal reliability. These parameters include the reliability of each set of photographs or images, the reliability of the interpretation of each set, the scale quality of each set, and the relationship of each set to the selected base mapping.

b. An important and common standard for all presentations of data is the inclusion of proper and sufficient notation on maps indicating the data sources, data interpretation and preparation methods, and their geographic integrity.

6-3. Statement of Work.

a. The SOW for a RECON task should be prepared by personnel with a detailed knowledge of the project's history, geospatial data, geospatial data systems, aerial photogrammetry, photo interpretation, spatial data analyses, range characteristics, UXO risk assessment processes and procedures, geophysical survey methodologies, and statistical sampling strategies. The RECON SOW should be results-oriented. In preparing the SOW for the RECON tasking, the project team should review the site-specific requirements as they relate to the following:

- (1) Work Plan and ASSHP;
- (2) Analysis of the ASR;
- (3) Spatial analysis (aerial survey);
- (4) Ground reconnaissance;
- (5) Technology evaluation; and
- (6) Analysis report/data archive.

b. The project team should ensure that the RECON SOW specifies that all geophysical investigations will be managed by a qualified geophysicist as defined in Chapter 7 and that all characterization sampling and analysis methodologies are managed by a qualified professional with a background in statistics.

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6-4. Planning Considerations. Each RECON action requires selection of equipment and methodologies that will accomplish the end objective without wasting manpower, time, and money. The selected RECON strategy should be unambiguous and provide the project team with the capability to develop a response action that will yield reasonably safe use of each identified area of the project for the planned land use specified by the stakeholder. Attachment 6-1 is a checklist to be used when planning the RECON activity.

a. RECON Work Plan. The RECON Work Plan should definitively describe the operational parameters to be followed during execution of each RECON activity discussed below.

(1) Analysis of the ASR. The RECON Work Plan should discuss how the existing ASR data will be enhanced and converted into a spatially coincident digital format. This conversion of data will allow the historical and site information to be used throughout the project.

(2) Spatial Analysis (Aerial Survey). The RECON Work Plan should discuss the methodology for conducting a detailed analysis of spatial data. Spatial analysis may provide information to assist in making valid decisions regarding predicted areas of interest at the site by differentiating potentially contaminated areas from uncontaminated areas.

(3) Ground Reconnaissance. The Work Plan should discuss the procedures that will be implemented to conduct a ground reconnaissance (ground RECON) to verify the results of the spatial analysis.

(4) Technology Evaluation. The RECON Work Plan should discuss the methodology for the technology evaluation. The purpose of the technology evaluation is to determine which OE detection instrument is most appropriate for a specific site within a reasonable cost.

(5) Analysis Report and Data Archive. The Work Plan will discuss the procedures to be used to archive the results of the ASR analysis, spatial analysis, ground RECON, and technology evaluation.

b. ASSHP. Since all RECON activities will be accomplished using approved anomaly avoidance procedures, an ASSHP may be utilized to address health and safety requirements. The ASSHP is prepared when preliminary project activities are non-intrusive and occur prior to the approval of the site-specific EE/CA Work Plan and SSHP. If a contractor will be executing the RECON, the UXO Safety Officer (UXOSO) will prepare the ASSHP. If only government personnel are involved in the RECON, the OE Safety Specialist will prepare the ASSHP. All site visit participants will read, sign and comply with the ASSHP and attend all safety briefings held by the UXOSO or OE Safety Specialist (as applicable). On FUDS projects, the property owner may accompany the site visit team and should be invited to attend safety briefings even though they cannot be expected to comply with the ASSHP. If the site is operating under an existing

SSHP that adequately addresses the appropriate OE safety issues, an ASSHP is not required. The ASSHP should be prepared in accordance with EP 1110-1-18.

c. Archival Data Compilation and Correlation.

(1) Data compilation and correlation starts with selection or construction of a base map that includes not only the project site but also such adjacent mapping attributes that may provide influences on, or be influenced by, OE response activities. Valid historic land-use characterization and site descriptions are best developed where aerial photographs or scanner images have been recorded during previous site use. Sources and characteristics of available historic photographs are described in Chapter 9, EM 1110-1-1802, Geophysical Exploration for Engineering and Environmental Investigations.

(2) Construction of a geospatially correct base map will expedite conversion of ASR data into a spatially coincident digital format. This correlation of data will enhance integration and life cycle management of historical and newly collected project information. Many of the daily operational procedures for a range may be interpreted from the evidence recorded on aerial photography. Activity types and previous land use may be identified by photographic or image clues, such as open trenches, burning debris piles, ground and water discoloration, grading scars, vehicle tracks, and structure remains. The sequence of the disturbance and approximate chronology may also be established.

d. Geo-Spatial Data Collection. Site-specific data gathered during archival data compilation and correlation may not, in many cases, be sufficiently detailed to support initial stages of the OE response decision-making process. Therefore, supplemental characterization data (i.e., aerial geophysical surveys, aerial mapping) may be collected during the RECON tasking.

(1) Aerial Mapping. All aerial mapping activities required by the project team to support data analysis and footprint reduction should be completed consistent with the requirements of EM 1110-1-1000, Photogrammetric Mapping.

(2) Conventional Mapping. All conventional mapping activities required by the project team should be completed in accordance with Engineer Circular (EC) 1110-1-73, Standards and Specifications for Surveys, Maps, Engineering Drawings, and Related Spatial Data Products and Software. In addition, requirements from the Tri-Service Spatial Data Standard (TSSDS) should be applied to conventional mapping.

e. Data Analysis/Footprint Reduction. Significant portions of larger tracts of land may be initially identified that do not require or result in any OE response action. Data analysis should be used to identify which portions of these larger tracts possess attributes attributable to UXO contamination requiring further OE response actions and should result in reduction of the investigation footprint as appropriate.

f. Field Confirmation.

(1) Field confirmation is required to verify and validate the results of the data analysis and footprint reduction. Reconnaissance personnel should review areas excluded for any evidence of OE contamination such as changes in vegetation, topographic and soil deformations and ground scars.

(2) Rights-of-entry are required for field confirmation activities on lands outside federal, state, or local governmental ownership.

g. Geophysical Technology Assessment. An assessment of geophysical technology (e.g., Instrument Prove Out, as described in Chapter 7) may be more effectively accomplished during the RECON phase. This would enable the project team to prepare a more definitive EE/CA SOW with regard to geophysical sampling.

h. Data Archive. A database tracking system should be established to archive all information gathered during the RECON phase. This database should contain information on all historic and current activities at the site. The data archive may be used to support the decision to continue or discontinue an investigation in an area of concern.

i. Report Preparation. The results of all RECON actions should be compiled into an Analysis Report. This information can then be used in developing the EE/CA SOW and documentation supporting any required TCRA.

ATTACHMENT 6-1
SITE RECONNAISSANCE CHECKLIST

Project Name: _____
 Project Location: _____
 Design Center POC: _____
 Preparer's Name and Title: _____
 Date of Preparation: _____

Y N N/A

RECON Planning Considerations

1. Have Data Quality Objectives in the following areas been considered for the RECON task:

- Geospatial Data and Geospatial Data Systems?
- Spatial Data Reference System?
- Base Mapping?
- Composite Data Modeling?
- Scale and Resolution?
- Imaging/Remote Sensing?
- Probability of Detection?
- Horizontal Accuracy?
- Spatial Analysis/Stratification?
- Quality Control?

2. Have the following components of the RECON task been considered in the SOW:

- Work Plan preparation?
- ASSHP preparation?
- Archival data compilation and correlation?

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	Y	N	N/A
• Geospatial data collection:			
– Aerial mapping?	_____	_____	_____
– Conventional mapping?	_____	_____	_____
• Data analysis/footprint definition?	_____	_____	_____
• Field confirmation?	_____	_____	_____
• Geophysical technology assessment?	_____	_____	_____
• Data Archive?	_____	_____	_____
• Report preparation?	_____	_____	_____

CHAPTER 7

GEOPHYSICAL INVESTIGATIONS FOR UNEXPLODED ORDNANCE (UXO)

7-1. Introduction. This chapter addresses the planning and performance of geophysical investigations at UXO sites. An overview of geophysical approaches, their capabilities and limitations is provided. Attachment 7-1 is a checklist for the project team to follow when planning geophysical investigations for UXO.

7-2. Objective.

a. Geophysical investigations are performed at UXO sites for one of three main purposes:

(1) Geophysical Sampling. Geophysical sampling is performed at representative portions of a site in order to characterize a larger area. The objective of geophysical sampling is to cost-effectively characterize the distribution, type and condition of UXO across a site.

(2) Geophysical Mapping. Geophysical mapping is performed across an entire area suspected of containing UXO. The objective of geophysical mapping is to locate all detectable UXO meeting pre-selected criteria such as UXO type, size, composition, depth or other similar parameters.

(3) Geophysical Interrogation. Geophysical interrogation can be performed at specific locations or small sites in order to obtain additional target information beyond that gathered by initial investigations. Techniques used for geophysical interrogation are generally too slow and expensive to be used over broad areas, but can yield important information about size, depth, composition and configuration of individual targets or target clusters.

b. In each case, the objective of the geophysical investigation is to efficiently locate buried UXO while minimizing the number of non-UXO geophysical anomalies.

7-3. Initial Geophysical Planning.

a. A geophysical investigation system capable of effectively locating buried UXO must have four fully integrated components, as follows:

(1) Experienced personnel - Personnel experienced with the theoretical and practical aspects of detecting relatively small UXO and discriminating the UXO from multiple non-UXO items that are also likely to be present. The selection and utilization of geophysical equipment is complex and requires qualified, experienced individuals. All geophysical investigations for UXO should be managed by a qualified geophysicist. A "qualified geophysicist" is a person with a degree in geophysics, geology, geological engineering, or closely related field and who has a minimum of five years of directly related geophysical experience.

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(2) Geophysical instruments - Geophysical instruments that are well suited to detecting buried UXO, taking into account site specific factors that include type and depth of target UXO, as well as terrain, vegetation, geologic and cultural features.

(3) Analysis procedures - Procedures for analyzing and interpreting geophysical data generated by geophysical instruments.

(4) Navigational accuracy and precision - The ability to accurately and precisely locate a geophysical target in relation to other known points, preferably in a common survey grid and/or datum.

b. If any of the above four components are lacking, the overall geophysical system will not be able to locate UXO effectively. Therefore, it is important to carefully plan and integrate all aspects of a geophysical investigation and not start field work prematurely.

7-4. Geophysical Instruments. Detection and location of UXO primarily depends on the ability of geophysical instruments to distinguish the physical characteristics of UXO from those of the surrounding environment. The best currently available detection systems all detect the metallic content of the UXO, not the explosive filler.

a. Considerations that affect selection of an applicable UXO detection system include:

(1) UXO composition - Some detectors are limited to particular types of metals.

(2) UXO size - The larger the item, the deeper it can be detected.

(3) UXO depth - Some types of detectors are more effective than others when searching for deep items.

(4) UXO fuzing - Some detectors generate an electrical signal and should not be used around some fuzing systems.

(5) Background interference from metallic scrap - Metallic scrap, particularly UXO fragments co-mingled with UXO, interferes with geophysical instruments and makes UXO detection more difficult.

(6) Soil composition and geology - Natural soil and geologic conditions can affect geophysical instruments.

(7) Vegetation and terrain - In areas of difficult vegetation and terrain, more portable geophysical instruments are often necessary. In open areas, large towed-arrays may be a better choice.

(8) Cultural features - Overhead and underground utilities, fences, houses, nearby roads, radio/radar transmitters and similar cultural features can all adversely affect geophysical instruments.

b. Types of Instruments. Geophysical equipment can be divided into two broad classes of instruments: active and passive. Active instruments emit an electromagnetic or other signal and measure the effect. The active instruments most commonly used for UXO detection are conductivity meters. Passive instruments measure existing electromagnetic fields and the fluctuations within those fields. Passive instruments commonly used to detect OE include all types of magnetometers and gradiometers. Table 7.1 presents examples of geophysical detection technologies.

(1) Magnetometers. Magnetometers were one of the first tools used for locating buried munitions and remain one of the best. Most bombs and gun shells contain iron. When such munitions are illuminated by the Earth's magnetic field, a disturbance in the field is generated which magnetometers detect. Some magnetometers use two magnetic sensors configured to measure the difference over a fixed distance of the magnetic field, rather than the absolute magnetic field, and are called gradiometers. Since magnetometers respond to ferro-magnetic metals, they should not be used to try to detect UXO that does not have a significant ferro-magnetic metallic content. In addition, magnetometers are sensitive to many iron-bearing minerals and "hot-rocks" which sometimes causes a high "false-positive" count. Currently, two types of magnetometers and gradiometers are most often used to detect buried munitions.

(a) Fluxgate Magnetometers. Fluxgate magnetometers are inexpensive, reliable, rugged, and have low energy consumption. Fluxgate magnetometers have long been a standard tool of EOD Units for a quick, inexpensive field reconnaissance of a site containing ferrous munitions.

(b) Optically Pumped Atomic Magnetometers. Optically pumped atomic magnetometers (also called atomic magnetometers or cesium-vapor magnetometers) utilize digital technology and are more expensive than fluxgate instruments. However, their high sensitivity, speed of operation, and high quality digital signal output make them a good choice for situations where digital data or digital post-processing is required.

(2) Conductivity Meters. Conductivity meters are electromagnetic induction instruments. They work by pulsing a small electrical current into the ground and measuring the induced electrical eddy currents that develop around metallic objects. They differ from magnetometers in that they are not limited to detecting ferrous items; they can detect any conductive metal. In addition, conductivity meters are usually less affected by geologic noise than magnetometers. There are numerous types of conductivity meters available; however, two are most commonly used in the search for UXO: time domain electromagnetic conductivity meters and frequency domain electromagnetic conductivity meters.

Table 7.1
Geophysical Detection Technologies
As of January 2000

Technology	Effectiveness	Implementability	Cost	Representative Instruments	Notes
Flux-Gate Magnetometer	Medium: Flux-gate mags have been used as the primary detector in some highly ranked systems.	High: Flux-gate mags are light and compact. They can be used in any transversable terrain. Instruments are widely available from a variety of sources.	Less than average in typical terrain.	Schonstedt 52-CX Schonstedt 72-CX	The analog output is not usually co-registered with navigational data.
Cesium Vapor (CV) Magnetometer	High: CV mags have been used in several highly ranked geophysical systems. Detects ferrous objects only.	Medium: CV mags are relatively light and compact. They can be easily used in open areas. In areas of difficult terrain or vegetation, it is difficult to maintain a correct navigational fix. CV mags are widely available from a variety of sources.	Average in typical terrain. Much below average when towed arrays can be used.	Geometrics G-858 Geometrics G-822 Scintrex Smart Mag	Digital signal should be co-registered with navigational data for best results.

Table 7.1
Geophysical Detection Technologies
As of January 2000
(Continued)

Technology	Effectiveness	Implementability	Cost	Representative Instruments	Notes
Time-Domain (TD) Electromagnetic Metal Detectors	High: TD electromagnetics have been used in several highly ranked systems. Detects both ferrous and non-ferrous metallic objects.	Medium: These instruments typically utilize a transceiver coil 1 meter square; small versions are also available. It is easy to use the instrument in open areas but difficult to use it in areas of difficult vegetation or terrain. The most commonly used instrument is widely available.	Average in typical terrain. Below average when towed arrays can be used.	Geonics EM 61 Geonics EM 61-hh	Digital signal should be co-registered with navigational data for best results.
Frequency-Domain (FD) Metal Detectors	FD electromagnetics have not been the primary detector in any highly ranked systems. (continued on the next page)	High: Mine/coin detectors are light and compact. They can be used in any traversable terrain. Instruments are widely available from a variety of sources.	Higher than average cost in typical terrain. Instruments are slow and can detect very small items.	Scheibbel ANPSS- 12 White All Metals Detector Fisher 1266X Garrett	The analog output is not usually co-registered with navigational data.

Table 7.1
Geophysical Detection Technologies
As of January 2000
(Continued)

Technology	Effectiveness	Implementability	Cost	Representative Instruments	Notes
Frequency Domain Electromagnetic Metal Detectors (continued)	Other experience shows that they are very good at detecting small items. They are not good at detecting for deeply buried, single items. Detect ferrous and non-ferrous metallic objects.				
Multifrequency Electromagnetic Metal Detectors	Medium: The GEM 2/3 was a primary detector in two highly ranked systems. However, they were never the highest ranked systems. Detects both ferrous and non-ferrous metallic objects.	Medium: These instruments are relatively light and compact and can be easily used in open areas. In areas of difficult terrain or vegetation it is difficult to maintain a correct navigational fix. Only a limited number of instruments are available.	Average in typical terrain.	GEM 2 GEM 3	Digital signal should be co-registered with navigational data for best results.

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Table 7.1
Geophysical Detection Technologies
As of January 2000
(Continued)

Technology	Effectiveness	Implementability	Cost	Representative Instruments	Notes
Ground Penetrating Radar	Low: Although a number of systems utilized ground penetrating radar as a detector, GPR was never successful as a stand-alone system. Detects both metallic and non-metallic objects.	Low: These instruments are large, bulky, and slow. They are difficult to use in any but the easiest terrain. Instruments are widely available from a variety of sources.	Much higher than average. Systems are slow and expensive.	GSSI SIR2, SIR3, SIR8, SIR10 Software & Sensors	The data output is usually viewed in transects, not maps.

(a) Time Domain Electromagnetics (TDEM). Time domain electromagnetic conductivity meters work by pulsing an electrical signal into the ground several times a second. The transmitting coil is turned off between pulses and eddy current decay is then measured. Time domain conductivity meters provide an excellent compromise between detection depth and resolution. Such instruments provide a capability to locate all types of metallic munitions.

(b) Frequency Domain Electromagnetics (FDEM). Frequency domain electromagnetic conductivity meters work by transmitting a continuous electrical signal of one frequency into the ground and measuring resulting eddy currents of other frequencies. Some commercial frequency domain instruments are particularly useful for detecting large, deeply buried caches of munitions, and for detecting disturbed earth associated with pits and trenches. In addition, landmine detectors are FDEM instruments specifically designed for detecting very small, very close objects such as metallic firing pins in willow land mines. However, since the resolution ability decreases dramatically with depth, frequency domain conductivity meters are not optimum for detecting individual, deeply buried munitions. Most commercial coin detectors are frequency domain conductivity meters.

(3) Multiple Instrument Arrays. In cases where a particular geophysical instrument provides good detection results, multiple instruments can be joined in an array to achieve greater data density and greater production rates than possible with a single sensor system. However, due to access and mobility limitations, such arrays are generally limited to large, open areas.

(4) Analog Geophysical Mapping (Mag & Flag). This methodology is the traditional approach used to locate buried ordnance. Hand-held metal detectors (usually magnetometers) are used to map an area. Whenever the instrument detects an anomaly, the operator places a small flag in the ground. Mag & flag is particularly effective in areas where vegetation and terrain limit the use of larger digital systems. Also, mag & flag approaches should be used when there is insufficient difference between UXO at the site and other metallic frag and debris such that digital discrimination is ineffective.

7-5. UXO Detection Rates and Detection Depths.

a. Detection Rates in Test Plots. Geophysical instruments do not have specific ordnance detection rates. Detection rates are always site specific and are highly dependent upon the type of ordnance at the site, how the ordnance was used, how deeply it is buried, environmental conditions, geologic conditions, and cultural influences. During tests sponsored by the Army Environmental Center at Jefferson Proving Ground (JPG), the best munition detection rates of both ground-based conductivity meters and magnetometers were approximately 95 percent. In comparison, other systems tested at JPG that did not utilize either magnetometry or electromagnetics had extremely poor detection rates for buried ordnance.

b. Detection Rates in the Field.

(1) The true UXO detection rate at an actual field site can be hard to determine. Several factors can significantly reduce the effectiveness of a geophysical survey, including the following:

- (a) Vegetation;
- (b) Terrain;
- (c) Geologic noise/gradients;
- (d) Cultural noise (utilities, fences, etc.);
- (e) UXO fragments; and
- (f) UXO penetration beyond detection.

(2) These factors will reduce the actual achieved detection rate. However, since the true amount of UXO at a site is unknown, the detection rate, based upon items recovered, is also

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unknown. Actual detection rates are typically between 70 to 90 percent of UXO present, even when the best available technology is applied.

c. Detection Depths.

(1) The general rule is, the larger the UXO, the deeper it can be detected. Based upon the work at JPG and other sites, the typical maximum detection depth for various UXO can be estimated as a function of diameter of the object. This empirical formula will provide an initial estimate of how deeply a UXO can be detected, provided proper instruments and procedures are utilized. The formulas for estimating maximum detection depth are presented in Table 7.2.

Table 7.2
Maximum Detection Depth Estimating Formulas

$\log(d) = 1.354 \log(dia) - 2.655 \quad (mag)$ $\log(d) = 1.002 \log(dia) - 1.961 \quad (EM)$
<i>Notes:</i> <i>d</i> = actual depth to top of buried UXO, in meters. <i>dia</i> = diameter of minor axis of UXO, in millimeters. "d" corresponds to the required clearance depth for that particular location on the project site and UXO "dia" is diameter of the minimum size item, as determined by the project team, that the geophysical investigation is responsible for detecting.

(2) The formulas in Table 7.2 were used to develop the Maximum Detection Depth data presented in Table 7.3. There are many site-specific factors that can affect detection depth. Therefore, Table 7.2 and Table 7.3 should be considered as guidance, not an absolute.

d. Penetration Depths. The maximum possible depth of UXO is an important consideration in the selection of an appropriate detection system. If UXO is intentionally buried, factors affecting burial depth may include type of soil, mechanical vs. hand-excavation, depth of water table, etc. If the munition was fired or dropped, then the depth of penetration can be estimated by considering soil type, munition type and weight, and impact velocity. There are many cases where UXO can penetrate deeper than geophysical instruments can currently reliably detect. On such sites, it is possible that undetected UXO remains deeper than it can be detected. Figure 7-1 shows the depth of recovery for thousands of OE items. The curve indicates that while the maximum depth of penetration of UXO will resemble the depth predicted in the penetration analysis, the actual depth of penetration for most items is much lower. In fact, most items were located less than two feet deep.

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Table 7.3
Ordnance Penetration/Detection

Ordnance Item	Depth of Penetration (ft) ^{1,2}			Typical Max Detection Depth ⁴ (ft)	
	Sand	Loam	Clay	Magnetometry	TDEM ⁵
14.5 mm Trainer/Spotter, M1813A1	0.2	0.3	0.4	0.3	0.5
20mm, M56A4	2.3	3.0	4.6	0.4	0.7
22 mm Subcal for 81 mm mortar	1.4	1.9	2.8	0.5	0.8
35 mm Subcal M73	0.5	0.7	1.0	0.9	1.3
37 mm, M63	3.9	5.2	7.9	1.0	1.3
40 mm, M822 (AA)	2.3	3.0	4.5	1.1	1.4
40 mm, M677 (Mk 19)	0.2	0.3	0.4	1.1	1.4
40 mm, M381 (M203/M79)	0.2	0.3	0.4	1.1	1.4
Mk 118 Bomblet	1.9	2.4	3.7	1.5	1.8
Mk 23 3 lb. Practice Bomb	2.7	3.5	5.4	1.7	2.0
57 mm, M306A1	2.7	3.6	5.5	1.7	2.0
M9 Rifle Grenade	0.1	0.2	0.2	1.7	2.0
2.25" Rocket, Mk 4	4.0	5.2	8.0	1.7	2.0
60 mm, M49A1 (charge 4)	1.1	1.5	2.3	1.9	2.2
2.36" Rocket, M6A1	0.4	0.5	0.8	1.9	2.2
66 mm, M72 LAW	0.9	1.2	1.8	2.1	2.4
66 mm TPA, M74	0.7	0.9	1.4	2.1	2.4
BLU-3/B,-27/B,-28/B	2.2	2.9	4.4	2.3	2.5
2.75" Rocket, Practice	8.1	10.7	16.3	2.3	2.5
6 lb. Incendiary Bomb	3.4	4.4	6.7	2.4	2.6
75 mm, M48	4.9	6.4	9.8	2.5	2.7
75 mm, M310	3.9	5.1	7.8	2.5	2.7
81 mm, M43A1 (charge 8)	2.7	3.5	5.4	2.8	2.9
83 mm SMAW Mk 3	2.8	3.6	5.6	2.9	3.0

Table 7.3
 Ordnance Penetration/Detection
 (Continued)

Ordnance Item	Depth of Penetration (ft) ^{1,2}			Typical Max Detection Depth ⁴ (ft)	
	Sand	Loam	Clay	Magnetometry	TDEM ⁵
84 mm, M136 (AT4)	2.5	3.7	5.0	2.9	3.0
3.5" Rocket, M28	0.8	1.1	1.7	3.2	3.2
90 mm, M371A1	2.0	2.7	4.1	3.2	3.2
25 lb. Frag Bomb ³	2.1	2.8	4.3	3.2	3.2
AN-M41A1 20 lb. Practice Bomb	5.0	6.6	10.0	3.3	3.3
105 mm, M1 (charge 7)	7.7	10.1	15.4	4.0	3.8
106 mm, M344A1	6.5	8.5	13.0	4.0	3.8
4.2" Mortar, M3 (max charge)	4.1	5.4	8.3	4.1	3.9
Dragon Guided Missile	0.9	1.1	1.7	4.3	4.0
155 mm, M107	14.0	16.4	28.0	6.7	5.6
8", M106 (charge 8)	16.4	24.2	36.9	9.7	7.3
M38A2 100 lb. Practice Bomb	8.6	11.3	15.2	9.9	7.4

¹Penetration depths include the following "worst-case" conditions assumptions: impact velocity is equal to maximum velocity of round; impact is perpendicular to ground surface; munition decelerates subsurface in a straight line; munition does not deform upon impact. Typical penetration depth for any individual item will usually be significantly less.

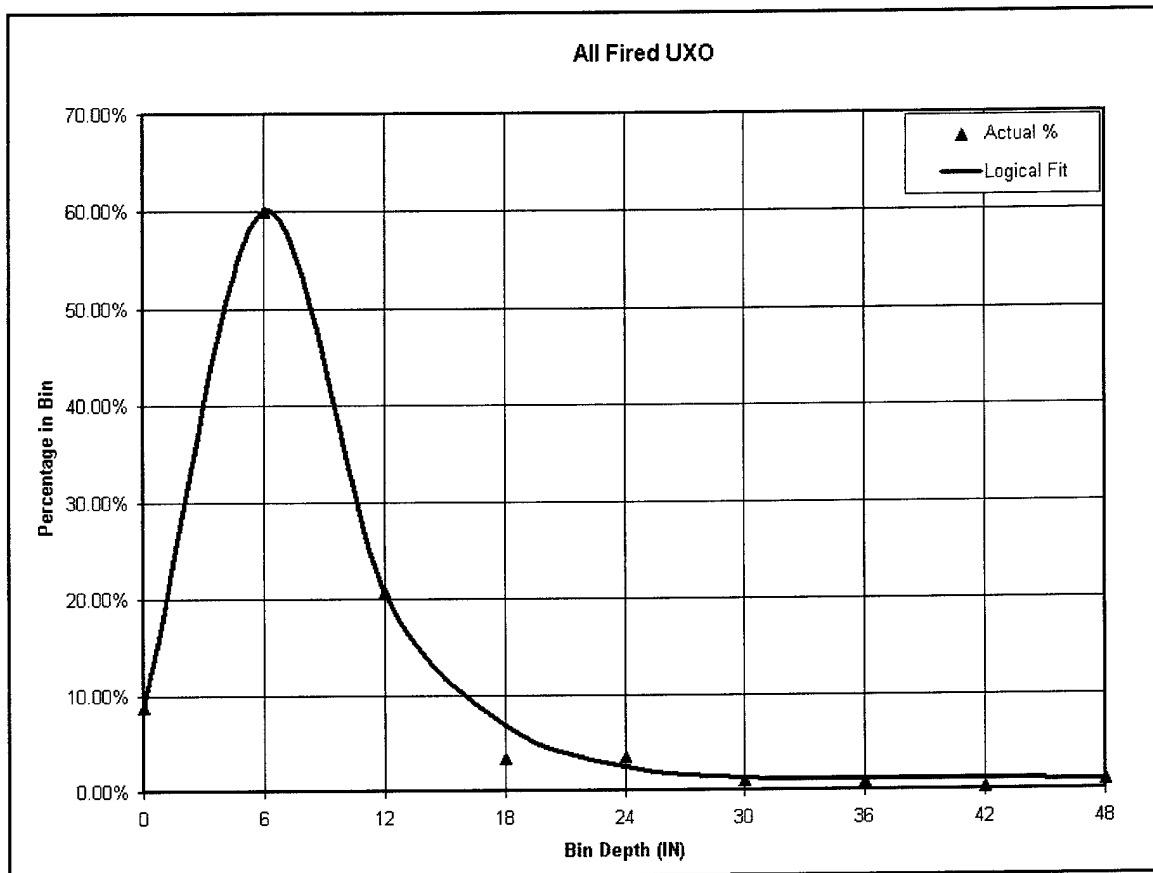
²Actual detection depth may vary based on field conditions and be either lower or deeper.

³All bombs are assumed to have an impact velocity of 1135 feet per second.

⁴Maximum depth of penetration assuming a velocity of 500 fps.

⁵Time Domain Electromagnetics

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Note: The database used to develop this graph was populated predominantly with UXO items typically used by or in close support of ground troops. Large naval ordnance and large aerial bombs are under-represented.

Figure 7-1
Actual Depth of Recovery of Fired UXO

7-6. Geophysical Instruments and Electric Fuze Safety. Some electric fuzing systems used in munitions are sensitive to certain electromagnetic frequencies. Although the probability is very low, such signals have the potential for causing sensitive munitions to detonate. This fact should be considered when planning geophysical investigations at munitions sites. The following safety precautions and safety recommendations are applicable on all OE projects:

a. Magnetometers and gradiometers are passive instruments that are not designed to introduce electrical energy into the ground. Therefore, passive magnetometers and gradiometers may be used at all OE sites in accordance with manufacturer's instructions.

b. Active instruments (including but not limited to mine and coin detectors, frequency-domain electromagnetic detectors and time-domain electromagnetic detectors) are designed to introduce electrical energy into the ground. Prior to any such systems being used at an OE site, the instrument operator must determine if fuzing systems containing electrical components are reasonably expected to exist at the site.

c. Active instruments may be used in accordance with manufacturer's instructions at OE sites not containing electrical fuzes.

d. Active instruments may not be used at OE sites where fuzing systems containing electrical components are reasonably expected to exist, unless a waiver is granted by the Design Center Safety Manager. The instrument operator must submit a request for waiver accompanied by a written hazard analysis documenting the need for use of the active instrument, the manner in which the instrument will be used, the power output of the instrument, a description of the electrical fuze system(s) anticipated at the site, the estimated risk of fuze detonation, and the consequences of such a detonation, were it to occur. Waivers may be granted on a case-by-case basis.

7-7. Analysis Software. There are many software packages that can be used to evaluate geophysical data. Often the geophysical equipment manufacturers provide specialized software for specific instruments. This software is primarily used to transfer the data from the instrument to the computer and perform corrections to the data. Corrections such as navigation adjustments and rotation and translation of coordinate systems are necessary before analyzing the data. The corrected data is then transferred into a software package designed to facilitate contouring, mapping and selection of anomalous data potentially representing UXO.

7-8. Navigation.

a. Navigation Systems. Positional precision and accuracy is a requirement for geophysical investigations at UXO sites. Since detection and removal of buried UXO is a multi-stage process, it is important that positional information gathered at one stage be useable at the next stage. This means that all data collected at each stage must be tied to a common positional system. The positional system can be either temporary (i.e., temporary monuments, landmarks, etc.) or permanent (i.e., standard reference survey grid, tied to permanent monuments). In actual

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practice, the use of temporary or assumed location systems on UXO projects is strongly discouraged. It is often difficult or impossible to register multiple temporary location systems to a common reference point after the fact. As a result, true locations of work performed become unrecoverable. U.S. Army Engineering and Support Center, Huntsville (USAESCH) recommends that all navigation be based on the local State Grid Plane system.

b. Positional Accuracy and Precision.

(1) Mag & Flag. The most typical geophysical survey technique in ordnance related surveys is "mag and flag". In these types of surveys, anomalies are selected by instrument response and flagged immediately in the field. The disadvantage of this technique is that without recorded data, there is no opportunity to revisit the data for additional interpretation or analysis at a later time.

(2) Digital Geophysics. More recently, magnetic and electromagnetic instruments have been combined with a ground based grid system to track the positions of collected data and to create a map of the survey. The grid system commonly involves utilizing a surveyor to set up rectangular or square grids having dimensions from ten to several hundred feet on a side. The geophysicist tracks his/her position in the grid by collecting data in a straight line from one edge of the grid to the other. The distance traveled along each linear traverse is usually calculated using either a distance tracking system, such as a wheel based unit which records distance traveled along with data collected, or by a constant pace method. The constant pace method assumes that the survey is being performed at a constant rate of speed and the time during which the survey is performed is divided by the actual distance traveled to determine the locations of specific data points. Marks are often inserted manually at specified distances by the geophysicist in each of these methods to assist in the positional accuracy.

7-9. Site Preparation and Vegetation Removal.

a. UXO Safety. Site preparation for geophysical investigations at UXO sites can be a significant issue. The first issue to be considered is the presence of surface UXO. Sites must be cleared of dangerous surface UXO prior to initiating subsurface geophysical investigations.

b. Vegetation and Obstacle Removal. There are no currently available "stand-off" sensors that can consistently detect buried UXO. All geophysical instruments currently in use to detect UXO must traverse directly over every square foot of area investigated, and as close to the ground surface as feasible. Airborne systems, even those only a few feet above ground surface, do not work. Therefore, in order to efficiently detect the maximum amount of buried UXO at a site, most or all surface vegetation and other obstacles must be removed. This may be acceptable for small sites, or sites already having only limited vegetation, but is generally unacceptable for larger sites. Also, at many sites it is environmentally unacceptable to cut down, burn away or otherwise remove the vegetation.

c. **Terrain.** Site terrain can limit the effectiveness of geophysical investigations for UXO. Very steep or rugged areas can be hazardous for geophysical investigation teams. In such cases, it is often best to use a mag & flag approach. Likewise, swampy areas present serious difficulties to geophysical investigation teams.

7-10. **Geophysical Prove-out.** The following paragraphs describe the project team's responsibilities during the instrument prove-out. It should be noted that the geophysical prove-out may be a complex, time-consuming effort.

a. **Data Quality Objectives for Prove-out.** When designing a geophysical prove-out plot care must be taken to identify DQOs. The prove-out plot must resemble the actual field site both in physical characteristics and in the UXO buried within it. The primary purposes of a prove-out plot include the following:

(1) To determine if a particular approach will work at a particular site. There are geologic, terrain and other differences that can cause proven geophysical approaches to not work at particular sites.

(2) To determine the optimum geophysical approach for a particular site. All geophysical approaches have inherent strengths and weaknesses. Very seldom will one instrument or approach have the best absolute detection rate, the lowest false alarm rate, the highest production rate, and the lowest cost. Test plots provide information used to select an optimum geophysical approach.

(3) To demonstrate detection depth capabilities. Team members and stakeholders often need site-specific data demonstrating detection depth. When a removal action is performed without a test plot, there may be little information to support the true depth of detection. A test plot, with target items buried at multiple depths, provides important information regarding depth and quality of clearance.

(4) To assure contractor compliance with the contract. Test plots provide a safe area for the geophysical investigation team to develop site-specific field and evaluation procedures necessary to demonstrate compliance with project requirements.

(5) Evaluate the project team's data collection, data transfer quality and data quality control method(s), and data transfer rates.

b. **Prove-Out Work Plan.** The first step of performing a geophysical prove-out is to develop a prove-out work plan. In the plan it is necessary to state the prove-out objectives and to describe how these objectives will be met. The elements described in the following sections should be addressed.

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(1) Prove-Out Grid Location and Construction. Selection of the prove-out grid or grids should be based upon the technical and site-specific considerations developed and finalized during the initial project site visit. Factors to be considered include the following:

- (a) Similarity of terrain, vegetation, and geologic conditions to actual field site;
- (b) Proximity to field site;
- (c) Isolation from overhead power lines, radio transmitters, underground utilities, etc;
- (d) Convenient access;
- (e) Likelihood that the area will be disturbed during period of use;
- (f) Rights-of-Entry; and
- (g) Possibility of pre-existing buried UXO.

(2) Pre-Seeding Geophysical Mapping. After a site has been selected and the surface prepared, a pre-seeding geophysical survey should be performed in order to determine and document base-line geophysical conditions at the site.

(a) Size and Configuration. Each plot is unique, but for sites where a significant amount of geophysical mapping is anticipated, a test plot of one-quarter acre to one acre in size with 20 to 50 separate buried items, would be typical. For sites with limited geophysical mapping, much smaller and less complex plots should be considered. Test plots need not be square; they can be any convenient shape.

(b) Survey Accuracy. Survey accuracy of the test plot corners and of all items buried in the test plot, should be to the nearest 0.1 ft.

(c) Layout. Test plots should have an area designated as a "known" area. The geophysical mapping team should be provided all pertinent information about the "known" area so that they can optimize their equipment and procedures. Once appropriate procedures are developed for the "known" area, the geophysical mapping team should proceed to the "unknown" area, perform geophysical mapping, and make predictions.

(d) Seeded Items. A listing of probable munitions items to be seeded in the grid must be developed. Historical records, such as the ASR, should be consulted and used to develop a list of items of interest. After the list is developed, sources of inert items must be determined. It is preferable that inert UXO be utilized in the prove-out grid. However, due to the difficulty in locating and transporting such items, it will often be necessary to manufacture surrogate items of approximately the same composition, size and shape for use in the test plot. In many cases, multiple UXO have been utilized at an area and it will not be feasible to duplicate all of them. In

such cases the geophysicist and UXO specialist should work together to determine when different UXO may be consolidated into one class for prove-out purposes

(e) Depths and Orientation. One major objective of a prove-out plot is to demonstrate the depth of detection of various UXO. In order to accomplish this, the UXO must be buried at various depths and orientations. There is seldom a reason to bury the UXO either excessively shallow or deep. Rather, the UXO should be buried in the proximity of the boundary between the detect zone and no-detect zone for items that size, as shown on Figure 7-2. The orientation of the item will also affect detectability. In general, duplicate items should be buried in an E-W orientation, a N-S orientation, and an up-down orientation, at each depth studied. The number of seeded items should be sufficient to provide a representative sampling of probable munitions (type, condition, and depth) and statistically support probability of detection calculations. The number, orientation, and depths of the OE items will be sufficient to characterize the limitations of the proposed geophysical equipment and to evaluate the ability of the proposed geophysical equipment to locate each type of OE at the anticipated depths. After the target items are buried, care should be taken to blend excavation locations back to natural conditions.

(f) Cultural Interference. Some field sites will have significant cultural interference. In such cases, consideration should be given to duplicating that interference in the test plot.

(g) UXO Fragment Interference. At most impact areas there are many more pieces of UXO metallic fragments (frag) than there are UXO. This frag often results in a serious degradation in the capability of the geophysical instruments to detect UXO. In such cases, consideration should be given to duplicating the effects of frag in the test plot, either through the use of artificially placed frag or by the establishment of the test plot in an area containing frag.

(3) Data Collection Variables. It is important to collect and analyze test plot data using the same equipment, personnel and procedures that are planned for field use. Multiple geophysical surveys using each proposed geophysical instrument will be performed. Geophysical instrumentation standardization will be completed prior to and upon completion of each prove-out grid to characterize system operation. When collecting data for a prove-out, the following elements are subject to modification and evaluation. It will not be necessary to evaluate every factor at every site. The project team must determine the elements to be evaluated for a particular project:

(a) Instrument Height. The height of the detection portion of the instrument can be modified. Generally speaking, the closer the detector is to the UXO, the more pronounced the

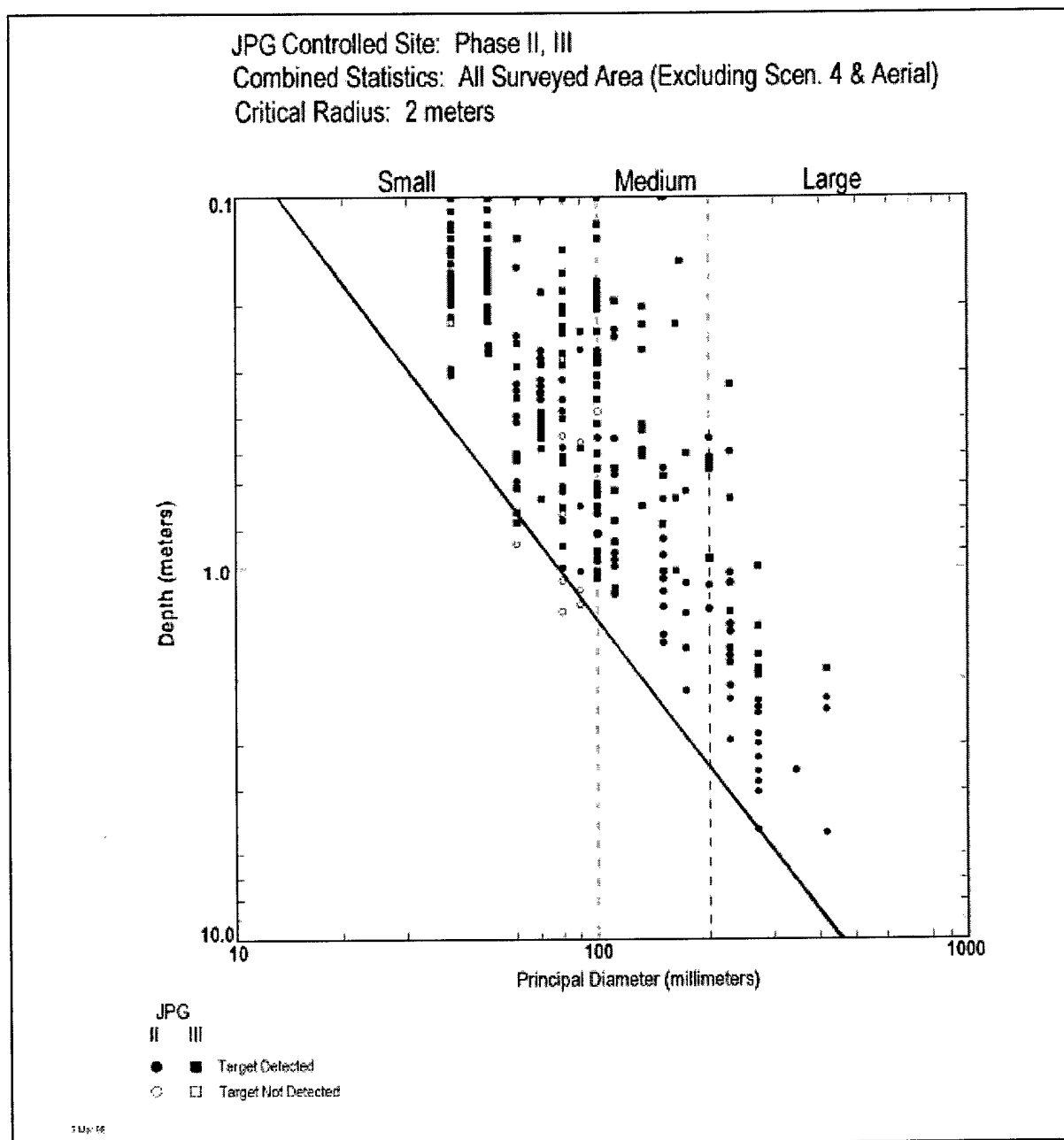


Figure 7-2
UXO Detection at Jefferson Proving Ground

instrument response will be. When the intended target is small, it may be beneficial to move the detector closer to the ground. On the other hand, if the intended target is large, it might be beneficial to raise the detector in order to minimize the influence of small items.

(b) Instrument Orientation and Direction of Travel. Instrument orientation and direction of travel can have a pronounced effect, particularly with magnetometry. A magnetometer can measure different values over a single location, depending on direction of travel and orientation. When precise surveys are being performed it is necessary to add a "heading correction" to each data point in order to account for this variation.

(c) Measurement Interval. Instrument readings should be collected at one-foot intervals or less.

(d) Lane Width. Lane width may be modified depending on the size of the intended UXO. For large items, a lane width of five (5.0) feet, or larger, is acceptable. For small items, lane widths of only one (1.0) foot may be necessary.

(4) Data Analysis and Interpretation. The ability to analyze and interpret the geophysical data collected at the prove-out grid will be demonstrated by the project team using the methods of its choice. The data collected at the prove-out grid from each geophysical instrument will be post-processed and analyzed. A final listing of selected target anomalies will be prepared and provided to the project team for comparison with seeded item locations.

(5) Data Evaluation.

(a) The geophysical data must be evaluated and scored so that the different geophysical approaches can be compared and ranked. Scoring criteria should include, as a minimum, the following: probability of detection (Pd); probability of false alarm (Pfa); production rate; cost per unit area; equipment durability and safety.

(b) No single geophysical system is likely to achieve maximum scores in all evaluated areas. Therefore, the evaluation team must determine which approach is likely to be most efficient for the site.

(6) Selection of Detection Instruments. The project team, based upon experiences at other project sites containing similar geophysical considerations, will nominate instruments for consideration. The project team will review its letter report describing proposed geophysical equipment, techniques, and methodologies. The letter report should also contain sufficient supporting information to justify the project team's recommendations, including manufacturer specifications for recommended geophysical equipment and a definition of the expected target anomalies based upon the ASR or EE/CA.

7-11. Geophysical Investigation Plan. Prior to initiating field activities, a Geophysical Investigation Plan should be prepared. This Plan, which is a subsection of the Work Plan, is prepared to describe the project requirements for all geophysical activities that will take place during an OE project. The Geophysical Investigation Plan will include a justification for the proposal of the geophysical instrumentation, methodology, and prove-out. The proposed goals, methods, and procedures will be tailored to anticipated site conditions and technical requirements as well as applicable safety and security regulations. The Geophysical Investigation Plan must include procedures for a geophysical instrument prove-out, if not previously completed.

a. Contents. The project team member reviewing the Geophysical Investigation Plan should ensure that the following elements are addressed:

- (1) Geophysical investigation methods:
 - (a) Equipment;
 - (b) Procedures;
 - (c) Personnel;
 - (d) Production rates;
 - (e) Data resolution, or line/grid width requirements;
 - (f) Data density; and
 - (g) Data processing.
- (2) Location surveying, mapping and navigation:
 - (a) System description; and
 - (b) If GPS systems are used, correlate satellite availability with work/rest periods.
- (3) Instrument standardization:
 - (a) Instrument drift (DC offset);
 - (b) Standardization procedures;
 - (c) Abbreviated standardization checks; and
 - (d) Instrument response to a known standard.

- (4) Data processing, correction and analysis:
 - (a) Instrument drift correction;
 - (b) Diurnal drift correction;
 - (c) Digital filtering and enhancement; and
 - (d) Correlation with ground truth.
- (5) Quantitative interpretation and dig sheet development.
- (6) Anomaly reacquisition.
- (7) Feed-back process (Comparison of dig-sheet predictions with ground-truth).
- (8) Quality control.
- (9) Corrective measures.
- (10) Records management.
- (11) Interim reporting.
- (12) Final reports and maps.

b. Geophysical Investigation Plan Review and Approval. The Geophysical Investigation Plan, a component of the Work Plan, will be submitted to the PM and Design Center POC. The Design Center POC will route the plan to the appropriate USACE technical staff for review, comment and approval. Once approved by the Design Center and CO, the Geophysical Investigation Plan represents the standard to which all geophysical activities are compared to assure compliance during the project.

7-12. Geophysical Sampling.

a. Pre-Sampling Studies. When planning geophysical investigations for UXO at current and former military installations, it is necessary to determine the limits of the area to be investigated. Military installations are often extremely large and not all areas are likely to have buried UXO. The ASR, historical aerial photographs, range-control records, facility engineering and master planning documents, personnel interviews, and other pertinent documents should be carefully evaluated in order to locate evidence of how, when and where munitions might have been used at a site.

b. Sectorization.

(1) Once the review of historical documents has been accomplished, the site must be sectorized. Sectorization is the process by which large, non-homogenous areas of a military installation are subdivided into smaller, more homogenous areas. When defining sectors, the following factors should be considered:

- (a) Former military use;
- (b) Anticipated UXO type;
- (c) Anticipated UXO distribution;
- (d) Terrain and vegetation;
- (e) Current land use; and
- (f) Natural and cultural boundaries.

(2) Obviously, it is not possible to define a sector that is completely uniform and homogenous. However, the goal is to define sectors such that any necessary future OE response action can be applied to the entire sector. It should be noted that sectorization is an active process. As the project continues and more data is collected, it is likely that sector boundaries will need to be modified to reflect actual site conditions.

7-13. Sampling Within a Sector. When geophysically characterizing a sector, an initial decision must be made regarding where the geophysical investigations will occur. Basically, there are two choices: either investigate the entire sector, or sample a representative portion of the sector and infer the results across the whole. On relatively small sectors, it can be efficient in terms of cost, schedule, and environmental impact to geophysically map the entire area. However, large sites can present significant cost, schedule, access and environmental impact challenges that preclude geophysically mapping large areas as a method of site characterization. Various site sampling methodologies are discussed below.

a. 100% Sampling. Complete geophysical mapping is a good approach for small sites. At such sites the mobilization/demobilization and other fixed costs can be relatively high when compared to the actual mapping costs. In these cases, the most cost-effective approach might be to map the entire site. Such an approach is especially recommended for sites smaller than about 20 acres.

b. Authoritative Sampling. With authoritative sampling, an expert having knowledge of the site designates where and when samples are to be taken. This type of sampling should only be considered when the objectives of the investigation are not of a statistical nature. Generally,

conclusions drawn from authoritative sampling apply only to the individual samples and aggregation may result in severe bias and erroneous conclusions.

c. Probability Sampling.

(1) When the study objectives involve estimation or decision making, some form of probability sampling is required. Probability sampling is sampling where every member of the target population has a known probability of being included in the sampling. This does not preclude use of an expert's knowledge of the site in designing a probability-based sampling plan; however, valid statistical inferences require that the plan incorporate some form of randomization in selecting the sampling locations. An efficient probability sampling design is one that uses all available existing information to stratify the region and set appropriate probabilities of selection. For example, probability sampling can take into consideration prior knowledge of areas with higher potential for UXO contamination (e.g., targets) by weighting such areas more heavily in the sample selection and data analysis.

(2) Probability sampling can be of various types, but all types use randomization, which allows valid probability statements to be made about the quality of estimates that are derived from the resultant data. USACE has developed a statistical process, known as UXO Calculator, to determine the amount of geophysical mapping necessary to characterize a homogenous sector of a UXO site. For a discussion of this methodology, refer to Chapter 10 of this manual. The statistical approach is designed to characterize "dispersed" UXO such as occurs at impact areas, bomb target areas, kick-out from open burn/open detonation operations, dispersal from munitions magazine explosions, and similar activities. It is not designed to statistically characterize activities that do not have random patterns, such as UXO intentionally buried, purposely hidden contraband munitions, and similar activities.

(3) The amount of necessary sampling within a sector is determined by USAESCH's UXO sampling protocols. The larger the sector, the smaller the percentage of sampling is required. UXO Calculator should be used on a site-specific basis to determine appropriate sampling percentages. However, Table 7.4 indicates the approximate amount of sampling (random plus directed) that should be anticipated.

(4) It should be remembered that mobilization/demobilization and other fixed costs can be relatively high when compared to total geophysical investigation costs at small sites. Therefore, at small sites it is often more cost-effective to geophysically investigate the entire site, rather than use statistical sampling.

Table 7.4
Typical Geophysical Sampling Requirements

Sector Size, Acres	Required Minimum Area Investigated	Recommended Minimum Area Investigated
< 50	5.0%	7.5%
51 -100	3.0%	4.5%
101 - 150	2.0%	3.0 %
151 - 1000	1.0%	1.5%
> 1000	0.5%	0.75%

(5) Probability sampling strategies include the following:

(a) Fixed Pattern Grid Sampling. Fixed-Pattern grid sampling is the process where grids are laid out in a pattern on a fixed percentage (often 10 percent) of a sector. Fixed pattern sampling is not normally used since other more random patterns can provide statistically valid results using fewer grids. An example of fixed pattern grid sampling is shown in Figure 7-3.

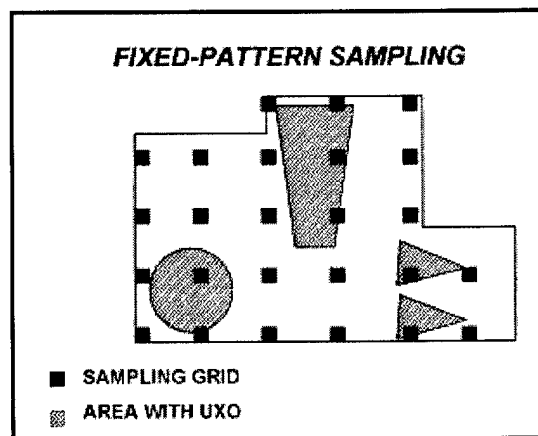


Figure 7-3
Fixed Pattern Grid Sampling

(b) Random Pattern Grid Sampling.

(1) Random pattern grid sampling uses a statistical approach to place grids randomly throughout a sector. The total area to be sampled is first determined using a statistical process, such as UXO Calculator. Then, grid size and shape is determined based on site terrain, vegetation, and the geophysical instruments to be used. Grids can be any convenient shape, but square or rectangular grids are the most common. Grids may be as small as 2,500 square feet or

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as large as one hectare in size. Grids need not all be the same size. An example of random pattern grid sampling is shown in Figure 7-4.

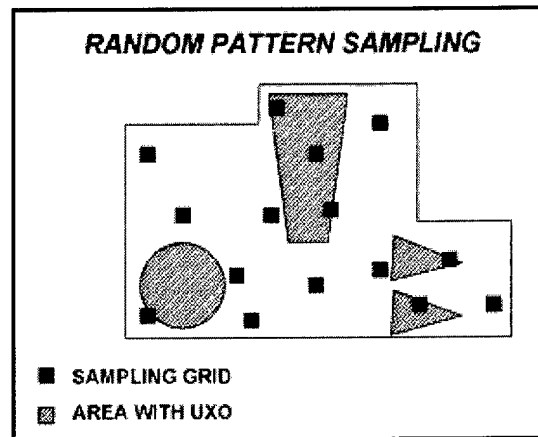


Figure 7-4
Random Pattern Grid Sampling

(2) Since in random pattern sampling grids are placed completely randomly, there can be large unsampled areas within a sector. Also, areas known to contain UXO might remain unsampled. For this reason, purely random pattern sampling is not recommended.

(c) Hybrid Sampling. In order to assure that a sector receives thorough sampling grid coverage, and that areas known or suspected to contain UXO are geophysically investigated, a modified version of random pattern sampling is recommended. In this hybrid approach, grids are placed randomly across the sector as described above. Afterwards however, approximately 20 percent more grids are placed in biased locations to fill any apparent data gaps. This approach is recommended when sampling grids are used. An example of hybrid sampling is shown in Figure 7-5.

(d) Transects. Geophysical investigation transects are another approach used to characterize sectors. Transects are also a good approach to determine boundaries of contaminated areas. When used for sector sampling, transects may simply be considered as very narrow, fixed pattern-grids. Transects are best utilized at sites with easy terrain and vegetation. An example of transect sampling is shown in Figure 7-6.

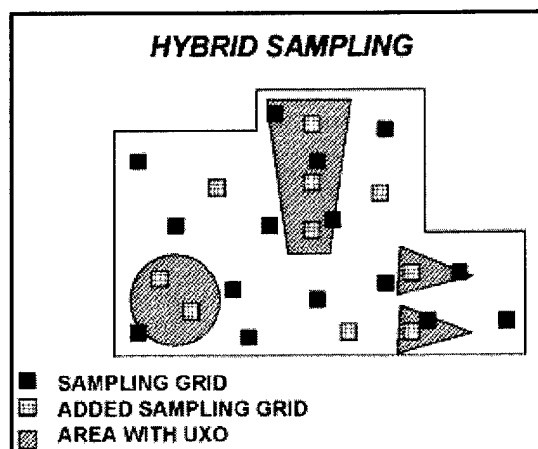


Figure 7-5
Hybrid Sampling

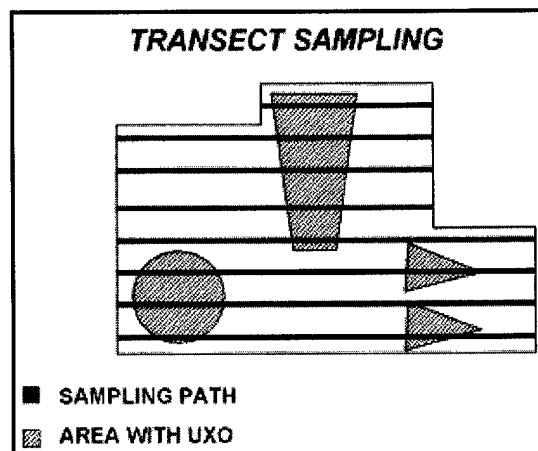


Figure 7-6
Transect Sampling

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(e) **Meandering Path Sampling.** Meandering path sampling is a process where a geophysical investigation instrument is integrated with a navigation instrument, usually differential Global Positioning System (GPS), that links extremely accurate positional data with the geophysical readings. Then, a geophysical team "meanders" randomly throughout a site, until the total area geophysically mapped equals the area that would have been required if sampling grids were used. Afterwards, the geophysical data is analyzed, anomalies are located, then excavated and evaluated. Meandering path sampling offers large cost savings at sites with difficult vegetation and terrain since vegetation removal costs are virtually eliminated and surveying costs are greatly reduced. An example of meandering path sampling is shown in Figure 7-7.

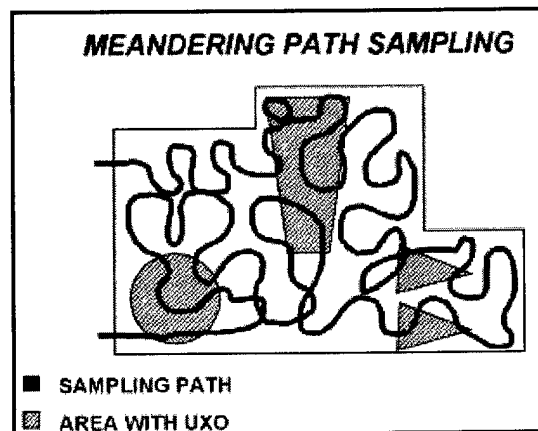


Figure 7-7
Meandering Path Sampling

7-14. **Sampling Anomalies Within a Grid.** After a grid or other area has been geophysically mapped, multiple "anomalies" are likely to have been located. For mag & flag projects, these anomalies will be marked as flags at the location of each subsurface anomaly. For projects where digital geophysical methods are used, the geophysicist will pick and evaluate anomalies with the help of analytical software. In either case, the anomalies must be excavated by qualified UXO personnel in order to determine if the anomaly represents a UXO or some other feature. On many grids, the number of anomalies will be manageable and all should be excavated in order to characterize the grid. However, on some sites, particularly those within impact areas, the number of anomalies may range from several dozen to several thousand anomalies per acre, most of which will be small metallic frag. When this occurs, statistical sampling of the grid may be necessary.

a. **100% Sampling.** When there are, on average, fewer than approximately 20 anomalies per grid, all anomalies should be excavated and evaluated.

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b. Statistical. When there are, on average, more than 20 anomalies per grid, it is necessary to statistically sample the anomalies. If the anomalies are identified using mag & flag or another geophysical method that does not evaluate of the "quality" of the anomaly (e.g., does not differentiate between anomalies considered more likely to be UXO from anomalies less likely to be UXO), then GridStats software should be used (refer to Chapter 10). On the other hand, when geophysical approaches that discriminate between anomalies are used, UXO Calculator software should be utilized to select anomalies for actual excavation and evaluation.

7-15. Data Interpretation, Resectorization and Decision Making.

a. After a site undergoes an analysis of historical information, is sectorized, sampling grids placed, geophysical sampling performed, and anomalies identified, excavated and evaluated, it is necessary to carefully interpret all the data and determine if project objectives have been met. Original sector boundaries may need to be changed, new sectors may need to be added, and data gaps may exist that must be filled prior to subsequent decisions being made.

b. The geophysical data and evaluations are usually incorporated into a larger study (e.g., EE/CA, Remedial Investigation/Feasibility Study, Site Characterization) and involve project stakeholders who make decisions regarding future work to be performed.

7-16. Geophysical Mapping. After a site has been investigated, characterized and determined to contain unacceptable amounts of UXO, a decision may be made to use geophysical mapping to locate UXO for removal. Unlike geophysical sampling, where only representative portions of the site are investigated, geophysical mapping in support of UXO removal must be performed on 100 percent of the area unacceptably contaminated. Geophysical mapping is performed basically the same way that geophysical sampling is performed. However, geophysical mapping for UXO removal is more rigorous since all possible UXO must be detected and removed.

a. Anomaly Discrimination. Computer-based evaluation is an important tool for interpreting geophysical data. The project team must consider which geophysical tool will be used during the anomaly discrimination process. The project team will ensure that it analyzes the geophysical data and provides hard copy and digital dig-sheets containing, as a minimum, the following pre-excavation information:

- (1) Project site;
- (2) Grid number;
- (3) Anomaly number;
- (4) Geophysical contractor;
- (5) Responsible field geophysicist;

- (6) Date geophysically mapped;
- (7) Responsible analyst;
- (8) Date geophysically analyzed;
- (9) Predicted location coordinates;
- (10) Predicted depth to top of item (optional);
- (11) Predicted length (optional);
- (12) Predicted diameter (optional);
- (13) Predicted azimuth (optional); and
- (14) Comments.

b. Anomaly Reacquisition and Marking.

(1) Anomaly reacquisition and marking is an extremely important aspect of a UXO geophysical mapping project which often receives inadequate attention. Often, errors resulting from the original positioning during the geophysical survey, data analysis adjustments, and positioning errors during reacquisition combine to yield a reacquired location up to several feet away from the actual anomaly location. The most accurate reacquisition is accomplished using the same instrument used in the geophysical survey to pinpoint the anomaly and reduce the area the excavation team needs to search to find the item.

(2) Discrepancies between original mapped locations of anomalies as shown on the dig-sheet and the actual reacquired location, as well as any anomalies that could not be reacquired, need to be recorded and included in the geophysical report.

c. Anomaly Excavation. After the location of a subsurface anomaly has been marked by the reacquisition team, the anomaly is excavated, identified, and properly disposed. This can be an extremely hazardous activity and should only be undertaken by qualified personnel working under an approved Work Plan. The excavation team must collect pertinent information regarding each anomaly and provide it to the geophysical team. Information to be collected includes, at a minimum, the following post-excavation information:

- (1) Project site;
- (2) Grid number;
- (3) Anomaly number;

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- (4) Excavation contractor;
- (5) Responsible OE Safety Specialist;
- (6) Date of excavation;
- (7) Actual location coordinates;
- (8) Weather conditions;
- (9) Anomaly identification (UXO, suspect UXO, ordnance scrap, and scrap);
- (10) Actual depth to top of item;
- (11) Soil type;
- (12) Actual length (Optional);
- (13) Actual diameter (optional);
- (14) Actual azimuth (optional);
- (15) Item material composition (optional); and
- (16) Comments.

d. **Data Feed-Back.** It is important to build a feed-back loop between the geophysicists mapping and analyzing site data and the individuals excavating anomalies and performing field quality control. Comparison of the type of items found in the field to the original data will allow the geophysicists to adjust the processing methodology and reduce the number of false selections. Information such as size, depth, weight and metallic nature (i.e., ferrous vs. non-ferrous) of items found can be useful to geophysicists in directing intrusive teams to the anomalies most likely representing ordnance.

7-17. Digital Data Format and Storage.

a. The project team should develop requirements and standards for a digital data management system tailored for the specific ordnance investigative needs of the project. All geophysical data generated by the project team as well as the data required to associate the geophysical data to its correct geographical location must be generated and stored in a format and media that permits loading, storage, and use on GIS workstations without modification or additional software. The use of an Internet connection should be considered. The geophysical mapping technology should digitally capture the instrument readings into a file coincident with the state grid coordinates. This field data must be checked, corrected and processed into ASCII files. Corrections for navigation, instrument bias, and diurnal magnetic shift should be applied

but there should be no filtering or normalization of the data. Any corrections should be documented.

b. Grids geophysically mapped will be exactly coincident with the grid system used by the UXO removal action project team and will use exactly the same datum and coordinate system. The data will be presented in delineated fields using x, y, and z coordinates where x and y are local State Grid Plane Coordinates in East and North and z is the instrument reading. Each of the data fields will be separated by a space (not a comma). There should be no header or other information included in the file. No individual file may be more than four megabytes in size and no more than 60,000 lines long. Each grid of data will be logically and sequentially named so that the file name can be easily correlated with the grid name used by other project personnel. The formats specified in this paragraph must be followed exactly, although the project team may choose to submit the data in additional formats as well.

7-18. Quality Management.

a. Objective. The general objective of geophysical investigations during an OE removal action is to efficiently locate buried UXO so that it can be properly evaluated, recovered and disposed. Specific geophysical investigation objectives of a project are defined by the project team and must be risk-based, measurable, and attainable.

b. General Approach.

(1) On OE projects, there are two elements which are subject to QA/QC: processes and products.

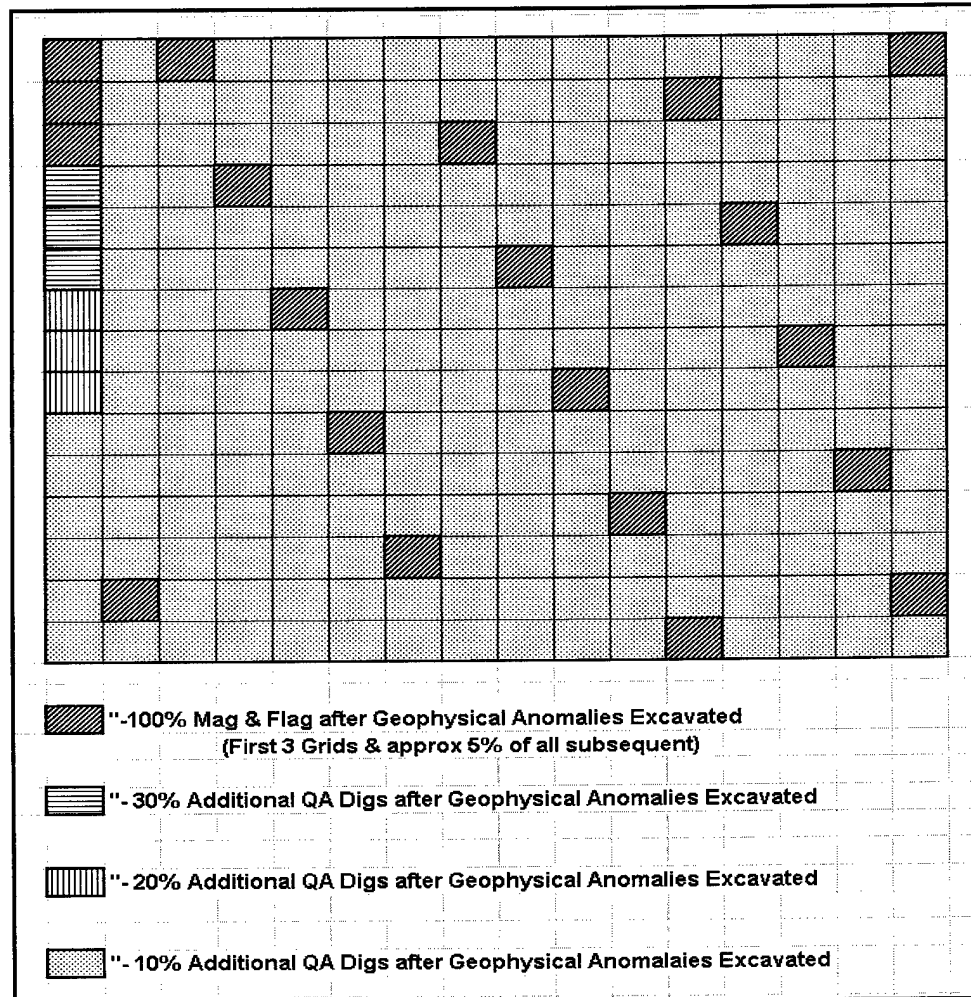
(a) "Processes" are the project-specific geophysical planning and data collection/data analysis procedures and methods that must be performed.

(b) "Products" are the final project-specific deliverables and results that must be achieved.

(2) Both the project processes and the project products must be part of a formal quality management process in order to demonstrate that project quality objectives are met.

c. Process Quality Management. The project team must periodically check the geophysical data provided by the project team to assure positional accuracy, proper instrument calibration, and analysis confirmation.

d. Product Quality Management. This section discusses the process for quality management at OE sites where digital geophysical mapping is used. Figure 7-8 provides an illustration of this process.



Notes:

1. If any of these first three 100% grids fail, then geophysical picking process has not yet been proven adequate for site. Correct problem.
 2. For 30%, 20% and 10% grids, field QA may pick additional anomalies for excavation using any method.
 3. Grid must have no QA failures in order to step down to next lower QA percentage.
 4. If any QA failure occurs, evaluate & correct cause, revert back to 30% QA and step down as described above.
 5. After 10% QA level is reached, approx. 5% of all grids should be 100 mag/flag in addition to digital geophysical mapping.
 6. A "failure" is defined to be any UXO or inert OE look-alike being found by QA, if within project-defined size/depth parameters. Project team may pick alternate "failure" definition.
 7. If UXO or inert-OE is found by geophysical mapping or QA that is outside of project parameters, evaluate.
- USAESCH 23 June 1999.

Figure 7-8
Quality Management Process at OE Removal Sites Where
Digital Geophysical Mapping Is Used

(1) One hundred percent of all anomalies should initially be removed from three to five grids. The results will be provided to the project geophysicist so that prioritized dig lists can be developed.

(2) The geophysical team will remain available during the entire anomaly removal process. The geophysical team should not perform site mapping and then leave. It is unlikely that the geophysical team can successfully pick anomalies without feedback of actual field data.

(3) Approximately 5 percent of the grids should be randomly selected for 100 percent anomaly removal.

(4) The remainder of the grids should have all suspect anomalies removed, plus 10 percent to 30 percent of additional anomalies dug, depending on the status of the project.

(5) If a grid has very few or very many suspect anomalies, 10 percent to 30 percent additional anomaly excavation may not be feasible. If so, a higher or lower number of QA/QC anomalies may be justified and selected.

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ATTACHMENT 7-1
GEOPHYSICAL INVESTIGATIONS CHECKLIST

Project Name: _____
Project Location: _____
Design Center POC: _____
Preparer's Name and Title: _____
Date of Preparation: _____

	Y	N	N/A
<u>Geophysical Planning Considerations</u>			
1. Is the geophysical planning being performed by or under the supervision of a geophysicist?	_____	_____	_____
2. Have objectives been considered for the geophysical investigation in the following areas:			
• Geophysical sampling?	_____	_____	_____
• Geophysical mapping?	_____	_____	_____
• Geophysical interrogation?	_____	_____	_____
3. Has the geophysical investigation planning process addressed:			
• Experienced personnel?	_____	_____	_____
• Geophysical instruments?	_____	_____	_____
• Analysis procedures?	_____	_____	_____
• Navigational accuracy and precision?	_____	_____	_____
<u>Geophysical Instrument Considerations</u>			
1. Have the following factors which affect geophysical instruments been considered:			
• UXO composition?	_____	_____	_____

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	Y	N	N/A
• UXO size?	_____	_____	_____
• UXO depth?	_____	_____	_____
• UXO fuzing?	_____	_____	_____
• Background interference from metallic scrap?	_____	_____	_____
• Soil composition and geology?	_____	_____	_____
• Vegetation and terrain?	_____	_____	_____
• Cultural Features?	_____	_____	_____
<u>Selection of Geophysical Instruments</u>			
1. Which type of geophysical instrument is the most appropriate:			
• Active (conductivity meter)?	_____	_____	_____
• Passive (magnetometer or gradiometer)?	_____	_____	_____
<u>UXO Detection Rates</u>			
1. Have the following factors been considered in determining the detection rate in the field for a geophysical instrument:			
• Vegetation?	_____	_____	_____
• Terrain?	_____	_____	_____
• Geologic noise/Gradients?	_____	_____	_____
• Cultural noise?	_____	_____	_____
• UXO fragments?	_____	_____	_____
• UXO penetration beyond detection?	_____	_____	_____
<u>UXO Detection Depths</u>			
1. Have maximum UXO detection depths been estimated in accordance with Tables 7.2 and 7.3?	_____	_____	_____
2. Has the maximum possible depth of UXO at the site been estimated?	_____	_____	_____

Y N N/A

Geophysical Instruments and Electric Fuze Safety

Have the following safety precautions been applied to the project:

1. Passive Instruments:

- Are the passive instruments being used in accordance with manufacturer's instructions?

2. Active Instruments:

- Prior to using an active instrument, has the operator determined if any fuzing systems exist at the site that contain any electrical components?
- If an OE site does not contain electrical fuzes, are the active instruments being used in accordance with manufacturer's instructions?
- If an OE site does contain or is reasonably expected to contain electrical fuzes, has the instrument operator submitted a request for a waiver from the Design Center Safety Manager?

Analysis Software

1. Has the appropriate analysis software been selected for the specific instrument?
2. Prior to using the software, have navigation adjustments been made?
3. Prior to using the software, have the coordinate systems been rotated and translated?

Navigation System

1. Which type of positional system was selected:

- Temporary?
- Permanent?

2. Is the navigation system based on the local State Grid Plane system?

	Y	N	N/A
<u>Geophysical Prove-out Planning</u>			
1. Have DQOs been developed?	_____	_____	_____
2. Has a Work Plan been developed for the prove-out?	_____	_____	_____
3. Does the Prove-out Work Plan describe the following:			
• Prove-out grid location and construction?	_____	_____	_____
• Factors influencing prove-out grid location and construction:			
– Terrain, vegetation, geological conditions?	_____	_____	_____
– Proximity to the field site?	_____	_____	_____
– Isolation from overhead power lines, radio transmitters, underground utilities, etc?	_____	_____	_____
– Convenient access?	_____	_____	_____
– Likelihood that the area will be disturbed during use?	_____	_____	_____
– Rights-of-Entry?	_____	_____	_____
– Possibility of pre-existing buried UXO?	_____	_____	_____
• Pre-Seeding geophysical mapping?	_____	_____	_____
• Have the following items been considered regarding pre-seeding:			
– Size and configuration?	_____	_____	_____
– Survey accuracy?	_____	_____	_____
– Layout?	_____	_____	_____
– Seeded items?	_____	_____	_____
– Depths and orientations?	_____	_____	_____
– Cultural interference?	_____	_____	_____
– UXO fragment interference?	_____	_____	_____

	Y	N	N/A
• Data collection variables, including:			
– Instrument height?	_____	_____	_____
– Instrument orientation?	_____	_____	_____
– Direction of travel?	_____	_____	_____
– Measurement interval?	_____	_____	_____
– Lane width?	_____	_____	_____
• Data analysis and interpretation?	_____	_____	_____
• Data evaluation?	_____	_____	_____
• Selection of detection instruments?	_____	_____	_____

Geophysical Investigation Plan

1. Does the Geophysical Investigation Work Plan address the following:

• Site Description:	_____	_____	_____
– Geophysical Investigation Program Objectives?	_____	_____	_____
– Specific Area(s) to be Investigated, including a map?	_____	_____	_____
– Past, current and future use?	_____	_____	_____
– Anticipated UXO type, composition and quantity?	_____	_____	_____
– Depth anticipated?	_____	_____	_____
– Topography?	_____	_____	_____
– Vegetation?	_____	_____	_____
– Geologic conditions (including bedrock type, mineralization and depth)?	_____	_____	_____
– Soil conditions (including soil type/composition, typical moisture content, and thickness)?	_____	_____	_____

	Y	N	N/A
– Shallow groundwater conditions (including depth, mineralization, existence of perched tables, and seasonal & tidal variations)?	_____	_____	_____
– Geophysical conditions, including background geophysical gradients?	_____	_____	_____
– Site Utilities?	_____	_____	_____
– Man-made features potentially affecting geophysical investigations?	_____	_____	_____
– Site-specific dynamic events such as tides, unusually strong winds, or other unusual factors affecting site operations?	_____	_____	_____
– Overall Site Accessibility and Impediments?	_____	_____	_____
– Potential Worker Hazards?	_____	_____	_____
• Geophysical Investigation Methods:			
– Equipment?	_____	_____	_____
– Procedures?	_____	_____	_____
– Personnel?	_____	_____	_____
– Production Rates?	_____	_____	_____
– Data Resolution, or line/grid width requirements?	_____	_____	_____
– Data density?	_____	_____	_____
– Data Processing?	_____	_____	_____
• Location Surveying, Mapping and Navigation:			
– System Description?	_____	_____	_____
– If GPS systems are used, correlate satellite availability with work/rest periods?	_____	_____	_____

	Y	N	N/A
• Instrument standardization:			
– Instrument drift?	_____	_____	_____
– Standardization procedures?	_____	_____	_____
– Abbreviated standardization checks?	_____	_____	_____
– Instrument response to a known standard?	_____	_____	_____
• Data processing, correction and analysis:			
– Instrument drift correction?	_____	_____	_____
– Diurnal drift correction?	_____	_____	_____
– Digital filtering and enhancement?	_____	_____	_____
– Correlation with ground truth?	_____	_____	_____
• Quantitative interpretation and dig sheet development?	_____	_____	_____
• Anomaly reacquisition?	_____	_____	_____
• Feed-back process?	_____	_____	_____
• Quality control?	_____	_____	_____
• Corrective measures?	_____	_____	_____
• Records management?	_____	_____	_____
• Interim reporting?	_____	_____	_____
• Final reports and map?	_____	_____	_____

Sectorization

1. When defining sectors, were the following factors considered:

• Former military use?	_____	_____	_____
• Anticipated UXO type?	_____	_____	_____
• Anticipated UXO distribution?	_____	_____	_____
• Terrain and vegetation?	_____	_____	_____

Y **N** **N/A**

-

1. Which sampling methodology is appropriate for the sector:

- [illegible]

1. Which sampling methodology is appropriate for the grid?

- 

1. Was the geophysical data interpreted after the geophysical investigation?

-

1. Do the dig sheets contain the following information:

- (continued)*

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	Y	N	N/A
• Anomaly number?	_____	_____	_____
• Name of the geophysical contractor?	_____	_____	_____
• Name of the responsible field geophysicist?	_____	_____	_____
• Date geophysical mapping occurred?	_____	_____	_____
• Name of the responsible analyst?	_____	_____	_____
• Date the data was geophysically analyzed?	_____	_____	_____
• Predicted location coordinates?	_____	_____	_____
• Predicted depth to top of item (optional)?	_____	_____	_____
• Predicted length (optional)?	_____	_____	_____
• Predicted diameter (optional)?	_____	_____	_____
• Predicted azimuth (optional)?	_____	_____	_____
• Comments.	_____	_____	_____

Anomaly Reacquisition and Marking

1. Was the same instrument used for reacquisition as that used in the geophysical survey?

2. Were discrepancies between original mapped locations of anomalies as shown on the dig-sheet and the actual reacquired location recorded and included in the geophysical report?

Anomaly Excavation

1. Was the following post-excavation information collected:
 - Project site?

 - Grid number?

 - Anomaly number?

 - Excavation contractor?

 - Name of the responsible OE Safety Specialist?

 - Date of excavation?

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	Y	N	N/A
• Actual location coordinates?	_____	_____	_____
• Weather conditions?	_____	_____	_____
• Anomaly identification?	_____	_____	_____
• Actual depth to top of item?	_____	_____	_____
• Soil type?	_____	_____	_____
• Actual length (optional)?	_____	_____	_____
• Actual diameter (optional)?	_____	_____	_____
• Actual azimuth (optional)?	_____	_____	_____
• Item material composition (optional)?	_____	_____	_____
• Comments.	_____	_____	_____

Digital Data Format and Storage

1. Were the requirements and standards for a digital data management system tailored for the specific ordnance investigative needs of the project?
2. Has the geophysical data been stored in a format and media that permits loading, storage and use of GIS workstations without modification or additional software?

_____	_____	_____
_____	_____	_____

Quality Management

1. Were procedures for process quality management followed?
2. Were procedures for product quality management followed?

_____	_____	_____
_____	_____	_____

CHAPTER 8 LOCATION SURVEYING AND MAPPING

8-1. Introduction.

a. The purpose of this chapter is to describe and discuss the location surveying and mapping considerations that should be addressed by the project team for an OE project. The project team should develop site-specific location surveying and mapping requirements for inclusion in the SOW for each OE project. Attachment 8-1 is a checklist of location surveying and mapping considerations.

b. USACE has various contract vehicles that may be used for obtaining location surveying and mapping services. Services may be supplied by the government as Government Furnished Information/Government Furnished Equipment or may be requested within the SOW of the OE project. Some OE projects may not require any specialized capabilities, while others may require comprehensive capabilities.

8-2. Overview. This chapter presents guidance in developing requirements for location survey and mapping associated with an OE project, specific SOW specifications, and technical or management considerations. There are many surveying and mapping techniques that may be used to acquire planimetric, topographic, hydrographic, or feature attribute data required in support of an OE project. Specifications for obtaining this data should be "performance-based" and not overly prescriptive or process oriented in accordance with EM 1110-1-2909, Geospatial Data and Systems. They should not be a survey procedural instruction. Project specifications should set forth the end results to be achieved and not the means, or technical procedures, used to achieve those results. They should succinctly define the location surveying and mapping requirements as derived from the functional project requirements developed by the project team and reference EM 1110-1-2909 and other applicable industry standards.

8-3. Data Quality Objectives. Prior to developing data quality objectives for the location surveying and mapping task, the project team should review the archival records of the project area or installation in which the project is located and inventory all existing survey and mapping data. Following the completion of these tasks, the project team should develop site-specific data quality objectives in the following areas:

a. Measurement Units. Location surveying and mapping performed in support of an OE response should be recorded and plotted in the units prescribed for the project by the district or project sponsor.

b. Spatial Coordinate Reference System.

(1) All OE projects should be adequately connected to nationwide or worldwide geographic reference systems directly derived from, or indirectly related to, GPS satellite observations where practical and feasible. Location surveys will be connected to existing local, state or national control markers and referenced to an appropriately recognized installation, local, state, or worldwide coordinate system as specified by the project team. The project team should select a spatial coordinate reference system that is compatible with existing district or project sponsor surveying and mapping activities.

(2) The base mapping should be accomplished in the appropriate English or metric State Plane Grid Coordinate System for the state where the project is located unless an equivalent local system is preferred by the customer at this location.

c. Control Markers. Project control markers may consist of markers and/or benchmarks established by any federal, state, local, or private agency with positional data within the minimum acceptable accuracy standards prescribed by the project team. The project team may require an increase in existing project control markers. Ties to local USACE or installation project control and/or boundary markers are absolutely essential and critical except when unfeasible or cost prohibitive. In order to minimize scale and orientation errors, at least two existing markers should be used as a baseline for the project geospatial coordinate reference system.

d. Accuracy. Every observed or measured spatial data element contains errors of a certain magnitude due to a variety of causes. The project team should evaluate data requirements and develop acceptable limits of error (accuracy and precision) based upon the nature and purpose of each location surveying and mapping activity or product. Engineering and construction surveys are normally specified and classified based on the minimum acceptable horizontal (linear) point closure ratio and vertical elevation difference standard.

e. Geospatial Data Standards. The project team should develop site-specific standards for the format, transfer, and storage of all location surveying and mapping data. Factors influencing formulation of project-specific specifications include:

(1) Compatibility with current OE MCX and district hardware and software platforms without modification or additional software;

(2) Existing digital data and geo-spatial referenced mapping; and

(3) Usability by all parties of concern, including stakeholders.

f. Quality Control. The project team should state in the SOW that quality control of location surveying and mapping activities and products will be performed by the contractor and

include independent tests which may be periodically reviewed by the government. USACE quality assurance and testing functions should focus on whether the contractor meets the required performance specifications.

g. Standardization. Standardization of equipment and instruments used in acquiring geospatial data and producing location survey and mapping products is required to improve the accuracy of the integrated conclusions. The project team should review the need for and develop minimum acceptable criteria for review of validation and calibration reports.

8-4. Statement of Work.

a. General. The Location Surveying and Mapping task of each SOW for OE projects should be prepared by project team personnel with a detailed knowledge of project history, site conditions, site-specific data requirements, and location survey and mapping methodologies. The SOW should require consideration of the following in development of the Work Plan:

- (1) Project and property boundaries;
- (2) UXO/OE types, hazard levels, and contamination levels;
- (3) Project location, size, topography, and vegetative cover;
- (4) Extent of existing planimetric features;
- (5) Density and accuracy of existing control markers;
- (6) Mission and objectives of OE response action;
- (7) Positioning requirements of proposed geophysical detection systems; and
- (8) Data formatting, transfer, and storage.

b. Personnel Requirements. The project team should ensure that the SOW discusses personnel requirements for a Registered or Professional Land Surveyor and a qualified UXO technician.

(1) Registered or Professional Land Surveyor (RLS/PLS). The project team should ensure that the OE project SOW specifies that all location surveying and mapping activities should be completed under the responsible charge of a RLS/PLS. The RLS/PLS should be registered and/or licensed by the appropriate Board of Registration, or an acceptable equivalent, for the state in which the work will be conducted. The RLS/PLS will only be required to sign drawings that contain boundaries, legal descriptions, or parcel closure information. Signatures are not required for EE/CA grid location and ordnance location data. In addition, the Field Surveyor

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assigned to the OE project should have a minimum of five years experience as a Survey Party Chief.

(2) UXO Technician II. The project team should also assure that the SOW requires a qualified UXO Technician II to accompany the Field Surveyor during all field surveying and mapping activities. The UXO Technician II should conduct visual surveys for surface ordnance prior to the Field Surveyor entering a suspected UXO contaminated area, and a survey with a geophysical instrument of each intrusive activity site to ensure the site is anomaly free prior to installation of monuments, driving stakes, or performing any other intrusive activity. Based on site conditions, it is possible that a UXO Technician II will not be required in all areas at all times after the initial site visit. However, such a decision should be made jointly by the UXO Technician II and the USACE OE Safety Specialist who may rescind or modify it at any time.

c. Safety. It is the responsibility of the project team to assure that the contractor is informed in the SOW to follow the safety requirements in EM 385-1-1, USACE Safety and Health Requirements Manual.

d. Resources. For general guidance in the development of surveying and mapping specifications, the project team may reference Chapter 11, "Accuracy Standards for Engineering, Construction, and Facility Management Surveying and Mapping", of EM 1110-1-2909. GPS surveying services may be required as an integral part of the location surveying and mapping effort. EM 1110-1-1003, NAVSTAR Global Positioning System Surveying, provides technical specifications and procedural guidance for surveying with GPS and includes a guide specification for development of SOWs with GPS survey requirements.

8-5. Location Surveys and Mapping Plan.

a. General. Prior to initiating field activities, a Location Surveys and Mapping Plan should be prepared. This plan, which is a chapter in the Work Plan, is prepared to describe the project requirements, proposed technical methodologies and procedures, and equipment recommendations for all surveying and mapping activities that will take place during an OE project.

b. Contents. When reviewing the Location Surveys and Mapping Plan, the project team should ensure that the following elements are addressed:

(1) Existing control markers (density, accuracy, and accessibility);

(2) Project and grid controls (requirements, material, location, construction, identification, and accuracy);

(3) Proposed methods and procedures (equipment, personnel, safety, work instructions, data processing and production rates);

- (4) Quality control (instrument calibration, data validation);
- (5) Interim reporting; and
- (6) Final reports and maps.

c. **Review and Approval.** The Location Surveys and Mapping Plan should be submitted as a chapter of the Work Plan to the PM and Design Center POC. The Design Center POC should route the plan to the appropriate USACE technical staff for review and comment. Once approved by the project team and CO, the Location Surveys and Mapping Plan represents the standard to which all survey and mapping activities are compared to assure compliance during the project. In the case of contractor execution, the approved Location Surveying and Mapping Plan is contractually binding.

8-6. Planning Considerations. Each OE project requires selection of location surveying and mapping equipment and methodologies that will accomplish the end objective without wasting manpower, time, and money. The project team should ensure that the following items are considered when planning for the location surveying and mapping task.

a. **Spatial Data Reference System.** Unless otherwise specified, all horizontal control will be based on either the English or metric system and reference to the NAD83 and the State Plane Grid System for the project location. Vertical control, if required, will also be based on either the English or metric system and referenced to the NAVD88.

b. **Project Control Markers.**

(1) The requirements for new or additional project control markers should be based on the availability of existing control markers, the type of location surveying equipment proposed, and the level of accuracy required for the type of activities proposed under the specific OE response project. Permanent concrete monuments are typically used for project control. Specifications for permanent markers are set forth in EM 1110-1-1002, Survey Markers and Monumentation and should be reviewed in consideration of the following:

- (a) Located within the project limits with a minimum separation of 300 feet;
 - (b) Set 10 meters (m) from the edge of any existing road inside the project limits; and
 - (c) Constructed with the top set flush with the ground and the bottom at a minimum of 0.6 meters below frost depth.
- (2) **Accuracy.**

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(a) The minimum accuracy standards for horizontal and vertical control will be Class I, Third Order, or better. Horizontal control will be based on either the English or metric system and referenced to the NAD83 and the State Plane Coordinate Grid System. Vertical control, if required, will also be based on either the English or metric system and referenced to NAVD88.

(b) If aerial photographs or orthophotography are used to provide the survey, the aerial targets used for control points will meet the same horizontal and vertical accuracy requirements detailed above.

(3) Monument Caps.

(a) The caps for any new monuments established should be 3-1/4 to 3-1/2 inch domed brass, bronze or aluminum alloy and stamped in a consecutively numbered sequence. The proposed identification stamping for each monument will be provided in the location surveying and mapping plan consistent with the following:

(Project Name) - (Numerical Sequence) - (Year) (Contracting OE Design Center)

(b) The dies for stamping the numbers and letters into these caps will be 1/8-inch to 3/16-inch in size. All coordinates and elevations will be shown to the closest one-thousandth of a meter (0.001m) and one-hundredth of a foot (0.01 ft).

(4) Description Cards. A Description Card should be required for all control monuments established or used for the OE response. The Description Cards should be prepared on cards 5 inches by 8 inches describing one monument per card, or on an 8-1/2 by 11 inch sheet of bond paper containing descriptions of two monuments. The Description Card should show the following:

(a) A north arrow;

(b) A sketch of each monument and its location relative to reference marks, buildings, roads, railroads, towers, trees, etc.;

(c) A typed description telling how to locate the monument from a well known and easily identifiable point;

(d) The monument's name or number; and

(e) The final adjusted coordinates and elevations in meters and feet (to the closest 0.001m and 0.01 feet).

c. Project Boundaries. Project boundaries should be delineated with permanent or semi-permanent markers, such as iron pipe or pins consistent with state or local subdivision

requirements. The accuracy standards for the location of project boundaries should be equal or greater than minimum standards for property boundary surveys established by the state within which the project is located.

d. Local Control Points. Local control points (i.e., grid corners, aerial targets) should be established using plastic or wooden hubs unless otherwise specified by the project team. The accuracy standards for aerial targets established as control points for aerial photographs or orthophotography should be the same as those prescribed for project control monuments. Accuracy standards for grid corners should be consistent with the mission and objectives of the OE response effort.

e. Anomalies and Recovered UXO. All recovered UXO/OE and any subsurface geophysical anomalies not completely investigated should be located. Each location will be estimated or measured for an approximate accuracy of plus or minus one foot.

8-7. Mapping.

a. The project team should review the extent of mapping requirements to be included in each OE project SOW. The project team should assure that the SOW states that all maps and drawings to be provided under the task will be prepared in accordance with Chapter 9 of this manual and sealed and signed by the RLS/PLS. Tri-Service Computer-aided Design and Drafting (CADD)/GIS Technology Center standards should be specified for all location survey and mapping deliverables of CADD, GIS, and other spatial and geospatial data in accordance with EM 1110-1-2909.

b. The project team should ensure that the following maps are provided:

(1) Location Maps. A location map showing the project site and surrounding points of interest should be required. The map(s) should be produced at a scale no smaller than 1:2,400 or 1":200'.

(2) Project Map.

(a) A map of all project related points of interest should be produced and delivered electronically at a scale specified by contract requirements. The Project Map should show the location and identification of all of the project control monuments recovered and/or established at the site in support of the OE response, local project controls, significant planimetric features, project boundaries, and property boundaries (if in close proximity to project boundaries). The location of recovered UXO/OE should also be plotted and identified on the map unless individual grid maps are also required.

(b) General project map requirements should also include grid, magnetic, and true north arrows with their angular differences; grid lines or tic marks at systematic intervals with values

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shown on the edges of the map; and a legend showing the standard symbols used for the mapping.

(3) Grid Maps. If required, individual maps for each grid should be prepared at a scale no smaller than 1:2,400 or 1":200'. The Grid Maps should include the plotted location of each surface UXO/OE, verified subsurface UXO/OE recovered, and each subsurface geophysical anomaly not completely investigated within the grid. Other notable planimetric features within the grid should also be sketched on the individual Grid Maps.

8-8. Deliverables. All deliverables should be submitted in accordance with contract requirements. When applicable, deliverables should be submitted in electronic format. The following deliverables should be submitted to the project team following the location survey and mapping task (the submittal dates should be specified for each delivery order):

- a. Original copies of all field books, layout sheets, computation sheets, abstracts and computer printouts;
- b. Tabulated listing of all project control markers established and/or used in support of the OE response showing adjusted horizontal and vertical positional values in meters and feet;
- c. Tabulated listing of all UXO/OE recovered and any specific anomalies not completely investigated;
- d. Completed description cards;
- e. Unique items created and/or used to create the end products and the narrative and description required by the SOW;
- f. Required location, project, and grid maps;
- g. The negatives and three sets of prints of the aerial photographs taken for the project, if aerial photography is required in the SOW; and
- h. All maps should be drawn on 841 mm by 594 mm (standard metric A-1 size drawing) reproducible (mylar) drawings generated by the CADD system. One original mylar and five blue-line prints of each final map and two copies of the digital data should be delivered to the Design Center.

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ATTACHMENT 8-1
LOCATION SURVEYING AND MAPPING CHECKLIST

Project Name: _____
 Project Location: _____
 Design Center POC: _____
 Preparer's Name and Title: _____
 Date of Preparation: _____

Y N N/A

SOW Requirements

1. Has the Location Surveying and Mapping task in the SOW been prepared by project team personnel with a detailed knowledge of project history, site conditions, site-specific data requirements and location survey and mapping methodologies? _____
2. Does the SOW state that all surveying and mapping activities must be conducted under the responsible charge of a Registered or Professional Land Surveyor registered and/or licensed in the State in which the work will be conducted? _____
3. Does the SOW state that the Field Surveyor assigned to the project must have a minimum of 5 years experience as a Survey Party Chief? _____
4. Does the SOW require that a qualified UXO Technician II accompany the Field Surveyor at all times, unless it is decided by the UXO Technician II and the OE Safety Specialist that the UXO Technician II is not required? _____
5. Does the SOW state that the contractor must follow the safety requirements in EM 385-1-1, US Army Corps of Engineers Safety and Health Requirements Manual? _____
6. Does the SOW specify the requirements for control point establishment? _____

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	Y	N	N/A
7. Does the SOW state the specifications for monument caps and monument identification?	_____	_____	_____
8. Does the SOW give procedures for plotting the control points?	_____	_____	_____
9. Does the SOW give requirements for grid corner establishment?	_____	_____	_____
10. Does the SOW state that the Registered Land Surveyor/Professional Land Surveyor should sign drawings that contain boundaries, legal descriptions or parcel closure information?	_____	_____	_____
11. Does the SOW prescribe the units to be used for recording and plotting location survey and mapping activities, as specified by the district or project sponsor?	_____	_____	_____
12. Does the SOW specify the spatial coordinate reference system to be used?	_____	_____	_____
13. Is the chosen spatial coordinate reference system compatible with existing district or project sponsor surveying and mapping activities?	_____	_____	_____
14. Does the SOW require that location surveys be connected to existing local, state or national control monuments and referenced to an appropriately recognized installation, local state, or worldwide coordinate system as specified by the project team?	_____	_____	_____
15. Does the SOW specify the minimum acceptable accuracy standards for positional data for project control markers (i.e., monuments, benchmarks)?	_____	_____	_____
16. Is densification of the existing project control markers required?	_____	_____	_____
17. If densification of existing project control markers is required, is this specified in the SOW?	_____	_____	_____
18. Does the SOW specify that at least two existing markers will be used as a baseline for the project geospatial coordinate reference system?	_____	_____	_____

	Y	N	N/A
19. Has the project team specified acceptable limits of error in terms of accuracy and precision based on the nature and purpose of each location surveying and mapping activity or product?	_____	_____	_____
20. Has the project team developed site-specific standards for the format, transfer and storage of all location surveying and mapping data?	_____	_____	_____
21. Were the following items considered in developing the standards for format, transfer and storage of data:			
• Compatibility with current OE MCX and district hardware and software platforms without modification or additional software?	_____	_____	_____
• Existing digital data and geospatial referenced mapping?	_____	_____	_____
• Usability by all parties of concern, including stakeholders?	_____	_____	_____
22. Does the SOW require contractor quality control of location surveying and mapping activities and products, including independent tests which may be periodically reviewed by the government?	_____	_____	_____
23. Has the project team established minimum acceptable criteria for standardization of equipment and instruments used in acquiring geospatial data and producing location survey and mapping products?	_____	_____	_____
24. Has the project team established minimum acceptable criteria for productivity?	_____	_____	_____
25. Are the following deliverables specified in the SOW:			
• Original copies of all field books, layout sheets, computation sheets, abstracts and computer printouts?	_____	_____	_____

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	Y	N	N/A
• Tabulated listing of all project control monuments established and/or used in support of the OE response showing adjusted horizontal and vertical positional values in meters and feet?	_____	_____	_____
• Tabulated listing of all UXO/OE recovered and any specific anomalies not completely investigated?	_____	_____	_____
• Completed description cards?	_____	_____	_____
• Unique items created and/or used to create the end products and the narrative and description required?	_____	_____	_____
• Required location, project and grid maps?	_____	_____	_____
• The negatives and three sets of prints of the aerial photographs taken for the project, if aerial photography is required in the SOW?	_____	_____	_____
• Map drawn on 841 mm by 594 mm (standard metric A-1 size drawing) reproducible (mylar) drawings and generated by the CADD system?	_____	_____	_____
• One original mylar and five blueline prints of each final map and two copies of the digital data will be delivered to the Design Center?	_____	_____	_____

Location Surveys and Mapping Plan

Are the following elements addressed in the Location Surveys and Mapping Plan:

1. Existing Control Markers:

• Density?	_____	_____	_____
• Accuracy?	_____	_____	_____
• Accessibility?	_____	_____	_____

	Y	N	N/A
2. Project and Grid Controls (New):			
• Requirements?	_____	_____	_____
• Material?	_____	_____	_____
• Location?	_____	_____	_____
• Construction?	_____	_____	_____
• Identification?	_____	_____	_____
• Accuracy?	_____	_____	_____
3. Proposed Methods and Procedures:			
• Equipment?	_____	_____	_____
• Personnel?	_____	_____	_____
• Safety?	_____	_____	_____
• Work Instruction?	_____	_____	_____
• Data Processing?	_____	_____	_____
• Production Rates?	_____	_____	_____
4. Quality Control:			
• Instrument Calibration?	_____	_____	_____
• Data Validation?	_____	_____	_____
5. Interim Reporting?	_____	_____	_____
6. Final Reports and Maps?	_____	_____	_____
<u>Electronic Submittal</u>			
1. Are disks readable?	_____	_____	_____
2. Are the disks labeled and dated?	_____	_____	_____

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	Y	N	N/A
3. Are the files in the correct format, as requested in SOW? (e.g., DOS, Win 95/98/NT, UNIX, etc.)	_____	_____	_____
4. Do they follow the Tri-Service Spatial Data Standard (TSSDS), if required?	_____	_____	_____
5. Are all of the detailed files included on the disks to make a complete data set?	_____	_____	_____
6. Is each individual file readable and useable?	_____	_____	_____
7. Is the file located electronically (geo-spatially) at the correct location on the ground?	_____	_____	_____
8. Is the coordinate system correct?	_____	_____	_____
9. Does the file contain North arrow, scale, specific spot coordinates for control points, and a grid or coordinate grid system displayed as part of the border or boundary?	_____	_____	_____
10. Are all files geographically located in the correct plane and datum?	_____	_____	_____
11. Are the X, Y, Z coordinates correct within the file?	_____	_____	_____
12. Are the correct number of copies submitted, depending on the submittal stage?	_____	_____	_____
<u>Paper or Hard Copy Submittal</u>			
1. Is the sheet the requested size?	_____	_____	_____
2. Is it plotted on the correct media (e.g., paper, vellum, mylar, blue-line, etc.)?	_____	_____	_____
3. Does it contain the correct border?	_____	_____	_____
4. Is the correct grid system and associated control shown on the sheet?	_____	_____	_____
5. Has the title block been completed (i.e., all required blocks filled in)?	_____	_____	_____
6. Is the sheet plotted at the scale shown in the title block?	_____	_____	_____
7. Are there grid marks or ticks (meters, feet, both, Lat/Lon, Local, etc.)?	_____	_____	_____

	Y	N	N/A
8. Is there a North arrow (magnetic declination, true North, and grid North) and graphical scale shown on the sheet, both graphically and printed text?	_____	_____	_____
9. Is there a legend for associated symbols on the sheet? Or, are all symbols used in a project shown on one legends and notes page?	_____	_____	_____
10. Is the sheet developed based on the TSSDS and the Tri-Service CADD Standard for line weights, color, and other graphical detail?	_____	_____	_____
11. If the drawing is to be certified or stamped, are the correct seals, stamps, and signatures contained on the sheet and legible?	_____	_____	_____
12. Is the state registration seal and associated state registration number shown on the sheet?	_____	_____	_____
13. Are all the sheets plotted and an index sheet prepared to make a complete set of drawings to convey a completed mapping product?	_____	_____	_____
14. Are all sheets numbered in a sequential order in the set?	_____	_____	_____
15. Are all sheets included in the set?	_____	_____	_____
16. Are the correct number of copies submitted?	_____	_____	_____
17. Are boundaries of required clearance or remediation areas shown?	_____	_____	_____
18. Are grids of areas investigated shown?	_____	_____	_____
19. Are the coordinates of grid corners shown on a drawing or in a table?	_____	_____	_____
20. Was the GIS submittal required? If so:	_____	_____	_____
• Are all required databases and map layers submitted?	_____	_____	_____
• Is the data submitted in the correct format (MGE, ArcView, MapInfo, etc.)?	_____	_____	_____
• Is the Users Manual modified for any project specific requirements or software modification from the standard?	_____	_____	_____

CHAPTER 9 GEOSPATIAL DATA AND SYSTEMS

9-1. Introduction. This chapter discusses the geospatial data and geospatial data system (GD&S) considerations that should be addressed by the project team for an OE project. The project team should develop project-specific GD&S requirements for inclusion in the SOW for each OE project. Attachment 9-1 is a checklist of GD&S considerations.

9-2. Requirements for the Acquisition and Access of Geospatial Data.

a. This chapter presents guidance in developing GD&S requirements associated with an OE project, specific SOW specifications, and technical or management considerations. ER 1110-1-8156, Policies, Guidance, and Requirements for Geospatial Data and Systems, establishes general criteria and presents policy and guidance for the acquisition, processing, storage, distribution, and utilization of geospatial data.

b. EM 1110-1-2909 identifies standards for GD&S acquired, produced, and/or utilized in support of an OE project. Specifications for obtaining this data should be "performance-based" and not overly prescriptive or process oriented; they should not be a procedural instruction. Project specifications should set forth the end results to be achieved and not the means or technical procedures used to achieve those results. They should succinctly define the GD&S requirements as derived from the functional project requirements developed by the project team and reference EM 1110-1-2909 and other applicable industry standards.

9-3. Data Quality Objectives. The project team should review the archival records of the project area or installation in which the project is located and inventory all existing GD&S information prior to developing site-specific data quality objectives.

a. Geospatial Data System. The project team should review the extent of Geospatial Data Systems (GDS) currently utilized by the OE MCX, Design Center, district, project sponsor, and stakeholders. Any automated system that employs or references data using absolute, relative, or assumed coordinates is considered a GDS. These include GIS, Land Information Systems (LIS), Remote Sensing or Image Processing Systems, CADD systems, and Automated Mapping/Facilities Management (AM/FM) systems. The selected GDS should accomplish today's mission but also allow for future reuse or use of the geospatial data by others without translation. Production of geospatial data in multiple formats for distribution or use should be avoided wherever possible.

b. Spatial Coordinate Reference System. All OE projects should be adequately connected to nationwide or worldwide geographic reference systems. All geospatial data should be indexed to existing local, state or national control monuments and referenced to an appropriately recognized installation, local, state, or worldwide coordinate system as specified by the project

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team. The project team should select a spatial coordinate reference system that is compatible with existing district or project sponsor GD&S activities.

c. **Geospatial Data Standards.** GD&S users need geospatial data standards to manage this data, reduce redundant data, make systems more efficient, and lower project costs. The Tri-Service CADD/GIS Technology Center standards for naming conventions, common GIS layers, and symbology should be specified for all deliverables of collected geospatial data. The project team should develop additional site-specific standards for the format, transfer, and storage of all geospatial data consistent with EM 1110-1-2909. Factors influencing formulation of project-specific standards include:

- (1) Compatibility with selected GDS without modification or additional software;
- (2) Format of existing digital data and geospatial-referenced mapping; and
- (3) Usability by all parties of concern, including stakeholders.

d. **Measurement Units.** Geospatial data produced in support of an OE project should be recorded and plotted in the units prescribed for the project by the district or project sponsor.

e. **Accuracy.** Every geospatial data element contains errors of a certain magnitude due to a variety of causes. The project team should evaluate data requirements and develop acceptable limits of error (accuracy and precision) based upon the nature and purpose of the GD&S.

f. **Quality Control.**

(1) The primary goal of data quality management is to ensure consistent and measurable accuracy throughout the database. Consistency is achieved through the use of documented, approved production procedures. Following production, an assessment of the quality of the data set should be conducted to measure the achievement of expected results. The project team should establish the level of production control and rigor with which quality assessments should be made consistent with the project-specific GD&S requirements. GD&S with stringent accuracy and consistency requirements may need to have detailed procedural documentation, a completion signature for each production step, and a comprehensive assessment of accuracy. Conversely, smaller-scale GD&S developed for production of background geospatial data may have much less stringent production documentation requirements and only a cursory accuracy assessment.

(2) The project team should state in the SOW that quality control of the GD&S activities and products should be performed by the contractor and include independent tests which may be periodically reviewed by the government. Therefore, USACE quality assurance and testing functions will focus on whether the contractor meets the required performance specifications.

g. Reliability. The development of an effective GDS facilitates a systemized approach to an OE project using all digital data and life cycle management of all applicable geospatial data. The project GD&S should provide a full digital record of all on-site activities with a reproducible trail to support ongoing and future Administrative Record decisions. The GD&S designated in the SOW by the project team should provide reliable results, support greater overall productivity, and lower total project costs.

9-4. Statement of Work.

a. The GD&S standards and specifications for each OE project SOW should be prepared by project team personnel with detailed knowledge of project history, archival information, various GDS platforms, and project-specific data requirements.

b. The project team should ensure that the OE project SOW specifies that a qualified GIS manager should manage all GDS activities. The SOW should specify that the individual will have a minimum of three years of direct experience managing geospatial data systems within the system environment (i.e., Microstation MGE or ArcInfo).

9-5. Planning Considerations. Each OE project requires selection of an appropriate GD&S that will accomplish the end objective without wasting manpower, time, and money. The project team should ensure that the following items are considered when planning for GD&S.

a. GD&S considerations for Work Plan preparation.

(1) Prior to initiating field activities, Work Plan chapters should be prepared to describe the project requirements, proposed technical methodologies and procedures, and equipment recommendations for all GD&S activities that will take place during an OE project.

(2) The following elements should be addressed in the Work Plan:

(a) Locating existing Geospatial Data (types and accuracy);

(b) Newly collected geospatial data (types, accuracy and location);

(c) Proposed system methods and procedures (hardware and software, personnel, work instructions/data format, data processing, analysis support, communication/data transfer, and data storage);

(d) Quality control (data validation); and

(e) Deliverables.

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b. Spatial Data Reference System. Unless otherwise specified, all horizontal control will be based on either the English or metric system and referenced to the NAD83 and the State Plane Grid System for the project location. Vertical control, if required, will also be based on either the English or metric system and referenced to the NAVD88.

c. Mapping. The project team should review the extent of mapping requirements to be included in each OE project SOW. The project team should assure that the SOW states that all maps and drawings to be provided under the task are sealed and signed by the RLS/PLS. Tri-Service CADD/GIS Technology Center standards should be specified for all location survey and mapping deliverables of CADD, GIS, and other spatial and geospatial data in accordance with EM 1110-1-2909. The project team should ensure that the following maps are provided:

(1) Location Maps. A location map showing the project site and surrounding points of interest should be required. The map(s) should be produced at a scale no smaller than 1:2,400 or 1":200'.

(2) Project Maps.

(a) A map of all project-related points of interest should be produced and electronically delivered at a scale specified by contract requirements. The Project Map should show the location and identification of all of the project control monuments recovered and/or established at the site in support of the OE response, local project controls, significant planimetric features, project boundaries, and property boundaries (if in close proximity to project boundaries). The location of recovered UXO/OE should also be plotted and identified on the map unless individual grid maps are also required.

(b) General Project Map requirements should also include grid, magnetic, and true north arrows with their angular differences; grid lines or tic marks at systematic intervals with values shown on the edges of the map; and a legend showing the standard symbols used for the mapping.

(3) Grid Maps. If required, individual maps for each grid should be prepared at a scale no smaller than 1:2,400 or 1":200'. The Grid Maps will include the plotted location of each surface UXO/OE and verified subsurface UXO/OE recovered and each subsurface geophysical anomaly within the grid not completely investigated. Other notable planimetric features within the grid will also be sketched on the individual Grid Maps.

d. Design File Requirements.

(1) An overall planimetric design file will be created and will be digitized into the appropriate GDS file at an elevation of zero. If contours and spot elevations are required, all data will be digitized into a second design file with each element (contours and spot elevations) at their correct elevation.

(2) Cut sheet plots and views into the project data will be created by referencing the planimetric and contour files. Each sheet will be a standard metric A-1 drawing, which is 841 mm by 594 mm (33.1 inches by 23.4 inches). Each sheet will have a standard border, a revision block, a complete index sheet layout, a bar scale, a legend, grid lines or a grid tic layout in feet or meters, a True North, a Magnetic North and a Grid North arrow, with their differences shown in minutes and seconds. Each sheet will be plotted at the horizontal scales required.

(3) The cell library used will be attached and provided with the digital data set along with all other supporting files or data. All production and work files will be fully documented into a concise data manual. This manual will include all specific information required for an outsider to be able to recreate all products and determine the location, names, structures and association of the data. The manual will be included as an ASCII file titled READ.ME that is included with all distributed digital data.

9-6. Deliverables.

a. No digital data will be acceptable until proven compatible with the GDS designated in the SOW. All revisions required to achieve compatibility with the SOW-designated GDS will be done at the contractor's expense.

b. Deliverables will be submitted to the project team in accordance with contract requirements. Whenever appropriate, deliverables should be submitted electronically. Deliverables which should be submitted upon completion of the OE project include:

(1) Unique items created and/or used to create the end products and the narrative and description required by the SOW;

(2) Digital data in the media as specified in the SOW along with cell library and all other supporting files; and

(3) Data manual documenting all production and work files.

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ATTACHMENT 9-1
GEOSPATIAL DATA AND SYSTEMS CHECKLIST

Project Name: _____
Project Location: _____
Design Center POC: _____
Preparer's Name and Title: _____
Date of Preparation: _____

Y N N/A

SOW Requirements

1. Has the Geospatial Data and System (GD&S) task in the SOW been prepared by project team personnel with a detailed knowledge of project history and archival information, site conditions, site-specific data requirements and GD&S platforms?

2. Does the SOW state that all GD&S activities should be managed by a qualified GIS manager with a minimum of 3 years direct experience managing geospatial data systems within the system environment to be used for the project (e.g., Microstation MGE or ArcInfo)?

3. Does the SOW specify the Geospatial Data System (GDS) to be used on the project:

- Were the systems currently utilized by the OE MCX, Design Center, district, project sponsor and stakeholders considered in choosing the project GDS?
- Will the chosen system avoid production of geospatial data in multiple formats for distribution or use?
- Will the chosen system accomplish the current mission but also allow for future reuse or use of the geospatial data by others without translation?

	Y	N	N/A
Will the chosen system provide reliable results, support greater overall productivity and lower total project costs?	_____	_____	_____
4. Does the SOW specify the spatial coordinate reference system to be used?	_____	_____	_____
5. Is the chosen spatial coordinate reference system compatible with the existing district or project sponsor GDS activities?	_____	_____	_____
6. Does the SOW require that location surveys be connected to existing local, state or national control monuments and referenced to an appropriately recognized installation, local state, or worldwide coordinate system as specified by the OE project team?	_____	_____	_____
7. Does the SOW specify that Tri-Service CADD/GIS Technology Center standards for naming conventions, common GIS layers, and symbology will be used for all deliverables?	_____	_____	_____
8. Does the SOW specify additional site-specific standards developed by the project team for the format, transfer, and storage of all geospatial data consistent with EM 1110-1-2909?	_____	_____	_____
9. Were the following factors considered by the project team when developing site-specific standards:	_____	_____	_____
Compatibility with selected GDS without modification or additional software?	_____	_____	_____
Format of existing digital data and geospatial referenced mapping?	_____	_____	_____
Usability by all parties of concern including stakeholders?	_____	_____	_____
10. Does the SOW prescribe the units to be used in recording and plotting geospatial data, as specified by the district or project sponsor?	_____	_____	_____

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	Y	N	N/A
11. Does the SOW specify the minimum acceptable limits for accuracy and precision based on the nature and purpose of the GD&S?	_____	_____	_____
12. Does the SOW require contractor quality control of GD&S activities and products, including independent tests that may be periodically reviewed by the government?	_____	_____	_____
13. Has the project team established the level of production control and rigor with which quality assessments must be made consistent with the project-specific GD&S requirements?	_____	_____	_____
14. Are the following deliverables specified in the SOW:			
• Unique items created and/or used to create the end products and the narrative and description required?	_____	_____	_____
• Digital data in the media as specified in the SOW along with cell library and all other supporting files?	_____	_____	_____
• Data manual as an ASCII file documenting all production and work files necessary for an outsider to recreate all products and determine the location, names, structures and associations of the data, such as layer description, weights, colors, symbology, referencing of files, etc.?	_____	_____	_____

Planning Considerations

Are the following considerations for GD&S activities addressed in the OE project SOW?

1. Locating of Existing Geospatial Data:

- Types?
- Accuracy?

2. Newly Collected Geospatial Data:

- Types?
- Accuracy?

	Y	N	N/A
• Location?	_____	_____	_____
3. Proposed System Methods and Procedures:			
• Hardware and Software?	_____	_____	_____
• Personnel?	_____	_____	_____
• Work Instructions/Data Format?	_____	_____	_____
• Data Processing?	_____	_____	_____
• Analysis Support?	_____	_____	_____
• Communication/Data Transfer?	_____	_____	_____
• Data Storage?	_____	_____	_____
4. Quality Control:			
• Data Validation?	_____	_____	_____
5. Interim Deliverables?	_____	_____	_____
6. Final Deliverables?	_____	_____	_____

CHAPTER 10 RISK CHARACTERIZATION

10-1. Introduction. This chapter discusses the project team responsibilities as a part of the risk characterization during the EE/CA phase of an OE response action. The project team conducts risk characterizations of OE sites to evaluate the proposed removal alternatives and prioritize among different sites or different areas of the same site. The objective of the project team during the risk characterization process is to estimate the potential for exposure to OE at a site or a portion of a site prior to a removal action. Attachment 10-1 presents a checklist for the project team to follow when planning a risk characterization approach for inclusion in a SOW.

10-2. Data Quality Objectives. The project team should consider data quality objectives for risk characterization regarding:

- a. Statistical validation of the sampling approach;
- b. Prioritization of the site or sectors of the site for OE removal; and
- c. Documentation of the risk characterization for future use in the ESS and other project documents.

10-3. Total Assessment Strategy. Total Assessment Strategy is a framework in which to apply all risk tools. Total Assessment Strategy provides a holistic approach to an OE response project by examining all factors that contribute to the OE problem at the site. It includes a methodical assessment of community problems resulting from ordnance contamination and the potential benefits of a response action undertaken by the federal government, with support of the community (i.e., local residents, local officials, state and federal regulators). Following this assessment, the potential for harm and the level of protectiveness at the site may be determined. Total Assessment Strategy implements functional planning into the OE Program through project justification (e.g., why is the existing condition unacceptable and what is the future without the project) and alternatives development to remedy those problems. For additional information on Total Assessment Strategy, contact the OE MCX.

10-4. Selection of Risk Characterization Tools.

- a. Prior to the development of the SOW, the project team should determine which risk characterization tool would be used during the site characterization process. The project team may select either a qualitative or quantitative risk characterization tool to assess risk.
- b. Factors to Consider. To select the appropriate risk characterization tool, the project team should consider the following:

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- (1) Purpose of the response action;
- (2) Level of risk acceptability at the site;
- (3) Qualitative versus quantitative risk characterization approach;
- (4) Amount of the site which needs to be sampled;
- (5) Methodology which should be used to determine how much of the site should be sampled;
- (6) Compatibility of the selected methodology with the technology that will be used during the project;
- (7) Project budget;
- (8) Political sensitivity of the project;
- (9) Statistical confidence required;
- (10) Availability of site-specific information;
- (11) Use of geophysical data for anomaly selection;
- (12) Use of homogeneous sectors; and
- (13) Extent of UXO contamination.

c. Sources of Information. When considering the above factors for the selection of a risk characterization tool, the project team may consult the following sources of information:

- (1) ASR;
- (2) Previous site investigation reports;
- (3) Interviews with local personnel; and
- (4) Field observations from the site visit.

10-5. Qualitative Tools. The project team may use a qualitative risk tool to make determinations of the types of risk that exist at areas within a potentially OE contaminated site. A qualitative tool generates a numeric score as the result of a series of general questions on the nature of OE contamination at the site. An example of a qualitative risk tool is the Risk Assessment Code. The Risk Assessment Code (RAC) is a numeric score derived from the completion of a RAC

worksheet, which presents a series of general questions on the nature of OE contamination at the site. An example of a RAC worksheet is presented in EP 1110-1-18. The results of the RAC evaluation are used to prioritize response actions for OE contaminated sites.

a. Use of the RAC. The RAC is used during the PAE and SI phases of the OE response process. During the PAE phase, the RAC is completed by the district and included in the INPR. The RAC is required for all INPRs, including sites with a decision of No DOD Action Indicated (NDAI), thus providing a permanent record to meet the congressional intent that a conscientious effort has been made to determine the presence or absence of ordnance. During the SI phase, the RAC is re-evaluated and included as a part of the ASR.

b Sources of Information to Support the RAC. The information for the RAC is derived from the following sources:

- (1) Information from records searches;
- (2) Reports from explosive ordnance disposal units;
- (3) Local law enforcement agencies;
- (4) Interviews; and
- (5) Field observations from the PAE of eligibility phase.

c. RAC Determination. The RAC is derived from a worksheet composed of checklists that are used by the project team to determine the following:

- (1) Types of UXO;
- (2) Amount of UXO; and
- (3) Proximity of the public to the UXO.

d. RAC Results. Following the completion of the RAC worksheet, a value is determined for several subsets of data and added together to derive a RAC score.

10-6. Quantitative Tools. Quantitative tools are available for the project team to use during an OE response project. The project team should contact the OE MCX for guidance on the selection of the proper quantitative tool. An example of a quantitative risk tool is the Ordnance and Explosives Cost Estimating Risk Tool (OECert). OECert is a prioritization tool developed by USAESCH to determine the risk at an OE contaminated site both before a removal action and after the proposed removal alternatives have been implemented. OECert can be used to cost out the removal alternatives and prioritize among different sites as well as among different areas at

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the same site. This tool is also helpful in the comparison of removal alternatives based on cost and associated risk reduction. Additional information about *OECert* may be found in CEHNC 1115-3-86, Ordnance and Explosives Cost Estimating Risk Tool Standing Operating Procedures.

10-7. Statistical Tools.

a. General. The project team may select a statistical tool to examine the density of UXO at a site or a portion of a site. Examples of statistical tools available to the project team include SiteStats/GridStats and the UXO Calculator. The project team should consider a statistical tool under the follow circumstances:

- (1) An adequate budget is available to allow for intrusive effort to characterize the anomalies;
- (2) The examined areas of the site should be divided into homogeneous sectors; and
- (3) Information on future land use, population and UXO density is available.

b. SiteStats/GridStats.

(1) General. SiteStats/GridStats is used to statistically characterize sites/grids through the use of a percentage of anomalies at a site/grid. It estimates the number of ordnance items at a site/grid in a logical, mathematically precise, repeatable manner. Using SiteStats/GridStats is considerably cheaper than investigating all anomalies at a site/grid.

(2) Considerations for Use. If SiteStats/GridStats is selected as the risk characterization tool, the project team should make the follow determinations:

- (a) How will the site be divided into homogeneous sectors?
- (b) What is the most probable number of grids needed to characterize a sector?
- (c) How will the grids be allocated across the site?
- (d) Will the grids be selected by the computer program or manually?
- (e) What grid dimensions will be used?

(3) Project Team Responsibilities. When GridStats/SiteStats is used during an OE project, the project team should ensure the following responsibilities are fulfilled:

- (a) The government provides a copy of GridStats/SiteStats and the program user manual to the OE investigation contractor;

- (b) The OE investigation contractor has a hard copy of the random sequence of investigation that is chosen for each grid;
- (c) The contractor uses an appropriate method of communication to report the results;
- (d) A manual log and hard copy of the SiteStats/GridStats results for each grid is provided with the draft OE investigation report; and
- (e) The Site/Grid Statistical Sampling Based Methodology (SiteStats/GridStats) Standing Operating Procedure found in CEHNC 1115-3-85, November 1996, is followed.

c. UXO Calculator. The UXO Calculator is a statistical model for determining the amount of UXO in a sector.

(1) Considerations for Use. To select the UXO Calculator, the project team should consider the following aspects of the tool:

- (a) Used during the EE/CA phase of a response action;
- (b) Requires 100 percent of geophysically picked anomalies in a grid to be investigated; and
- (c) Used to develop statistical confidence intervals for UXO density and to perform statistical tests concerning UXO densities.

(2) Project Team Responsibilities. When the UXO Calculator is selected as the risk characterization tool, the project team is responsible for the following:

- (a) Determining the sectors, the size of each sector, and the target density for each sector;
- (b) Ensuring that the sectors are homogenous (i.e., equal likelihood of UXO across the sector);
- (c) Ensuring that the sectors are contiguous, have the same future land use and (possibly) the same past land use;
- (d) Ensuring that mathematical procedures for determining sectorization are approved by USAESCH; and
- (e) Ensuring that the Standing Operating Procedure for the UXO Calculator is being followed.

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10-8. Risk Characterization Report. Following the risk analysis, the project team should review and approve the risk characterization report. This report should present the following:

- a. Description of the proof of sectors;
- b. Discussion of the density range;
- c. Discussion of qualitative factors, such as what was looked for and what was found;
- d. Discussion on the use of the report to make removal action decisions; and
- e. Limitations of the method to obtain quantitative data.

ATTACHMENT 10-1
RISK CHARACTERIZATION CHECKLIST

Project Name: _____
Project Location: _____
Design Center POC: _____
Preparer's Name and Title: _____
Date of Preparation: _____

Y N N/A

**SOW Development Considerations for Risk
Characterization**

1. Has the level of risk acceptability for the OE site been defined? _____

2. How much of the site needs to be sampled? _____

3. Which approach is most appropriate for this project: _____

• Qualitative risk characterization? _____

• Quantitative risk characterization? _____

4. Is the selected methodology compatible with the technology that will be used during the project? _____

Selection of Risk Characterization Tools

1. Has the project team considered the following factors: _____

• Purpose of the response action? _____

• Level of risk acceptability at the site? _____

• Qualitative versus quantitative risk characterization approach? _____

• Amount of the site which needs to be sampled? _____

• Methodology which should be used to determine how much of the site should be sampled? _____

	Y	N	N/A
• Compatibility of the selected methodology with the technology that will be used during the project?	_____	_____	_____
• Project budget?	_____	_____	_____
• Political sensitivity of the project?	_____	_____	_____
• Statistical confidence required?	_____	_____	_____
• Use of geophysical data for anomaly selection?	_____	_____	_____
• Use of homogeneous sectors?	_____	_____	_____
• Extent of UXO contamination?	_____	_____	_____
<u>Selection of Qualitative Risk Characterization Tools</u>			
1. If the RAC will be used as a risk characterization tool, has the project team considered the following:			
• Types of UXO?	_____	_____	_____
• Amount of UXO?	_____	_____	_____
• Proximity of the public to UXO?	_____	_____	_____
<u>Selection of Quantitative Risk Characterization Tools</u>			
1. Has the project team considered the use of OECert?	_____	_____	_____
<u>Selection of Statistical Tools</u>			
1. Has the project team confirmed the following:			
• Geophysical data will be used to discriminate anomalies?	_____	_____	_____
• Adequate budget is available to allow for intrusive effort to characterize the anomalies?	_____	_____	_____
• The examined areas of the site will be divided into homogeneous sectors?	_____	_____	_____
• Information on future land use, population and UXO density is available?	_____	_____	_____

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	Y	N	N/A
2. If the project team is considering SiteStats/GridStats, have the following determinations been made:			
• How will the site be divided into homogeneous sectors?	_____	_____	_____
• What is the most probable number of grids needed to characterize a sector?	_____	_____	_____
• How will the grids be allocated across the site?	_____	_____	_____
• Will the grids be selected by the computer program or manually?	_____	_____	_____
• What grid dimensions will be used?	_____	_____	_____
3. If SiteStats/GridStats is selected, have the following been completed:			
• Has the government provided a copy of GridStats/SiteStats and the program's user manual to the OE investigation contractor?	_____	_____	_____
• Has the OE investigation contractor received hard copy of the random sequence of investigation that is chosen for each grid?	_____	_____	_____
• Has the contractor used an appropriate method of communication to report the results?	_____	_____	_____
• Has the project team received a manual log and hard copy of the SiteStats/GridStats results for each grid with the draft OE investigation report. Follow the Site/Grid Statistical Sampling Based Methodology (SiteStats/GridStats) Standing Operating Procedure found in CEHNC 1115-3-85, November 1996.	_____	_____	_____
4. If the project team is considering the use of the UXO Calculator, have the following items been considered:			
• Is the project in the EE/CA phase of a response action?	_____	_____	_____

	Y	N	N/A
• Will 100 percent of geophysically picked anomalies in a grid be investigated?	_____	_____	_____
• Are statistical confidence intervals for UXO density needed?	_____	_____	_____
5. If the project team selects the UXO Calculator, have the following been completed:			
• Determination of the sectors, the size of each sector, and the target density for each sector?	_____	_____	_____
• Determination that the sectors are homogenous (equal likelihood of UXO across the sector)?	_____	_____	_____
• Determination that the sectors are contiguous, have the same future land use and (possibly) the same past land use?	_____	_____	_____
• Mathematical procedures for determining sectorization are approved by USAESCH?	_____	_____	_____
• The Standing Operating Procedure is followed?	_____	_____	_____

Risk Characterization Report

1. The project team should ensure that the Risk Characterization Report contains the following:			
• Description of the proof of sectors?	_____	_____	_____
• Discussion of the density range?	_____	_____	_____
• Discussion of qualitative factors, such as what was looked for, what was found?	_____	_____	_____
• Discussion on the use of the report to make removal action decisions?	_____	_____	_____
• Limitations of the method to obtain quantitative data?	_____	_____	_____

CHAPTER 11 BLAST AND FRAGMENT PROTECTION

11-1. Introduction.

a. This chapter describes the blast and fragment protection requirements for unintentional and intentional detonations. These requirements should be addressed by the project team when planning and conducting an OE response action. A checklist of planning considerations has been provided as Attachment 11-1.

b. The minimum separation distance calculated to perform work on an OE site may include the minimum separation distance for unintentional OE detonations, intentional OE detonations, or both depending on the SOW for the site. Preliminary site work performed at an OE-contaminated site, such as surveying, laying out search lanes, and non-intrusive geophysical investigations, do not require the establishment of a minimum separation distance. The minimum separation distance requirements for intentional and unintentional detonations are discussed in the following paragraphs.

11-2. Data Quality Objectives. When evaluating the blast and fragment protection components of an OE project, the project team should consider data quality objectives in the following areas:

- a. Calculation of minimum separation distances in accordance with DOD 6055.9-STD, Ammunition and Explosives Safety Standards;
- b. Proper design and approval of engineering controls; and
- c. Procedures for reviewing government and contractor planning documentation.

11-3. Explosives Safety Considerations.

a. General. When developing the SOW for an OE project, the project team will need to evaluate several resources to find information relating to the current characteristics of the site, the type of OE project being proposed, the historical use of the site, and the nature of the OE items that were used at the site. These resources may include:

- (1) INPR;
- (2) ASR;
- (3) Historical records relating to the operation of the installation;
- (4) Previous site investigation reports; and

(5) Other historical or investigative reports which may give an indication of the current state of the site.

b. Reviewing this background information is essential to determine the level of involvement of the structural engineering branch in the proposed project. Specific site characteristics that should be examined when reviewing these reports include:

- (1) Site layout;
- (2) Land use of the project site and the surrounding area;
- (3) Physical characteristics of the project site (e.g., topography, vegetation); and
- (4) Man-made structures on the site (e.g., buildings, roads).

c. OE Response Action. The type of OE response action proposed for a site will influence the type and amount of blast and fragment protection requirements for a project. The project team will need to consider the type of OE response action being proposed for the site, such as:

- (1) UXO Support;
- (2) EE/CA; or
- (3) Removal Action.

d. Probable Ordnance Characteristics. The project team will need to consider the type of OE items that could potentially be found at the project site. This information may be obtained from any archival information available on the project site or from any other reports that have previously been generated. Some of the elements to be considered in this category include:

- (1) Conventional versus chemical OE items;
- (2) Live versus inert OE items;
- (3) The type and amount of OE anticipated;
- (4) The potential age, condition, and burial depth of OE; and
- (5) The potential fuzing of the OE items.

e. Most Probable Munition. For all OE sites, a Most Probable Munition (MPM) must be determined. The MPM is that OE item that has the greatest hazard distance based on calculations of the explosion effects of the OE items anticipated to be found at a site. Typically, the MPM is the OE item with the greatest fragmentation or overpressure distance based on the

type of OE items that were historically used at the site. The project team should select the correct MPM for the site based on the available historical site information such as that listed in paragraph 11-2.

f. Explosive Soils. For explosive soils, the MPM concept does not apply. Instead, the concept of maximum credible event (MCE) applies. For soil, the MCE is the concentration of explosives times the weight of the mix. For example, 1000 pounds of soils containing 15 percent Trinitrotoluene (TNT) has an MCE of 150 pounds. When the concentration varies within the area, weighted averages or any other valid mathematical technique can be used, as long as the technique is explained and technically supported in the submission. Overpressure and soil ejecta radius must be considered when determining the Quantity Distance (Q-D) for explosive soils. For additional information on explosive soils, contact the OE MCX.

11-4. Explosion Effects.

a. A major component of the structural engineering branch's involvement during an OE project is the calculation of minimum separation distances for unintentional and intentional detonations of OE items. A review of the explosion effect calculations that should be used by the project team in the determination of minimum separation distances is provided in this paragraph. This paragraph also provides the source documentation for these minimum separation distance calculations.

b. There are six factors of an OE detonation that should be considered by the project team when either siting an area for intentional OE detonations (such as when setting up an Open Burn/Open Detonation area) or when the possibility exists of an unintentional detonation during the course of an OE site investigation. These six factors include:

- (1) Fragmentation;
- (2) Overpressure;
- (3) Thermal flux;
- (4) Ground shock;
- (5) Noise; and
- (6) Ejected soil.

c. Controlling Factors. To determine the appropriate minimum separation distance, the project team should use the explosion effect calculation that yields the greatest minimum separation distance, unless an engineering control will be used to limit the explosion effect. Typically, either fragmentation or overpressure is the controlling factor in determining the

necessary minimum separation distance. However, thermal flux and soil ejecta may become controlling factors if a buried detonation is planned, as discussed in paragraph 11-4d.

(1) Fragmentation. The method to be used in determining the separation distance due to fragmentation depends upon whether the circumstance is an unintentional or intentional detonation. For both intentional and unintentional detonations, the standards listed in Chapter 5, paragraph C.5.5.4, DOD 6055.9-STD should be used. In accordance with this paragraph, the maximum fragment throw range for a specific item, with an appropriate safety factor, may be used to replace the default distances listed in paragraph C5.5.4. USAESCH has developed approved methodologies to determine OE item-specific fragment throw ranges. These methodologies are detailed in HNC-ED-CS-S-98-1, "Methods for Predicting Primary Fragmentation Characteristics of Cased Explosives", and HNC-ED-CS-98-2, "Method for Calculating Range to No More Than One Hazardous Fragment per 600 Square Feet".

(2) Overpressure. The method to be used by the project team in determining the minimum separation distance for overpressure is the same for both unintentional and intentional detonations. In both circumstances, the equation $D=KW^{1/3}$ is used. However, the safety factor 'K' differs depending on whether the circumstance is an unintentional or intentional detonation. For unintentional detonations a K value of 50 should be used, while for intentional detonations a K value of 328 should be applied.

d. Secondary Factors. The following secondary factors are considered in calculating minimum separation distances. These factors are typically not controlling factors in minimum separation distance determinations.

(1) Thermal Flux. Thermal flux will rarely be a controlling factor in minimum separation distance determinations. However, in some instances, the thermal flux generated from the exothermic reactions that result from the detonation of certain OE items may generate a minimum separation distance greater than either the fragmentation or overpressure distance. The project team should use the same method for determining the minimum separation distance based on thermal considerations for both unintentional and intentional detonations. The project team should use the standards listed in Technical Manual (TM) 5-1300, Structures to Resist the Effects of Unintentional Explosions, to determine the minimum separation distance due to thermal flux. If the minimum separation distance due to thermal flux listed in TM 5-1300 cannot be met, then shields complying with MIL-STD-398, Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance, should be used to provide an acceptable level of thermal protection.

(2) Ejected Soil. The project team should calculate the distance that soil may be ejected as a result of an intentional detonation. In addition to the hazards posed by ejected soil during a subsurface OE detonation, the burial depth calculation may also assist in determining the amount of earth cover necessary to defeat the fragmentation generated during an OE detonation. A

computer model has been created to assist in determining the amount of earth cover necessary to mitigate the fragmentation hazard from an OE detonation. The project team should reference HNC-ED-CS-S-97-7-Revision 1, Buried Explosion Module: A Method for Determining the Effects of Detonation of a Buried Munition, for additional details on the use of this computer model.

(3) Ground Shock. The project team should use the same method for determining the minimum separation distance based on ground shock for both unintentional and intentional detonations. In those areas where vibration damage may occur due to an OE detonation, the project team should consult the requirements listed in TM 5-1300. In addition, state and local regulations may exist that are more stringent than the federal regulations. As a result, local regulators should be contacted during the planning process to determine the level of ground shock allowed according to any local codes.

(4) Noise. The project team should use the same method for determining the minimum separation distance based on noise for both unintentional and intentional detonations. The project team should use the criteria presented in paragraph 5-7k(2)(b), Department of the Army (DA Pam) 385-64, Ammunition and Explosives Safety Standards. In addition, state and local regulators should be contacted during the planning process to determine if there are more stringent local regulations in regards to noise generated as a result of an OE detonation.

11-5. Minimum Separation Distances.

a. The project team should ensure that, if practical, the Department of Defense Explosives Safety Board (DDESB) minimum separation distances, as promulgated in Chapter 5, paragraph C5.5.4, DOD 6055.9-STD, have been used.

b. In addition to these fragmentation guidelines, the project team should also ensure that the overpressure minimum separation distance has been correctly calculated using the equations outlined above using the K value of 50 for unintentional detonations and the K value of 328 for intentional detonations, in accordance with DDESB guidelines. If site constraints do not allow for the use of these minimum separation distances, then the project team will ensure that the minimum separation distances have been calculated in accordance with the methodologies detailed below in paragraphs 11-7 and 11-8.

11-6. Unintentional Versus Intentional Detonation Minimum Separation Criteria. When the project team or the UXO contractor determines the minimum separation distance to be used on an OE project, two sets of minimum separation distance criteria may need to be considered.

a. The first set of criteria has been established for unintentional detonations. An unintentional detonation is a detonation that is not planned in advance. Unintentional detonations are discussed in paragraph 11-7.

a. Minimum Separation Distance for Unintentional Detonations. The minimum separation distance for unintentional detonations is the safe separation distance for non-project personnel from intrusive operations. The minimum separation distance for unintentional detonations is calculated by taking the greatest value of:

(1) Overpressure at K value of 50.

(2) Fragmentation. When determining which fragment range to use, the project team should use the following guidelines. If the identification of the UXO expected at the site is unknown, the default distances listed in Chapter 5, paragraph C5.5.4, DOD 6055.9-STD will be used. If it is not practical to use these default distances and the identification of the UXO is expected at the site is known, then the maximum fragment throw range calculated in accordance with HNC-ED-CS-S-98-1 will be used. The item with the maximum fragment distance will become the MPM for the site. For unintentional detonations, the project team may request from the USAESCH OE Safety Branch, approval to use the range to no more than one hazardous fragment per 600 square feet (1/600 distance) calculated in accordance with HNC-ED-CS-S-98-2 in lieu of the maximum fragment throw range. The maximum fragment distances and the 1/600 distances will be calculated by the USAESCH Structural Branch and provided to the PM.

(3) 200 feet.

b. Team Separation Distance. The TSD is the distance the project teams must be separated during intrusive operations. The TSD is calculated by taking the greatest value of:

(1) Overpressure at a K value of 50, or

(2) 200 feet.

11-8. Intentional Detonations. The minimum separation distance for intentional detonations is the distance that both project personnel and the public must be from the intentional detonation. The minimum separation distance for intentional detonations is calculated by taking the greatest value of:

a. Overpressure at a K value of 328, or

b. The maximum fragmentation distance is determined in accordance with HNC-ED-CS-S-98-1 unless engineering controls are implemented. The item having the greatest distance will become the MPM for an OE area within a site, or

c. 200 feet.

b. The maximum fragmentation distance is determined in accordance with HNC-ED-CS-S-98-1 unless engineering controls are implemented. The item having the greatest distance will become the MPM for an OE area within a site, or

c. 200 feet.

11-9. Explosives Siting Plan.

a. General.

(1) The proposed minimum separation distances for unintentional detonations, intentional detonations, and siting of critical project components are discussed in the Explosives Siting Plan, a component of the project Work Plan. The Explosives Siting Plan will be reviewed by the project team to ensure that the appropriate minimum separation standards have been applied. The project team should review the Explosives Siting Plan to ensure that it properly describes the minimum separation distances and other safety criteria that will be employed during an OE operation. The following explosives operations will be described in the plan and sited on a site map with a minimum scale of 1 inch equals 400 feet:

- (a) OE areas;
- (b) Explosives storage magazines; and
- (c) Planned or established demolition areas.

(2) The minimum separation distances calculated for the operation should be discussed in the text of the plan and Q-D arcs for the above-listed project elements drawn on the map.

b. Quantity-Distance. Explosives safety distance tables prescribe the necessary separations and specify the maximum quantities for various classes of explosives permitted in any one location. The Q-D tables provided in DOD 6055.9-STD reflect the acceptable minimum criteria for the storage and handling of various classes and amounts of explosives. These distances will be used for siting storage locations. The project should site Open Burn/Open Detonation areas in accordance with EP 1110-1-17, "Establishing a Temporary Open Burn and Open Detonation Site for Conventional Ordnance and Explosives Projects."

c. OE Areas. The project team should confirm that the minimum separation distances during intrusive operations are determined in accordance with the criteria discussed in paragraphs 11-7 and 11-8.

d. Explosives Storage Magazines. The project team should ensure that the following items are discussed in the Explosives Siting Plan in regards to the Explosives Storage Magazine:

(1) Type of explosives storage magazine, (e.g. portable commercial, above ground, shed, earth-covered, etc.);

(2) NEW and hazard division to be stored in each magazine, (generally, recovered OE is considered to be Hazard Division 1.1);

(3) Q-D criteria used to site the magazine;

(4) Design criteria for any proposed engineering controls if the Q-D criteria cannot be met; and

(5) Designation of commercial explosives into a DOD Hazard Classification and Storage Compatibility Group by the U.S. Army Technical Center for Explosives Safety (USATCES) prior to being stored in a DOD facility. (See paragraph 16-3g, DA Pam 385-64 for procedure).

(6) Lightning Protection.

(a) FUDS. Lightning protection is not required if the following criteria are met:

- The magazine is constructed of metal that is 3/16-inch steel or larger (reference Appendix L of National Fire Protection Association 780);
- The magazine is grounded (see Figure 11-1); and
- The magazine is located at least 6.5 feet from the nearest fence.

(b) BRAC and Active Installations. Lightning protection for BRAC and active installations will meet the provisions in DOD 6055.9-STD.

e. Planned or Established Demolition Areas. The project team should confirm that the minimum separation distances are in accordance with the intentional detonation requirements (PSD) discussed in paragraph 11-8.

f. Footprint Areas. The project team will ensure that the following footprint areas are addressed in the Explosives Siting Plan. These areas, however, do not have to be shown on the map:

(1) Blow-in-Place Areas. Minimum separation distances for all personnel should be determined using the for intentional detonations requirements, as discussed in paragraph 11-8.

(2) Collection Points. Collection points, if used, should have the same minimum separation distance as that identified for unintentional detonations, as discussed in paragraph 11-7.

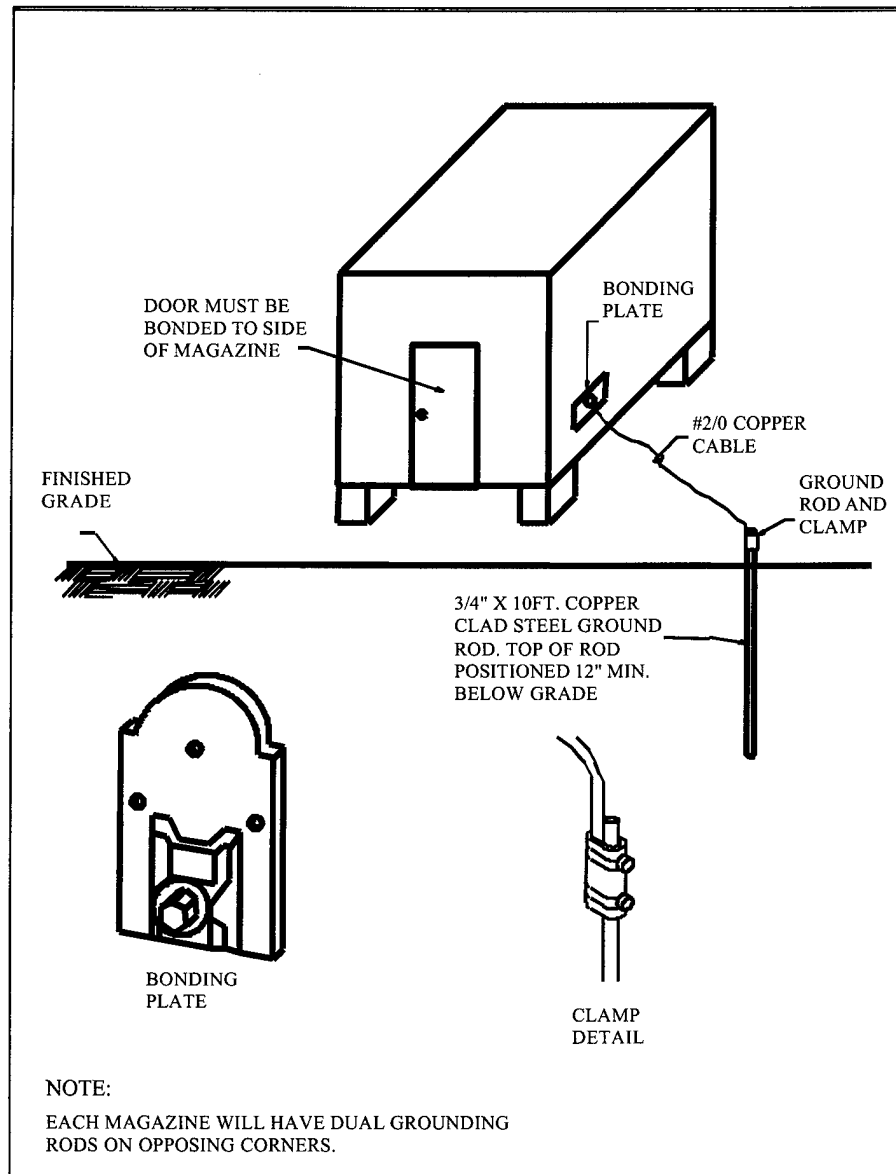


Figure 11-1. Magazine Grounding Detail

(3) In-Grid Consolidated Shots. Minimum separation distances for all personnel should be determined using the requirements for intentional detonations, as discussed in paragraph 11-8. The procedures for in-grid consolidated shots are presented in the USAESCH document "Procedures for Demolition of Multiple Rounds (Consolidated Shots) on Ordnance and Explosives Sites, dated July 1998. This document and the corresponding DDESB approval letter must be available on-site. USAESCH documents are available on the OE MCX website at <http://www.hnd.usace.army.mil/oew>.

11-10. Engineering Controls. Engineering controls are used to mitigate the effects of unintentional or intentional explosions if the calculated minimum separation distance for the OE items to be destroyed cannot be met. The primary goals of using engineering controls are to improve personnel safety and/or to reduce the minimum separation distance. This paragraph discusses engineering controls that can be used by the project team for either an unintentional or intentional explosion scenario.

a. Engineering Controls for Unintentional Detonations. Engineering controls used for unintentional detonations include the barricade. The project team should design barricades in accordance with approved DOD standards. To implement a barricade that has previous approval by DDESB, the project team should contact the USAESCH Engineering Directorate, Structural Branch. If a barricade has not been previously approved, a complete structural design package should be submitted to the USAESCH Engineering Directorate, Structural Branch as part of the ESS. The structural design package should include design drawings, design details, calculations, drawings, and relevant testing details. The design must show how fragmentation is captured and overpressure is reduced. The design package, as part of the ESS, is forwarded through the appropriate channels to DDESB for approval.

b. Engineering Controls for Intentional Detonations. The most common engineering controls used during intentional detonations are either soil cover or sand bags. If controls are required for intentional explosions, the Design Center should be contacted to arrange for the preparation of a design (or a review of a design already prepared) with the USAESCH Engineering Directorate, Structural Branch.

(1) Soil Cover. If soil is proposed to be used over a to-be-detonated OE, the project team may use one of several computerized models to determine the required thickness of soil cover necessary for the intentional detonation of OE items. The Buried Explosion Module is one such computerized model. The methodology used in this software is documented in HNC-ED-CS-S-97-7-Revision 1. The use of soil as an engineering control reduces the fragment and soil ejecta distances.

(2) Sandbags. Sandbags may be used for an OE item no larger than 155-mm. If sandbags are proposed to be used as an engineering control to mitigate the fragmentation and overpressures generated during an intentional OE detonation, the project team should refer to HNC-ED-CS-S-

98-7, Use of Sandbags for Mitigation of Fragmentation and Explosion Effects Due to Intentional Detonation of Munitions.

(3) On-Site Ordnance Demolition Container (ODC). Another engineering control that may be proposed for the intentional detonation of OE items is the ODC. The ODC has been approved by DDESB for the intentional detonation of OE items. The ODC is designed to contain all significant explosion pressures for a total NEW of up to 6 pounds of TNT or its equivalent. The ODC is designed to capture all fragmentation from OE items with fragmentation characteristics up to those from an 81-mm mortar. When using the ODC, the required minimum separation distance is 75 feet. Detailed design drawings for the ODC and the supporting technical report, HNC-ED-CS-S-97-3, Safety Submission for On-Site Demolition Container for Unexploded Ordnance are available.

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ATTACHMENT 11-1
BLAST AND FRAGMENT PROTECTION REVIEW CHECKLIST

Project Name: _____
Project Location: _____
Design Center POC: _____
Reviewer's Name and Title: _____
Date of Review: _____

	Y	N	N/A
<u>Engineering Considerations for SOW Preparation</u>			
1. Has the SOW properly taken into account the physical characteristics of the site?	_____	_____	_____
2. Has the SOW taken into account the type of OE response action being contemplated?	_____	_____	_____
3. Has the SOW taken into account the characteristics of the probable OE items that will be encountered at the site?	_____	_____	_____
4. Has the correct Most Probable Munition been identified for the site?	_____	_____	_____
<u>Minimum Separation Distances</u>			
1. Are the minimum separation distances being proposed for the site?	_____	_____	_____
2. Have the following criteria for an unintentional detonation been evaluated:			
• Minimum Separation Distance for Unintentional Detonations: Which will provide the greatest distance?			
– Overpressure at a K value of 50?	_____	_____	_____
– Maximum fragmentation distance?	_____	_____	_____
– 200 feet?	_____	_____	_____
• Team Separation Distance: Which will provide the greatest distance:			

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	Y	N	N/A
– Overpressure at a K value of 50?	_____	_____	_____
– 200 feet?	_____	_____	_____
3. Have the following criteria for an intentional detonation been evaluated:			
• Minimum Separation Distance for Intentional Detonations: Which will provide the greatest distance?			
– Overpressure at a K value of 328?	_____	_____	_____
– Maximum fragmentation distance?	_____	_____	_____
– 200 feet?	_____	_____	_____

Explosives Siting Plan Review Considerations

1. Has a map been included with the Explosives Siting Plan and is it at an appropriate scale?	_____	_____	_____
2. Does the map identify the OE areas, the location for the explosives storage magazine, and any planned or established demolition areas?	_____	_____	_____
3. Has the OE area been properly identified and has an appropriate minimum separation distance been calculated for the area?	_____	_____	_____
4. Have the Q-D arcs for the OE areas been drawn from the outermost edge of each area?	_____	_____	_____
5. Has the proposed explosives storage magazine been properly sited?	_____	_____	_____
6. Has the proposed demolition area been properly sited?	_____	_____	_____
7. Have footprint areas for any Blow-in-Place areas, Collection Points, or In-Grid Consolidated Shots been discussed in the Explosives Safety Plan?	_____	_____	_____
8. Has an appropriate team separation distance been identified between intrusive investigation teams in the Explosives Safety Plan?	_____	_____	_____
9. Have any engineering controls been proposed in the Explosives Safety Plan?	_____	_____	_____

Engineering Controls for Unintentional Detonations

1. Barricades. The project team should consider the following elements regarding barricade selection:

- Have barricades been specified for the project?
- Has the correct barricade been specified for the application in accordance with the DOD standards?
- If the proposed barricade has not been previously approved, has a complete structural design package been submitted to the USAESCH Engineering Directorate, Structural Branch?
- Has the design package been forwarded through appropriate channels to DDESB for review?

Engineering Controls for Intentional Detonations

1. Is soil being proposed as an engineering control for an intentional detonation?
2. Has the amount of soil to be placed on top of the OE items been properly calculated?
3. Are sandbags being proposed as an engineering control to limit the fragmentation and overpressure from an intentional OE detonation?
4. Has the amount of sandbags being proposed been properly calculated based on the type of OE to be destroyed?
5. Has the Ordnance Demolition Container (ODC) been specified to be used on the site?
6. Is the ODC capable of safely containing the blast and fragmentation effects of the munitions to be found at the site?

CHAPTER 12

QUALITY ASSURANCE/QUALITY CONTROL

12-1. Introduction.

a. This chapter discusses project team requirements for quality control (QC) and quality assurance (QA) during OE projects. QA/QC requirements for various phases of an OE response project (e.g., geophysical, location surveying, safety, and techniques) are discussed in their respective chapters in this manual.

b. General QA/QC requirements for USACE projects are described in ER 1110-1-12, Quality Management. Attachment 12-1 is a checklist that highlights the general QA/QC requirements.

12-2. Performance Objectives. The performance objectives for QA/QC activities on OE response projects include:

- a. Clear definition of customer needs and appropriate quality measures;
- b. Preventive action and controls to avoid customer dissatisfaction;
- c. Optimizing quality related costs for the required performance and grade of services; and
- d. Continuous review of product and service requirements and achievements to identify opportunities for product and service quality improvement.

12-3. Project Management. The PM should manage the project in accordance with a Project Management Plan. The Design Center POC is responsible for assisting the PM in the preparation of a Project Management Plan, if requested.

12-4. OE Assistance Visits. The OE MCX Safety and Quality Assurance Team schedules OE Assistance Visits on randomly chosen projects once per quarter, as requested by project teams, and at any other time based on areas needing improvement as identified by employees, customers, nonconforming products, and lessons learned. The project team may request an OE Assistance Visit through the Design Center POC or Design Center Manager. Appropriate coordination with Major Subordinate Commands (MSC) and districts will be made prior to OE Assistance Visits.

a. Objective. OE Assistance Visits are conducted to:

(1) Ensure that QA oversight is being conducted by the OE Safety Specialist in accordance with accepted procedures and project Work Plans;

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(2) Ensure contractor compliance with the QC Plan; and

(3) Ensure that the Administrative Record has been established and maintained appropriately.

b. OE Assistance Visit Findings. At the conclusion of the OE Assistance Visit, findings should be presented to the PM in a letter report. A provisional agreement should be made regarding the response due date for each Corrective Action Report generated (generally 15 working days although shorter or longer periods may be warranted).

12-5. Lessons Learned Program. As required by ER 1110-1-12, a Lessons Learned Program should be developed by each Design Center to provide for the exchange of information regarding problems that may occur during the OE response process.

a. Objective. The objective of the Lessons Learned Program is to capture and share past experiences or recognized potential problems or better business practices to:

- (1) Prevent the recurrence of repetitive design/execution deficiency;
- (2) Clarify interpretation of regulations or standards;
- (3) Reduce the potential for mistakes in high risk/probability areas of concern;
- (4) Pass on information specific to an installation or project;
- (5) Promote a good work practice that should be ingrained for repeat application; and
- (6) To promote efficient and cost effective business practices.

b. Project Team Responsibilities. The project team is responsible for identifying and submitting lessons learned for review and approval. Throughout each project, project team members should consider how their experiences might be appropriate for the Lessons Learned Program.

c. Lessons Learned Submittals. Lessons learned submittals should be provided to the OE MCX on a periodic basis.

12-6. Contractor Quality Control Plan. The project team should require contractors to include a QC Plan as a chapter in the Work Plan. Attachment 12-1 provides a checklist for the project team to use when reviewing the contractor's QC Plan.

a. Objective. The objective of the QC Plan is to document the approach and procedures to be used to ensure quality throughout the execution of a project. The contractor is solely responsible for the control of product quality and for offering to the government only

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products/services that conform to the contractual requirements. All QC records and documentation should be maintained on-site and be made available for government inspection upon request. All QC documentation should be submitted as part of or as supporting documentation for the final report.

b. Contents. The project team should ensure that the contractor's QC Plan documents all processes affecting quality, including the following items:

- (1) Audit procedures including pass/fail criteria and records generated;
- (2) Corrective/preventive action procedures;
- (3) Data management;
- (4) Anomaly acquisition and reacquisition;
- (5) Field operations;
- (6) Calibration/maintenance requirements;
- (7) Documentation and submittal of lessons learned;
- (8) Procedures for reviewing and processing contract submittals to ensure they meet contractual requirements;
- (9) Procedures for making changes to existing documents and communicating such changes to the appropriate personnel;
- (10) Training plan for all on-site personnel to ensure each employee meets qualification requirements as defined in the contract and to address all site-specific and routine training requirements for contractor personnel and site visitors; and
- (11) If applicable, a Chemical Data Quality Management Plan.

c. Quality Control Specialist. The project team should ensure that the contractor has appointed a UXO Quality Control Specialist (UXOQCS) to enforce the contractor's QC Plan and to perform quality conformance inspections (QCI). The UXOQCS will have sufficient, well-defined responsibilities, to include stop-work-authority and the organizational freedom to identify and evaluate quality problems; to initiate, recommend or provide solutions; and to approve corrective actions to ensure all work complies with stipulated contractual requirements. The qualifications for the UXOQCS will be described in the .

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ATTACHMENT 12-1
QUALITY CONTROL PLAN REVIEW CHECKLIST

Project Name: _____
Project Location: _____
Design Center POC: _____
Reviewer's Name and Title: _____
Date of Review: _____

Y N N/A

Review of Contractor Quality Control Plan. The project team should ensure that the Quality Control Plan, a chapter within the Work Plan, has been prepared in accordance with the SOW and contract specifications. Does the Quality Control Plan document all procedures affecting quality, including the following items:

- | | | | |
|--|-------|-------|-------|
| • Audit procedures? | _____ | _____ | _____ |
| • Corrective/preventive action procedures? | _____ | _____ | _____ |
| • Data management? | _____ | _____ | _____ |
| • Anomaly acquisition and reacquisition? | _____ | _____ | _____ |
| • Field operations? | _____ | _____ | _____ |
| • Equipment calibration/maintenance requirements (geophysical instruments, radios/cell phones, vehicles/machinery, air monitoring equipment and personal protective equipment etc.)? | _____ | _____ | _____ |
| • Pass/fail criteria for all quality audits and records generated (daily logs, meeting minutes, inventory forms, inspection forms etc.)? | _____ | _____ | _____ |
| • How lessons learned will be captured, documented and submitted to the government? | _____ | _____ | _____ |

	Y	N	N/A
• Procedures used to ensure contract submittals (reports, work plans, etc.) are reviewed/processed in accordance with contractual requirements?	_____	_____	_____
• How changes to existing documents will be processed and communicated to appropriate personnel?	_____	_____	_____
• Process/training plan for all on-site personnel that ensures each employee meets the qualifications requirements (education, training, and/or experience), as defined for this contract to perform the duties of the job for which they were hired?	_____	_____	_____
• Site-specific and routine training requirements for contractor personnel and site visitors?	_____	_____	_____
• Statement that all QC documentation will be submitted as part of or as supporting documentation for the final report?	_____	_____	_____
• Statement that all QC records and documentation will be kept on site and made available for government inspection upon request?	_____	_____	_____

CHAPTER 13 CHEMICAL WARFARE MATERIEL

13-1. Introduction. This chapter presents general guidance for the project team on projects involving non-stockpile chemical warfare materiel (CWM). This guidance applies to those sites where the probability of encountering CWM is categorized as occasional, probable, or frequent (as defined in AR 385-10, The Army Safety Program). OE response activities at sites where the probability of encountering CWM is categorized as improbable or remote may be conducted using the conventional OE response process if the District Commander or designated representative assumes the associated risk. If the District Commander or designated representative does not assume the associated risk, the OE response activities at the site will be conducted by the USAESCH Design Center.

13-2. Responsibilities.

a. OE response actions at non-stockpile CWM sites will be performed in accordance with ER 1110-1-8153. The USACE is responsible for the overall project management and on-site management for non-stockpile CWM projects. The USAESCH Design Center is the only USACE command authorized to execute non-stockpile CWM projects. The specific responsibilities of the HQUSACE, MSCs, districts, USAESCH Design Center, and OE MCX for non-stockpile CWM activities are presented in ER 1110-1-8153.

b. If the presence of CWM is suspected at a site, the PM must coordinate with USAESCH prior to beginning any on-site work. If non-stockpile CWM is encountered during activities at any site, all site activities will be stopped and a CWM response action will be initiated. For additional information on the procedures for conducting a non-stockpile CWM response, contact the OE MCX.

13-3. Project Considerations Specific to Non-Stockpile CWM Sites.

a. The OE response process at sites containing non-stockpile CWM typically follows the same procedures as those followed for conventional OE. EP 1110-1-18 provides a description of those areas of the OE response process where a different approach is required for non-stockpile CWM sites as compared to conventional OE sites.

b. The scope and intent of proposed activities along with the probability of encountering CWM are factors in determining what type of planning documents are required. For additional information on the planning requirements for various proposed activities at non-stockpile CWM sites, contact the OE MCX.

c. Safety Submission. For investigative and assessment activities (e.g., soil and water sampling, geophysical analysis, monitoring well installation, etc.) which are conducted using ordnance avoidance techniques, a SSHP approved by the OE MCX is required. Additional

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documents may be required depending on site-specific characteristics and planned activities. For surface removal or excavation of non-stockpile CWM when the intent is to uncover, characterize, and remove geophysical anomalies, a Safety Submission approved by HQUSACE is required. The Safety Submission provides the specifications for conducting work activities at the site. ER 1110-1-8153 delineates the contents and organizational responsibilities for the safety submission. Additional information is available from the OE MCX. The Safety Submission includes the Work Plan, the SSHP, and Supporting Plans.

(1) Work Plan. The requirements for the Work Plan are similar to those outlined in Chapter 3 of this manual for the Removal Action Work Plan. Additional information is provided in ER 1110-1-8153.

(2) SSHP. Refer to safety guidance documents and ER 1110-1-8153 for additional information on the SSHP.

(3) Supporting Plans. The Supporting Plans are prepared by government agencies and may include the plans listed below. Information on the contents of these plans is available from the OE MCX.

(a) Technical Escort Unit Support Plan;

(b) Edgewood Chemical and Biological Center Air Monitoring and Analysis Plan;

(c) Protective Action Plan;

(d) Project Manager for Non-Stockpile Chemical Materiel Plans (includes Interim Holding Facility Plan, Transportation Plan, and Disposal Plan); and

(e) Anomaly Review Board Plan (if appropriate).

d. In addition to the items requiring consideration at a conventional OE site which have been discussed in the other chapters of this manual, the project team must also include consideration of the following items at a non-stockpile CWM site: MCE, No Significant Effect (NOSE) distances, tabletop exercises, and pre-operational surveys. These items will be discussed in the Safety Submission.

(1) Maximum Credible Event. The USAESCH project team should develop a site-specific MCE as a basis for generating hazard zones. Hazard zones will be calculated using the MCE and the Army approved atmospheric dispersion modeling tool, D2PC. The project team should also develop quantitative RACs to assess response hazards (e.g., dispersion of agent-contaminated soil, and explosive hazards). Public risk information and controls will be addressed in safety planning documents.

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(2) No Significant Effect (NOSE) Distance. The USAESCH project team must prepare NOSE calculations to design contingency plans and to determine the evacuation areas around a non-stockpile CWM site. The NOSE distance is defined as the distance beyond which the public would not experience any adverse health effects in association with a chemical agent release. For most CWM projects, the NOSE distance is significantly greater than the overpressure and fragmentation distances.

(3) Engineering controls. Engineering controls are used to improve personnel safety and/or to reduce the NOSE during removal operations. If an engineering control design is required, the USAESCH project team will arrange for the design with the USAESCH Engineering Directorate, Structural Branch.

(4) Tabletop Exercise. The Tabletop Exercise should be tailored to the expected conditions and hazards specific to the site. Tabletop Exercises, which are conducted to evaluate emergency plans and procedures and to resolve questions of coordination and responsibility, must be successfully completed prior to initiating any intrusive work. The Tabletop Exercise is to be conducted by the Major Command. Generally, this responsibility is delegated to USAESCH. USAESCH has a team from the OE MCX that conducts the Tabletop exercise and determines when it is concluded.

(5) Pre-operational Survey.

(a) A pre-operational survey consists of a formal review and assessment of an operation that has the potential for chemical agent exposure. The pre-operational survey will be tailored to the expected conditions and hazards specific to the site. If a Safety Submission is required, the pre-operational survey will be conducted by the Headquarters Department of the Army Safety Office or may be delegated to HQUSACE, in which case the USACE Safety Office will conduct the pre-operational survey with assistance from the OE MCX. If a Safety Submission is not required, the USAESCH Design Center will conduct the pre-operational survey.

(b) The USAESCH project team and the district will participate in the pre-operational survey, which must be successfully completed prior to initiating any intrusive work. The pre-operational survey is concluded once the survey team determines that any findings of potential deficiencies have been addressed.

(c) The PM will ensure that the pre-operational survey is scheduled well in advance and that a formal request is forwarded through channels to HQDA at least six weeks prior to the actual date.

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ATTACHMENT 13-1
CWM CHECKLIST

Project Name: _____
Project Location: _____
Design Center POC: _____
Preparer's Name and Title: _____
Date of Preparation: _____

Y N N/A

Planning Documents

- | | | | |
|---|-------|-------|-------|
| 1. If investigative and assessment activities will be conducted using anomaly avoidance techniques, has a SSHP been approved by USAESCH? | _____ | _____ | _____ |
| 2. If surface removal or excavation of non-stockpile CWM will be conducted with the intent to uncover, characterize and remove geophysical anomalies, has a Safety Submission been approved by HQUSACE? | _____ | _____ | _____ |
| 3. If a Safety Submission is required, has the project team ensured that it includes the following items: | | | |
| • Work Plan (contents similar to Removal Action Work Plan described in Chapter 3 of this manual)? Refer to ER 1110-1-8153 for additional information. | _____ | _____ | _____ |
| • SSHP? Refer to safety guidance documents and ER 1110-1-8153 for additional information on the SSHP. | _____ | _____ | _____ |
| • Supporting Plans? | _____ | _____ | _____ |

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	Y	N	N/A
<u>Maximum Credible Event</u>			
1. Has the project team developed a site-specific MCE as a basis for generating hazard zones?	_____	_____	_____
2. Have hazard zones been calculated using the MCE and the Army approved atmospheric dispersion modeling tool, D2PC?	_____	_____	_____
3. Has the project team developed quantitative RACs to assess response hazards (e.g., dispersion of agent-contaminated soil, and explosive hazards)?	_____	_____	_____
4. Do the planning documents address this public risk information and controls?	_____	_____	_____
<u>No Significant Effect Distance</u>			
1. Has the project team prepared NOSE calculations to design contingency plans and to determine the evacuation areas around the site?	_____	_____	_____
<u>Engineering Controls</u>			
1. If an engineering control design is required, has the project team arranged for a design with the USAESCH Engineering Directorate, Structural Branch?	_____	_____	_____
<u>Tabletop Exercise</u>			
1. Prior to initiating intrusive activities, has the district conducted successful tabletop exercises for the USAESCH project team, OE MCX and other Army agencies and local responders involved in or supporting the activity?	_____	_____	_____
<u>Pre-operational Survey</u>			
1. Has a formal request for the pre-operational survey been forwarded through channels to HQDA at least six weeks prior to the actual date?	_____	_____	_____
2. Prior to initiating intrusive activities, have the project team and district successfully participated in a pre-operational survey?	_____	_____	_____

CHAPTER 14 PROJECT COMPLETION

14-1. Introduction. This chapter presents the project team requirements for project completion activities at FUDS and BRAC/IR sites. The purpose of project completion activities is to ensure that all deliverables (data and reports) are in compliance with the requirements of the SOW.

14-2. Performance Objectives. The project team should consider the following performance objectives during project completion activities:

- a. Electronic data deliverables are in compliance with the format specified by the SOW;
- b. OE project reports, maps, figures, etc. are produced and submitted in compliance with the project requirements specified in the SOW; and
- c. All appropriate information has been posted to a server or web-page host for public availability, as specified in the SOW.

14-3. Requirements for Completion of OE Removal Action Projects at Formerly Used Defense Sites. The project team's requirements for the completion of project completion activities at FUDS are dependent on whether the district or Design Center executes the project. Attachment 14-1 presents a checklist of project completion considerations for the project team.

a. District. When the district executes an OE removal action at a FUDS, the project team will perform project completion activities in accordance with the provisions of the Defense Environmental Restoration Program FUDS manual.

b. Design Center. When a Design Center executes an OE removal action at a FUDS, the project team should ensure that the following activities have been completed:

(1) The project completion memorandum is prepared, summarizing the OE removal action activities. This memorandum, which is typically prepared by the contractor, will also state that the OE removal action has been completed and will describe any requirements for periodic reviews (e.g., five-year reviews) to ensure that the response action remains protective. A sample memorandum is provided in EP 1110-1-18.

(2) The project completion memorandum is forwarded to the PM for subsequent property/project completion of the entire FUDS.

(3) The PM includes a copy of the project completion memorandum in the Administrative Record for the project and forwards copies by cover letter to all affected property owners.

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14-4. Requirements for Completion of OE Removal Actions at Base Realignment and Closure/Installation Restoration Program Sites. The project team from the executing district or Design Center will ensure that the following project completion activities for BRAC/IR sites are completed in the following order:

a. The USACE element responsible for executing the OE removal action will prepare a Statement of Clearance and the Finding of Suitability to Transfer (FOST). An example format for the Statement of Clearance is provided in EP 1110-1-18.

b. The Statement of Clearance and FOST will be coordinated with the OE MCX for review. The Commander of the executing OE Design Center or district will sign the Statement of Clearance. The Installation Commander will sign the FOST. The Statement of Clearance will be provided to the installation representative as a supporting document to the FOST. The FOST will be submitted to the installation representative for approval and submission to DDESB in accordance with AR 405-90, Disposal of Real Estate.

c. A copy of the Statement of Clearance and FOST will be included in the Administrative Record for the

ATTACHMENT 14-1
PROJECT COMPLETION CHECKLIST

Project Name: _____
 Project Location: _____
 Design Center POC: _____
 Preparer's Name and Title: _____
 Date of Preparation: _____

Y N N/A

General

1. Have all the required electronic submittals been obtained and verified for compatibility with required systems? _____
2. Have all required reports, documents, maps, figures, multi-media pages, etc. been submitted and verified? _____
3. Has all appropriate information been posted to a server or web-page host for public availability, as required by the SOW? _____

**Project Completion Procedures for OE Removal
Actions at FUDS**

1. Was the project executed by a:
 - USACE District? _____
 - Design Center? _____
2. For projects executed by a district:
 - Were the project completion activities completed in accordance with the provisions of the DERP FUDS manual? _____
3. For project executed by an Design Center:
 - Did the contractor prepare a project completion memorandum? _____

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	Y	N	N/A
Did the project completion memorandum summarize the OE removal activities which occurred at the site?	_____	_____	_____
Did the project completion memorandum state that the OE removal action has been completed?	_____	_____	_____
Is the project completion memorandum in accordance with the format provided in EP 1110-1-18?	_____	_____	_____
Has the project completion memorandum been forwarded to the PM?	_____	_____	_____
Has the project completion memorandum been placed in the project's Administrative Record?	_____	_____	_____
<u>Project Completion Procedures for OE Removal</u> <u>Actions at BRAC/IR Sites</u>			
1. Did the USACE element responsible for executing the OE removal action prepare a Statement of Clearance?	_____	_____	_____
2. Was the Statement of Clearance prepared in accordance with the format provided in EP 1110-1-18?	_____	_____	_____
3. Did the USACE element responsible for executing the OE removal action prepare the FOST?	_____	_____	_____
4. Were the Statement of Clearance and FOST reviewed by the OE MCX?	_____	_____	_____
5. Has the Commander of the executing district or Design Center signed the Statement of Clearance?	_____	_____	_____
6. Has the Installation Commander signed the FOST?	_____	_____	_____
7. Has the Statement of Clearance been provided to the installation representative as supporting documentation for the FOST?	_____	_____	_____
8. Has the FOST been submitted to the installation representative for approval and submission to DDESB in accordance with AR 405-90?	_____	_____	_____
9. Has a copy of the Statement of Clearance and the FOST been placed in the project's Administrative Record ?	_____	_____	_____

APPENDIX A
REFERENCES

Base Realignment and Closure Act of 1988, Public Law (PL) 100-526, 102 Stat. 2632.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, PL 96-510, 94 Stat 2767, 42 USC 9601.

Defense Base Realignment and Closure Act of 1990, PL 101-510, 104 Stat. 1808.

Defense Environmental Restoration Program, PL 99-499, Section 211, 100 Stat 1719, 10 USC 2701 et seq.

Resource Conservation and Recovery Act (RCRA) of 1976, PL 94-580, 90 Stat 2796, 42 USC 6901, et seq., as amended

Superfund Amendment and Reauthorization Act (SARA) of 1986, PL 99-499, 100 Stat 1613, amending CERCLA, 42 USC 9601 et seq., and miscellaneous other sections

29 CFR 1910

OSHA Hazardous Waste Operations and Emergency Response

40 CFR Part 260, et al

U.S. Environmental Protection Agency (EPA) Military Munitions Rule

Federal Acquisition Regulation as of January 1, 1999

DOD 6055.9-STD

Ammunition and Explosives Safety Standards

AR 200-2

Environmental Effects of Army Actions

AR 385-10

The Army Safety Program

AR 405-90

Disposal of Real Estate

DA Pam 385-64

Ammunition and Explosives Safety Standards

TM 5-1300

Structures to Resist the Effects of Unintentional Explosions

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TM 9-1300-214
Military Explosives

ER 1110-1-12
Quality Management

ER 1110-1-8153
OE Response

ER 1110-1-8156
Policies, Guidance, and Requirements for Geospatial Data and Systems

EP 1110-1-17
Establishing a Temporary Open Burn/Open Detonation Site for Conventional Ordnance and Explosives

EP 1110-1-18
OE Response

EM 385-1-1
U.S. Army Corps of Engineers Safety and Health Requirements Manual

EM 1110-1-1000
Photogrammetric Mapping

EM 1110-1-1002
Survey Markers and Monumentation

EM 1110-1-1003
NAVSTAR Global Positioning System Surveying

EM 1110-1-1802
Geophysical Exploration for Engineering and Environmental Investigations

EM 1110-1-2909
Geospatial Data and Systems

MIL-STD-398
Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance

CEHNC 1115-3-85
Site/Grid Statistical Sampling Based Methodology Standing Operating Procedures

CEHNC 1115-3-86

Ordnance and Explosives Cost Estimating Risk Tool Standing Operating Procedures.

HNC-ED-CS-S-97-3

Safety Submission for On-Site Demolition Container for Unexploded Ordnance

HNC-ED-CS-S-97-7-Revision 1

Buried Explosion Module (BEM): A Method for Determining the Effects of Detonation of a Buried Munition

HNC-ED-CS-S-98-1

Methods for Predicting Primary Fragmentation Characteristics of Cased Explosives

HNC-ED-CS-S-98-2

Method for Calculating Range to No More Than One Hazardous Fragment per 600 Square Feet

HNC-ED-CS-S-98-7

Use of Sandbags for Mitigation of Fragmentation and Blast Effects Due to Intentional Detonation of Munitions

National Fire Protection Association 780

GLOSSARY

Section I**Abbreviations**

A-E	Architect-Engineer
AM/FM	Automated Mapping/Facilities Management
AR	Army Regulation
ARAR	Applicable or Relevant and Appropriate Requirement
ARB	Anomaly Review Board
ASR	Archives Search Report
ASSHP	Abbreviated Site Safety and Health Plan
BRAC	Base Realignment and Closure
CADD	Computer-aided Design and Drafting
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CESO	Corps of Engineers Safety Office
CFR	Code of Federal Regulations
CO	Contracting Officer
COR	Contracting Officer's Representative
CV	Cesium Vapor
CWM	Chemical Warfare Materiel
DA Pam	Department of the Army Pamphlet
DDESB	Department of Defense Explosives Safety Board
DOD	Department of Defense
DOT	Department of Transportation
DQO	Data Quality Objective
EE/CA	Engineering Evaluation/Cost Analysis
EM	Engineer Manual
EOD	Explosive Ordnance Disposal
EP	Engineer Pamphlet
EPP	Environmental Protection Plan
ER	Engineer Regulation
ESS	Explosives Safety Submission
FAR	Federal Acquisition Regulation
FD	Frequency Domain
FDEM	Frequency Domain Electromagnetics
FOST	Finding of Suitability to Transfer
FUDS	Formerly Used Defense Site
GD&S	Geospatial Data and Geospatial Data Systems
GDS	Geospatial Data System
GIS	Geographic Information System

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GPS Global Positioning System
HAZWOPER Hazardous Waste Operations and Emergency Response
HQUSACE.....Headquarters, United States Army Corps of Engineers
HTRW Hazardous, Toxic, and Radioactive Waste
IDW.....Investigative Derived Waste
INPR Inventory Project Report
IRP Installation Restoration Program
JPG.....Jefferson Proving Ground
LIS.....Land Information Systems
MCACES Micro Computer Aided Cost Engineering System
MCE.....Maximum Credible Event
MCX Mandatory Center of Expertise
MPM Most Probable Munition
MSC.....Major Subordinate Command
NAD83 North American Datum of 1983
NAVD88 North American Vertical Datum of 1988
NCP.....National Oil and Hazardous Substance Pollution Contingency Plan
NDAI.....No DOD Action Indicated
NEW Net Explosive Weight
NOSE No Significant Effects
NTCRA Non-Time Critical Removal Action
ODC.....Ordnance Demolition Container
OE Ordnance and Explosives
OECert Ordnance and Explosives Cost Estimating Risk Tool
OSHA.....Occupational Safety and Health Administration
PAE.....Preliminary Assessment of Eligibility
Pd Probability of Detection
Pfa Probability of False Alarm
PLS.....Professional Land Surveyor
PM.....Project Manager
POC.....Point of Contact
PPE.....Personal Protective Equipment
QA.....Quality Assurance
QC.....Quality Control
QCI.....Quality Conformance Inspections
Q-D Quantity-Distance
RAC Risk Assessment Code
RACER Remedial Action Cost Engineering and Requirements System
RECON.....Reconnaissance
RLS Registered Land Surveyor
SI Site Inspection

SOW.....	Statement of Work
SSH.....	Site Safety and Health Plan
TCRA.....	Time Critical Removal Action
TD	Time Domain
TDEM	Time Domain Electromagnetics
TM.....	Technical Manual
TNT.....	Trinitrotoluene
TSD	Team Separation Distance
TSSDS	Tri-Service Spatial Data Standard
USACE	United States Army Corps of Engineers
USAESCH	U.S. Army Engineering and Support Center, Huntsville
USATCES.....	U.S. Army Technical Center for Explosives Safety
UXO.....	Unexploded Ordnance
UXOSO.....	Unexploded Ordnance Safety Officer
UXOQCS	UXO Quality Control Specialist

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Section II

Terms

Action Memorandum

Approves time-critical removal action and also concludes the engineering evaluation/cost analysis. Provides a concise, written record of the decision to select an appropriate removal action. As the primary decision document, it substantiates the need for a removal action, identifies the proposed action, and explains the rationale for the removal action selected.

Active Installations

Installations under the custody and control of DOD. Includes operating installations, installations in a standby or layaway status, and installations awaiting closure under the Base Realignment and Closure (BRAC) legislation.

Active Range

A military range that is currently in service and is being regularly used for range activities. (40 CFR 266.201)

Administrative Record

The body of documents that "forms the basis" for the selection of a particular response at a site. Documents that are included are relevant documents that were relied upon in selecting the response action as well as relevant documents that were considered but were ultimately rejected. (ER 1110-1-8153)

Anomaly

Any item that is seen as a subsurface irregularity after geophysical investigation. This irregularity should deviate from the expected subsurface ferrous and non-ferrous material at a site (i.e., pipes, power lines, etc.). (EP 1110-1-18)

Anomaly Avoidance

Techniques employed by EOD or UXO personnel at sites with known or suspected OE to avoid any potential surface UXO and any subsurface anomalies. This usually occurs at mixed hazard sites when HTRW investigations must occur prior to execution of an OE removal action. Intrusive anomaly investigation is not authorized during ordnance avoidance operations. (ER 1110-1-8153)

Anomaly Review Board (ARB)

The ARB is a technical group established to review decisions and recommendations made by the OE project team on the detection and evaluation of subsurface anomalies. ARBs should be used only in exceptional circumstances, such as at CWM sites.

Applicable or Relevant and Appropriate Requirements (ARARs)

Applicable requirements are cleanup standards, standards of control, and other substantive environmental protection requirements promulgated under federal or state environmental law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance found at a CERCLA site. Relevant and appropriate requirements are cleanup standards that while not "applicable", address situations sufficiently similar to those encountered at a CERCLA site that their use is well-suited to the particular site.

Approval Memorandum

Secures management approval to conduct the engineering evaluation/cost analysis.

Archives Search Report (ASR)

A detailed investigation to report on past OE activities conducted on an installation. The principal purpose of the Archives Search is to assemble historical records and available field data, assess potential ordnance presence, and recommend follow-up actions at a DERP-FUDS. There are four general steps in an Archives Search: records search phase, site safety and health plan, site survey, archives search report including risk assessment.

Base Realignment and Closure (BRAC)

Program governing the scheduled closing of Department of Defense sites. (Base Closure and Realignment Act of 1988, Public Law 100-526, 102 Stat. 2623, and the Defense Base Closure and Realignment Act of 1990, Public Law 101-510, 104 Stat. 1808)

Chemical Warfare Materiel (CWM)

An item configured as a munition containing a chemical substance that is intended to kill, seriously injure, or incapacitate a person through its physiological effects. Also includes V- and G- series nerve agent, H- series blister agent, and lewisite in other- than-munition configurations. Due to their hazards, prevalence, and military-unique application, chemical agent identification sets (CAIS) are also considered CWM. CWM does not include: riot control agents, chemical herbicides; smoke and flame producing items; or soil, water, debris, or other media contaminated with chemical agent. (HQDA Interim Guidance for Biological Warfare Materiel and Non-Stockpile Chemical Warfare Materiel Response Activities)

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)

CERCLA authorizes federal action to respond to the release or threatened release of hazardous substances into the environment or a release or threat of release of a pollutant or contaminant into the environment that may present an imminent or substantial danger to public health or welfare.

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Construction Support

Support provided by qualified UXO personnel during construction activities at potential OE sites to ensure the safety of construction personnel from the harmful effects of UXO. When a determination is made that the probability of encountering UXO is low (e.g., current or previous land use leads to an initial determination that OE may be present), a minimum of a two person UXO team will stand by in case the construction contractor encounters a suspected UXO. When a determination is made that the probability of encountering a UXO is moderate to high (current or previous land use leads to a determination that OE was employed or disposed of in the parcel of concern, e.g., open burn and open detonation areas, maneuver areas, etc.), UXO teams are required to conduct subsurface UXO clearance for the known construction footprint either in conjunction with the construction contractor or prior to construction intrusive activities. The level of effort will be determined on a case-by-case basis in coordination with the OE MCX. (ER 1110-1-8153)

Control Markers

Project control markers may consist of markers and/or benchmarks established by any federal, state, local, or private agency with positional data within the minimum acceptable accuracy standards prescribed by the project team.

Conventional Ordnance and Explosives

The term "conventional OE" refers to ordnance and explosives (see definition) other than CWM, BWM and nuclear ordnance. (ER 1110-1-8153)

Data Quality Objective

A Data Quality Objectives (DQO) is a qualitative and quantitative statement developed to clarify study objectives, define the type of data needed, and specify the tolerable levels of potential decision errors. A DQO is used as the basis for establishing the type, quality and quantity of data needed to support the decisions that will be made.

Defense Environmental Restoration Program

Established in 1984, DERP promotes and coordinates efforts for the evaluation and cleanup of contamination at Department of Defense installations. (10 U.S.C. 2701)

Design Center

A specified USACE field office assigned a singular technical mission that is permanent and USACE-wide in scope. The designated office is to be considered the "lead activity" in a specialized area where capability needs to be concentrated for maximum effectiveness, economy, and efficiency. The OE Design Center (in coordination with the PM) will execute all phases of the OE response project after the approval of the INPR unless the removal action is transferred to an approved district. Only the USAESCH OE Design Center is authorized to execute any phase of a Non-Stockpile CWM response. (ER 1110-1-8153)

Engineering Evaluation/Cost Analysis (EE/CA)

An EE/CA is prepared for all non-time-critical removal actions as required by Section 300.415(b)(4)(i) of the NCP. The goals of the EE/CA are to identify the extent of a hazard, to identify the objectives of the removal action, and to analyze the various alternatives that may be used to satisfy these objectives for cost, effectiveness, and implementability.

Exclusion Zone

A safety zone established around an OE work area. Only project personnel and authorized, escorted visitors are allowed within the exclusion zone. Examples of exclusion zones are safety zones around OE intrusive activities and safety zones where OE is intentionally detonated. (DDESB-KO, 27 January 1990)

Explosive Ordnance Disposal (EOD)

The detection, identification, field evaluation, rendering safe, recovery, and final disposal of unexploded ordnance or munitions. (EP 1110-1-18)

Explosives Safety Submission (ESS)

The document which serves as the specifications for conducting work activities at the project. The ESS details the scope of the project, the planned work activities, and potential hazards (including the maximum credible event) and the methods for their control. (EP 1110-1-18)

Explosive Soil

Explosive soil refers to mixtures of explosives in soil, sand, clay, or other solid media at concentrations such that the mixture itself is explosive.

(a) The concentration of a particular explosive in soil necessary to present an explosion hazard depends on whether the particular explosive is classified as "primary" or "secondary." Guidance on whether an explosive is classified as "primary" or "secondary" can be obtained from the OE MCX or Chapters 7 and 8 of TM 9-1300-214, Military Explosives.

(b) Primary explosives are those extremely sensitive explosives (or mixtures thereof) that are used in primers, detonators, and blasting caps. They are easily detonated by heat, sparks, impact, or friction. Examples of primary explosives include Lead Azide, Lead Styphnate, and Mercury Fulminate.

(c) Secondary explosives are bursting and boosting explosives (i.e., they are used as the main bursting charge or as the booster that sets off the main bursting charge). Secondary explosives are much less sensitive than primary explosives. They are less likely to detonate if struck or when exposed to friction or to electrical sparks. Examples of secondary explosives include Trinitrotoluene (TNT), Composition B, and Ammonium Picrate (Explosive D).

(d) Soil containing 10 percent or more by weight of any secondary explosive or mixture of secondary explosives is considered "explosive soil." This determination was based on

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information provided by the USAEC as a result of studies conducted and reported in USAEC Report AMXTH-TE-CR 86096.

(e) Soil containing propellants (as opposed to primary or secondary high explosives) may also present explosion hazards. (ER 1110-1-8153)

Formerly Used Defense Sites (FUDS)

FUDS includes those properties previously owned, leased, or otherwise possessed by the U.S. and under the jurisdiction of the Secretary of Defense; or manufacturing facilities for which real property accountability rested with DOD but were operated by contractors (Government owned - contractor operated) and which were later legally disposed of. FUDS is a subprogram of the DERP. Restoration of military land was extended to formerly used sites in 1983 under Public Law 98-212 (DOD Appropriations Act of FY84).

Geophysical Techniques

Techniques utilized for the detection and measurement of buried anomalies (e.g., ferromagnetic indicators and ground penetrating radar) to investigate the presence of munitions. (EP 1110-1-18)

Hazardous, Toxic, and Radioactive Waste (HTRW) Activities

HTRW activities include those activities undertaken for the Environmental Protection Agency's Superfund program, the Defense Environmental Restoration Program (DERP), including Formerly Used Defense Sites (FUDS), and Installation Restoration Program (IRP) sites at active DOD facilities, HTRW actions associated with Civil Works projects, and any other mission or non-mission work performed for others at HTRW sites. (EP 1110-1-18)

Intentional Detonation

An intentional detonation is a planned, controlled detonation.

Intrusive activity

An activity which involves or results in the penetration of the ground surface at an area known or suspected to contain OE. Intrusive activities can be of an investigative or removal action nature. (EP 1110-1-18)

Inventory Project Report (INPR)

The report resulting from the preliminary assessment of eligibility. The INPR includes data as well as a recommendation for further action and guides investigators through further site studies. Documents whether DOD is responsible for contamination at a FUDS. (EP 1110-1-18)

Mandatory Center of Expertise (MCX)

An MCX is a USACE organization that has been approved by HQUSACE as having a unique or exceptional technical capability in a specialized subject area that is critical to other USACE commands. Specific mandatory services to be rendered by an MCX are identified on the MCX's

homepage at <http://www.hnd.usace.army.mil/ow>. These services may be reimbursable or centrally funded. The USAESCH is the OE MCX for the USACE. (ER 1110-1-8153)

Maximum Credible Event (MCE)

The worst single event that could occur at any time, with maximum release of a chemical agent from a munition, container, or process as a result of unintended, unplanned, or accidental occurrence. (HQDA Interim Guidance for Biological Warfare Materiel (BWM) and Non-Stockpile Chemical Warfare Materiel (CWM) Response Activities)

Military Munitions

All ammunition products and components produced or used by or for the U.S. DOD or the U.S. Armed Services for national defense and security, including military munitions under the control of the DOD, the US Coast Guard, the US DOE, and National Guard personnel. The term military munitions includes: confined gaseous, liquid, and solid propellants, explosives, pyrotechnics, chemical and riot control agents, smokes, and incendiaries used by DOD components, including bulk explosives and chemical warfare agents, chemical munitions, rockets, guided and ballistic missiles, bombs, warheads, mortar rounds, artillery ammunition, small arms ammunition, grenades, mines, torpedoes, depth charges, cluster munitions and dispensers, demolition charges, and devices and components thereof. Military munitions do not include wholly inert items, improvised explosive devices, and nuclear weapons, nuclear devices, and nuclear components thereof. However, the term does include non-nuclear components of nuclear devices, managed under DOE's nuclear weapons program after all required sanitization operations under the Atomic Energy Act of 1954, as amended, have been completed. (ER 1110-1-8153)

Most Probable Event (MPE)

The most likely event, as a result of an accidental, unplanned, or unintended detonation of an item of ordnance, that could occur during OE activities. The event must be realistic with reasonable probability of occurrence. (EP 1110-1-18)

National Oil and Hazardous Substance Pollution Contingency Plan (NCP)

Revised in 1990, the NCP provides the regulatory framework for responses under CERCLA. The NCP designates the Department of Defense as the removal response authority for ordnance and explosives hazards. (EP 1110-1-18)

Non-Stockpile Chemical Warfare Materiel

CWM (see definition) that is not included in the chemical stockpile. Non-stockpile CWM is divided into five categories: buried CWM, recovered chemical weapons (items recovered during range clearing operations, from chemical burial sites, and from research and development testing), former chemical weapon production facilities, binary chemical weapons, and miscellaneous CWM (unfilled munitions and devices and equipment specially designed for use directly in connection with employment of chemical weapons). (HQDA Interim Guidance for

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Biological Warfare Materiel (BWM) and Non-stockpile Chemical Warfare Materiel (CWM) Response Activities)

Non-Time Critical Removal Action (NTCRA)

NTCRAs are actions initiated in response to a release or threat of a release that poses a risk to human health, its welfare, or the environment. Initiation of removal cleanup actions may be delayed for six months or more.

Ordnance and Explosives (OE)

OE consists of either (1) or (2) below:

(1) Ammunition, ammunition components, chemical or biological warfare materiel or explosives that have been abandoned, expelled from demolition pits or burning pads, lost, discarded, buried, or fired. Such ammunition, ammunition components, and explosives are no longer under accountable record control of any DOD organization or activity. (HQDA Policy Memorandum "Explosives Safety Policy for Real Property Containing Conventional OE")

(2) Explosive Soil. See definition under "Explosive Soil." (ER 1110-1-8153)

OE Safety Specialist

USACE Personnel, classified as a GS-018 Safety Specialist, and who is UXO qualified. OE Safety Specialists perform safety, quality assurance and UXO subject matter expert functions for the Government. The Safety Specialist may reside in and report to the construction field office or may reside in the engineering/construction office within the OE Design Center. (ER 1110-1-8153)

Preliminary Assessment of Eligibility (PAE)

The PAE is the initial phase of the non-time-critical response action process. A PAE includes a review of existing information and an off-site reconnaissance, if appropriate, to determine if a release may require additional investigation or action. A PAE may include an on-site reconnaissance, if appropriate. The findings of the PAE are reported in the INPR, along with recommendations for further action, if appropriate. This document is used to determine property and project eligibility under DERP-FUDS.

Project Team

The Project Team normally consists of the PM, OE Safety Specialists and multi-disciplined representatives from the technical/functional elements necessary to execute the project.

Quality Assurance (QA)

A process that provides oversight to quality control and involves an audit/review of the quality control process. (ER 1110-1-12)

Quality Control (QC)

A process that monitors and checks the design process to insure that the product will meet agreed-upon requirements of the customer, is on schedule and within budget. (ER 1110-1-12)

Quantity-Distance (Q-D)

The quantity of explosives material and distance separation relationships that provide defined types of protection. These relationships are based on levels of risk considered acceptable for the stipulated exposures and are tabulated in the appropriate Q-D tables provided in DOD 6055.9-STD. Separation distances are not absolute safe distances but are relative protective safe distances. Greater distances than those shown in the Q-D tables shall be used whenever possible. (DOD 6055.9-STD)

Removal Action

The cleanup or removal of OE from the environment to include the disposal of removed materiel. The term includes, in addition, without being limited to, security fencing or other measures to prevent, minimize, or mitigate damage to the public health or welfare or to the environment. (ER 1110-1-8153)

Response Action

Action taken instead of or in addition to a removal action to prevent or minimize the release of OE so that it does not cause substantial danger to present or future public health or welfare or the environment. (ER 1110-1-8153)

Risk Assessment Code (RAC)

An expression of the risk associated with a hazard. The RAC combines the hazard severity and accident probability into a single arabic number on a scale from 1 to 5, with 1 being the greatest risk and 5 the lowest. The RAC is used to prioritize response actions.

Senior UXO Supervisor

Supervises all contractor on-site UXO activities. This individual will be a graduate of the U.S. Army Bomb Disposal School, Aberdeen Proving Ground, MD or the U.S. Naval Explosive Ordnance Disposal School, Indian Head, MD. This individual will have combined active duty military EOD and contractor UXO experience, including experience in supervisory positions. Experience in active duty in military EOD units is required. This individual will have documented experience with or specialized training in the type of OE expected to be encountered on the site. (USAESCH OE MCX Personnel and Work Standards for Ordnance Response, 30 July 1996)

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Site Inspection (SI)

Activities undertaken to determine whether there is a release or potential release and the nature associated threats. The purpose is to augment the data collected in the PAE and to generate, if necessary, sampling and other field data to determine the presence, type, distribution, density and location of OE. The results of the SI are reported in an Archives Search Report (ASR). (EP 1110-1-18)

Stakeholder

Stakeholders include federal, state, and local officials, community organizations, property owners, and others having a personal interest or involvement, or having a monetary or commercial involvement in the real property which is to undergo an OE response action. (EP 1110-1-18)

Team Separation Distance.

The TSD is the distance the project teams must be separated during intrusive operations.

Technical Escort Unit (TEU)

Military chemical agent response unit. (EP 1110-1-18)

Time Critical Removal Action (TCRA)

TCRAs respond to a release or threat of release that poses such a risk to public health (serious injury or death), or the environment, that clean up or stabilization actions must be initiated within six months.

Unexploded Ordnance (UXO)

Military munitions that have been primed, fuzed, armed, or otherwise prepared for action, and have been 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. (40 CFR 266.201)

Unintentional Detonation

A detonation not planned in advance.

UXO Personnel

Contractor personnel who have completed specialized military training in EOD methods and have satisfactorily performed the EOD function while serving in the military. Various grades and contract positions are established based on skills and experience. Check with the OE MCX for current ratings. (ER 1110-1-8153)

UXO Safety Officer (UXOSO)

Contractor personnel with the responsibility of enforcing the contractor's SSHP. This individual must therefore be in the field whenever possible to observe operations. This individual will have the same minimum qualifications as the UXO Supervisor. In addition, this individual will have the specific training, knowledge, and experience necessary to implement the SSHP and verify compliance with applicable safety and health requirements.

UXO Technician I

This individual will be a graduate of the EOD Assistant's Course at Redstone Arsenal, AL; Eglin AFB, FL or a DOD certified equivalent course. A UXO Assistant may advance to a UXO Specialist category after obtaining active duty military EOD and contractor UXO experience. A UXO Assistant will not perform UXO procedures without the direct supervision of a UXO Specialist, UXO Supervisor, or Senior UXO Supervisor.

UXO Technician II

This individual shall be a graduate of the U.S. Army Bomb Disposal School, Aberdeen Proving Ground, MD or U.S. Naval EOD School, Indian Head, MD. The UXO Specialist may be a UXO Assistant with combined military EOD and contractor UXO experience.

UXO Technician III

Supervises a UXO team. This individual will be a graduate of the U.S. Army Bomb Disposal School, Aberdeen Proving Ground, MD or the U.S. Naval Explosive Ordnance Disposal School, Indian Head, MD. This individual will have combined active duty military EOD and contractor UXO experience. This individual will have experience in OE clearance operations and supervising personnel.