FINAL

FORT ORD ORDNANCE AND EXPLOSIVES RISK ASSESSMENT PROTOCOL

BASED ON OUTCOMES OF

ORDNANCE AND EXPLOSIVES RISK ASSESSMENT PROJECT TEAM MEETINGS

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ABSTRACT

This Fort Ord OE Risk Assessment Protocol was prepared through a combined effort of the Army, the California Environmental Protection Agency's Department of Toxic Substances Control (DTSC), and the United States Environmental Protection Agency (EPA). The purpose of the Protocol is to allow for review of ordnance and explosives (OE) risks at OE-impacted sites at the former Fort Ord Installation.

The Army is currently conducting a Remedial Investigation/Feasibility Study (RI/FS) for Fort Ord's OE-impacted sites. As part of the RI/FS process, the Army will conduct an OE risk assessment.

A risk assessment is used to describe and estimate the likelihood of adverse outcomes from an encounter with an OE hazard. Several methods exist for performing an OE risk assessment on OE-impacted sites; however, there is no single OE risk assessment methodology that has been widely accepted, tested, and fully implemented that is applicable to a variety of OE sites. The Army, through the Base Realignment and Closure (BRAC) Cleanup Team (BCT), formed a focus group to develop a broadly applicable OE risk assessment approach described herein.

The Fort Ord OE Risk Assessment Protocol is a qualitative risk assessment approach based on seven input factors. The input factors are both qualitative and quantitative. Two process matrices combine six of the input factors into scores for Accessibility and Exposure. A third process matrix combines the scores for Accessibility, Exposure, and Overall Hazard (the seventh input factor) into a single qualitative score for estimating OE Risk. The output of the approach was tested using a sensitivity analysis and a Beta Test to determine effectiveness. The results of these tests were used to improve the OE risk assessment approach, and to ensure that the drafted approach was fully implementable.

The Fort Ord OE Risk Assessment Protocol is not designed to assess absolute risk. The Overall OE Risk score is an approach for comparing the relative risk between remedial alternatives on an OE-impacted site at the Fort Ord facility. The Overall OE Risk score produced by this Protocol should not be compared to risks from other OE-impacted facilities, because the Fort Ord OE Risk Assessment Protocol was developed using site-specific categories. The Overall OE Risk score will be reevaluated as part of the five-year reviews of Fort Ord.

The purpose of this report is to explain and document the development of the Fort Ord OE Risk Assessment Protocol and to present the protocol so that it can be used to conduct the OE risk assessments on each sector in the OE RI/FS.

Throughout the OE RI/FS process, public involvement is encouraged. Specifically, public comments are requested on the Feasibility Study and Proposed Plan documents and during the remedial design, remedial action, and post-remedial action. Likewise, this Protocol was provided to the public for review so that public concerns are considered before it is used to determine OE risk at Fort Ord.

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ACRONYMS AND ABBREVIATIONS

BCT	Base Realignment and Closure Cleanup Team
bgs	Below Ground Surface
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (Title 40, CFR, Part 300) commonly referred to as "Superfund."
CFR	Code of Federal Regulations
DoD	United States Department of Defense
DoE	United States Department of Energy
DoT	United States Department of Transportation
DQO	Data Quality Objectives
DTSC	California Environmental Protection Agency – Department of Toxic Substances Control
EOD	Explosive Ordnance Disposal
EPA	United States Environmental Protection Agency
FORA	Fort Ord Reuse Authority
IR3M	Interim Range Rule Risk Methodology
MRA	Multi-Range Area
NAS	National Academy of Sciences
NAVEODTECHDIV	United States Naval Explosive Ordnance Disposal Technology Division
OE	Ordnance and Explosives
OECERT	Ordnance and Explosives Cost Estimating Risk Tool
OE RIA	Ordnance and Explosives Risk Impact Analysis
RI/FS	Remedial Investigation and Feasibility Study
SMART Team	Strategic Management, Analysis, Requirements and Technology Team
USDA	United States Department of Agriculture
USLE	Universal Soil Loss Equation
UXO	Unexploded Ordnance
WEQ	Wind Erosion Equation

DEFINITIONS

Adverse Event* – An event or series of events leading (or which may lead) to a human, biological, or environmental harm or loss.

Closed Range** – A military range that has been taken out of service and either has been put to new uses that are incompatible with range activities or is not considered by the military to be a potential range area. A closed range is still under the control of a DoD component.

Consequence* – The effect of an adverse event.

Encounter* – An interaction (e.g., contact) that has the potential to transfer energy to OE.

Explosive* – Any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion (i.e., with substantial instantaneous release of gas and heat).

Exposure* – Contact of an organism with a physical agent or chemical. Exposure is quantified as the amount of agent or energy available for transfer at the exchange boundaries of the organism.

Military Munitions** – All ammunition products and components produced or used by or for DoD or the U.S. Armed Services for national defense and security, including military munitions under the control of DoD, the U.S. Coast Guard, the U.S. Department of Energy (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 the DoE's nuclear weapons program, after all required sanitation operations under the Atomic Energy Act of 1954, as amended, have been completed.

Military Range** – Any land mass or water body that is or was used for the conduct of training, research, development, testing, or evaluation of military munitions or explosives. Ranges include firing lines and positions, maneuver areas, firing lanes, test pads, detonation pads, impact areas, and buffer zones with restricted access and exclusionary areas. The definition of a military range does not include airspace, or water, or land areas underlying airspace used for training, testing, or research and development where military munitions have not been used.

Mortar*** – A projectile fired from a short-barreled cannon.

Multi-Range Area (MRA)*** – The MRA consists of approximately 8,000 acres in the southwestern portion of former Fort Ord, bordered by Eucalyptus road to the north, Barloy Canyon Road to the east, South Boundary Road to the south, and North-South Road to the west.

Ordnance and Explosives (OE)*** – OE is anything related to munitions designed to cause damage to personnel or materiel through explosive force or incendiary action including bombs, warheads, missiles, projectiles, rockets, antipersonnel and antitank mines, demolition charges, pyrotechnics, grenades, torpedoes and depth charges, high explosives and propellants, and all similar and related items or components explosive in nature or otherwise designed to cause damage to personnel or materiel.

Ordnance Scrap* – A military munition, or components thereof, which contain no energetic materiel. These can be, but are not limited to, practice munitions without spotting charges, drill rounds, inert training munitions, or expended ejection munitions. Fragments of military munitions, which have functioned as designed or were recovered from areas where munitions were intentionally destroyed, are ordnance scrap if they have no explosive, pyrotechnic, or chemical filler. These items pose no imminent threat to public safety, but may require venting or some other action prior to release from government control.

Projectile* – Ordnance fired from a barrel, such as a rifle, cannon, or artillery.

Reasonably Anticipated Future Land Use – Realistic assumptions concerning how the former range property will be used in the future, typically based on information such as current use, the surrounding area, local land use planning and development, and other relevant information.

Removal Depth* – The depth below ground surface to which all ordnance and other detected items are removed.

Risk** – The probability that a substance or situation will produce harm under specified conditions. Risk is a consideration of two factors: (1) the probability that an adverse event will occur, and (2) the consequences of an adverse event.

***Risk Assessment** – An organized process used to describe and estimate the likelihood of adverse outcomes from an encounter.

***Sector** – A contiguous area located within a range or OE site. A sector is a classification of a portion of a range that is homogeneous with respect to terrain, future land use, expected ordnance density, previous data, need for characterization, topography, geology, or other physical characteristics.

Surface Removal* – Removal of OE from the ground surface by UXO teams using visual identification aided by magnetometers.

Track 0* – Track 0 areas are identified as those that have never been suspected as having been used for ordnance-related activities of any kind. These areas are expected to consist largely of land that has been developed throughout Fort Ord's history and areas that have no physical or documented evidence of OE-related training. The decision for entering areas into the Track 0 process will be based on the results of the literature review. Areas not identified as suspected OE sites would be candidates for no further investigation or action.

Track 1* – Track 1 sites are those where OE was suspected to have been used but was not found. Track 1 sites may be categorized following reconnaissance or sampling activities. As part of the OE RI/FS, the fieldwork and data evaluation procedures implemented for Track 1 sites will be examined to verify that procedures were appropriate and satisfy data quality objectives (DQOs). Track 1 sites will not have any land use controls based on future identified reuses.

Track 2* – Track 2 sites are those where OE was found, and the appropriate removal actions have been completed. These sites will be evaluated in the OE RI/FS to verify that procedures were appropriate and satisfy DQOs. Track 2 sites differ from Track 1 sites in that a removal action has occurred. Land use controls may be applicable based on future identified reuses and results of the removal actions.

Track 3 [***] **–** Track 3 sites are: (1) those areas where OE is suspected or known to exist, but response actions are not yet complete or need to be initiated, or (2) any areas identified in the future. Once reconnaissance, sampling, or removal data is collected for these sites, they will be evaluated in relation to the cleanup goals, selection of response alternatives, and appropriate cleanup methods that will be identified in the OE RI/FS. Track 3 will provide a plug-in mechanism for managing existing and potential future sites, and is anticipated to consist of several different categories of sites that will be evaluated and assigned appropriate response actions in the OE RI/FS, e.g., sites where:

- No response action is required, or
- A removal action with or without land use controls is required.
- In addition, all sites considered under Tracks 0, 1, and 2 could potentially become Track 3 sites if they do not meet the criteria of the other tracks at any point in the OE RI/FS or long-term management process.

Transferred Range [**] – A military range that has been released from military control. The transfer may have been by deed or lease, or by return under the terms of a withdrawal, special-use permit or authorization, right-of-way, public land order, or other instrument under which DoD used the property.

Transferring Range [**] – A military range that is proposed to be leased, transferred, or returned from the DoD to another entity, including Federal entities. Transfer may be by deed or lease, or by return under the terms of a withdrawal, special-use permit or authorization, right-of-way, public land order, or other instrument under which DoD used the property. An active range will not be considered to be a "transferring range" until the transfer is imminent.

Unexploded Ordnance (UXO) [**] **–** Military munitions that have been primed, fused, 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 materiel and remain unexploded either by malfunction, design, or any other cause.

[*] Definitions taken from the Interim Range Rule Risk Methodology (DoD 2000).

[**] Definitions taken directly from Munitions Rule (EPA 1997b) and/or Proposed Range Rule (DoD 1997).

[***] Definitions taken from Ordnance and Explosives Remedial Investigation/Feasibility Study Work Plan, Former Fort Ord, Monterey County, California (USACE, 1999).

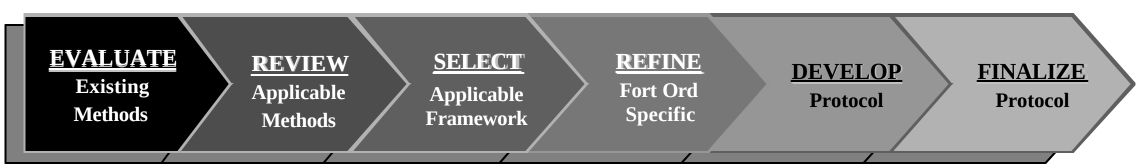
[****] Definition taken from Presidential/Congressional Commission on Risk Assessment and Risk Management, 1997.

1.0 INTRODUCTION

This Fort Ord OE Risk Assessment Protocol was prepared jointly by the Army (United States Army Presidio of Monterey Department of Environmental and Natural Resources, United States Army Corps of Engineers Sacramento District, United States Army Engineering and Support Center Ordnance and Explosives Mandatory Center of Expertise and Design Center), the California Environmental Protection Agency's Department of Toxic Substances Control (DTSC), and the United States Environmental Protection Agency Region 9 (EPA). The purpose of the Protocol is to assess ordnance and explosives (OE) risks at OE-impacted sites at the former Fort Ord installation.

The Army is currently conducting a Remedial Investigation/Feasibility Study (RI/FS) for the former Fort Ord (Fort Ord) OE-impacted sites. Federal law, under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund), created the RI/FS process (40 Code of Federal Regulations (CFR) Part 300) to identify the nature and extent of risks at a site and to determine the applicability of various cleanup methods. Because the RI/FS is an analytical process designed to support risk management decision-making for Superfund sites, risk assessment plays an essential role. CERCLA (40 CFR 300.430) requires that a site-specific baseline risk assessment be conducted to characterize the current and potential threats to human health and the environment. According to CERCLA, the results of the risk assessment should help establish acceptable remediation levels for use in developing remedial alternatives during the FS. However, for OE hazards, the risk assessment will not establish acceptable levels due the current state of the science, but will be used to develop and evaluate remedial alternatives during the FS. This is the first RI/FS ever conducted specifically for an OE site in the United States. As part of the RI/FS process, the Army will conduct an OE risk assessment.

The Fort Ord OE Risk Assessment Project Team developed the OE risk assessment approach using six steps:



1. **Evaluate:** The Team evaluated ten existing OE risk assessment methods.
2. **Review:** The Team reviewed the applicable methods for input factors and scoring criteria.
3. **Select:** The Team chose the framework for the Fort Ord OE Risk Assessment Protocol based on the first two steps.
4. **Refine:** The Team refined the chosen framework using risk assessment expertise, OE expert knowledge, and site-specific conditions.
5. **Develop:** The Team drafted the Fort Ord OE Risk Assessment Protocol and performed preliminary testing of the approach.
6. **Finalize:** The Team will further refine the approach, based on initial testing and public review, to create a technically sound, flexible, and straightforward approach.

This report provides information concerning the decisions made in each of the steps in five sections:

> **<u>Section 1.0 – Introduction:</u>** This section introduces the concepts related to OE risk and the partnered development of the Fort Ord OE Risk Assessment Protocol.
>
> **<u>Section 2.0 – Evaluation and Review of Existing Methods:</u>** This section describes the ten existing OE risk assessment methods and how they were evaluated for use at Fort Ord.
>
> **<u>Section 3.0 – Defining the Protocol Input Factors:</u>** This section explains each of the input factors used to analyze the OE risk at Fort Ord's OE-impacted sites and the modifications to existing methodologies required for Fort Ord-specific use.
>
> **<u>Section 4.0 – Defining the Protocol Process Matrices:</u>** This section defines the "matrices" or the logic for combining the input factors into an overall OE risk result.
>
> **<u>Section 5.0 – Using the Fort Ord OE Risk Assessment Protocol:</u>** This final section combines the information from Sections 1.0 to 4.0 and shows the reader how the Fort Ord OE Risk Assessment Protocol will be used to evaluate the overall OE risk of Fort Ord's OE-impacted sites.

The Nature of Risk: Chemical Risk and OE Risk

The National Academy of Sciences (NAS) defines risk as the potential for adverse effects to an exposed population (NAS 1983). It is a function of the probability of an accident (or adverse situation) occurring within a certain period of time and resulting in consequences to people, property, or the environment. A more recent definition of risk that seems more specific to risks at military ranges comes from the Presidential/Congressional Commission on Risk Assessment and Risk Management, 1997:

> Risk is the probability that a substance or situation will produce harm under specified conditions and is a combination of two factors: (1) the probability that an adverse event will occur, and (2) the consequences of an adverse event.

EPA has developed general risk assessment methods for evaluating human health and environmental risks at hazardous and toxic waste sites that follow the basic approach established by NAS. These general risk assessment methods are conducted through four basic steps: (1) hazard identification, (2) dose response modeling, (3) exposure assessment, and (4) risk characterization (NAS 1983, EPA 1989). These methods are typically used to quantify risk from long-term, chronic exposure to low levels of contamination.

OE is anything related to munitions designed to cause damage to personnel or materiel through explosive force or incendiary action. OE sizes range from small grenades to bombs. OE risk occurs when the potential exists for people to contact and disturb OE on former ranges or training areas and that contact or disturbance would cause the OE item to detonate or function. The consequence of OE detonation is associated with physical forces (e.g., thermal transfer, overpressure, fragmentation, and impact). Exposure to OE occurs when a receptor enters a range with OE, or if OE is removed from a range by a receptor. The threat from OE, however, typically results from a single encounter and may have one of three outcomes: no effect; injury; or death. In addition, more than one receptor, that is, individuals in the surrounding area, may be harmed by a single encounter. Therefore, the established methods for characterizing risk associated with chemical exposures are not directly applicable to OE risks. Consequently, risk assessment methodologies to analyze the unique nature of OE risks have been developed.

An OE encounter requires the presence of three critical items:

1. ***Source of Contamination*** *(in this case, OE),*
2. ***Pathway*** *(such as range access and digging), and*
3. ***Receptor*** *(someone applying physical force to the item, or in some cases, in close proximity to OE).*

Applying the unique elements of OE risk described above, OE risk is the probability that OE will produce harm under specified conditions. Similarly, OE risk is a combination of two factors: (1) the probability that an adverse event will occur, namely the probability of an encounter between a person and OE, and (2) the consequences of an adverse event, namely the probability that the OE will detonate and the impact of that detonation. The potential for an OE encounter depends on the presence of three critical items: the presence of OE, a pathway (such as range access and digging), and a receptor (someone applying physical force to the item directly or indirectly). OE risk at a range is based on the characteristics of the OE, the potential pathways for an OE encounter, and the frequency with which a receptor may be exposed to OE.

Considering the state of the art of available OE detection and removal technologies, it is not possible to confirm that all (100%) OE has been identified and, therefore, removed from a site. Instead, the Base Realignment and Closure (BRAC) Cleanup Team (BCT) agrees on the detection procedures that can be implemented. These procedures are then evaluated and one or more are implemented. The Army can then state that, to the best of its ability, all detectable OE has been removed. For this reason, coupled with the acute nature of OE hazards, and the absence of an OE cleanup standard, it will always be assumed there is residual OE risk at the site. The OE risk assessment will be used to understand the sources of the OE risk and how to best manage any post remedial action residual risk. It is important to note that an integral part of any OE risk management process will include recurring review of the site.

OE Risk Assessment

An OE risk assessment is used to describe and estimate the risk or likelihood of adverse consequences from an encounter with OE. This Protocol does not calculate the probability of adverse consequences, but instead assumes that encounters with OE items will result in adverse consequences and, therefore, describes and estimates the OE risk recognizing that basic assumption. The OE risk assessment at Fort Ord will be used several times over the course of the OE RI/FS process. Initially, a baseline risk assessment is performed to establish the existing OE risk at an OE-impacted site. The baseline risk assessment will evaluate the OE site before base closure. Using this baseline risk, the Feasibility Study determines the degree of OE risk reduction that would be achieved by each remedial alternative. After a remedial alternative is chosen and implemented at the site, the residual risk is estimated and the actions needed to manage it are determined.

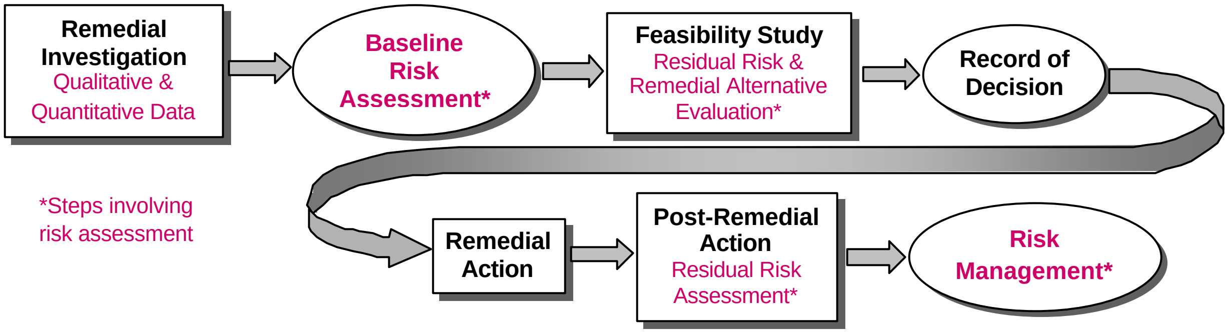


Figure 1-1. Risk Assessment in the CERCLA RI/FS Process

As seen in Figure 1-1, the OE risk assessment is one part of the decision process for a site. During the Feasibility Study, the following nine criteria are used to evaluate the various remedial alternatives as outlined in the National Contingency Plan (NCP):

1. Overall protection of human health and the environment,
2. Compliance with Applicable or Relevant and Appropriate Requirements,
3. Long-term effectiveness and permanence,
4. Reduction of toxicity, mobility, or volume through treatment,
5. Short-term effectiveness,
6. Implementability,
7. Cost,
8. State acceptance, and
9. Community acceptance.

The OE risk assessment will help the Army evaluate the overall protectiveness of human health (Criterion 1) and to a degree, the effectiveness (Criteria 3 and 5) of the remedial alternatives. Because this Protocol focuses on risk to humans from OE, protecting the environment (ecological risk) will be considered separately as part of criterion 6 (implementability) in the Feasibility Study.

Throughout the OE RI/FS process, public involvement is encouraged. Specifically, public comments are requested on the Feasibility Study and Proposed Plan documents and during the remedial design, remedial action, and post-remedial action stages. As part of the Feasibility Study process, this Protocol was provided to the public for review so that any public concerns can be considered before using the Protocol to determine OE risk.

Fort Ord OE Risk Assessment Protocol

Several methods exist for performing risk assessments on OE-impacted sites; however, there is no OE risk assessment methodology that has been widely accepted, evaluated, and fully implemented for a variety OE sites. Thus, this Protocol was developed to determine the current and future OE risk at Fort Ord.

The Protocol parallels the three goals of CERCLA risk assessments:

- establish a baseline risk assessment,
- refine preliminary remediation goals, and
- evaluate remedial alternatives risk.

Given the differences between OE risk and chemical risk, and in the absence of established preliminary remediation goals for OE, remediation goals are developed on a site-specific basis and the OE RI/FS process for OE will be adjusted to parallel the typical process.

The Army, through the BCT, formed a Project Team representing various areas of expertise in the OE RI/FS process and OE risk, comprised of Army, U.S. EPA, and DTSC representatives, to develop the site-specific OE risk assessment methodology. This team consists of a focus group of risk assessors, trained OE experts, and key decision makers who worked together to develop objectives and plan the OE risk assessment process for the Army. Over the past year (beginning in June 2001), the Project Team's site, OE risk, and risk assessment applications experience combined to produce the draft Protocol. The Team's discussions resulted in the following initial decisions which were followed throughout the development process:

The objectives of the OE Risk Assessment Protocol for Fort Ord will be to:

- estimate baseline OE risk;
- estimate residual OE risk;
- assist in remedial action and OE risk management action selection;
- assist in OE risk communication; and
- complete the CERCLA process (as outlined above).

The audience of the OE Risk Assessment will be:

- the Fort Ord OE BCT; and
- the public.

The OE Risk Assessment will be used at:

- Track 2 RI/FS sites; and
- Track 3 RI/FS sites.

The Protocol should be

- technically solid;
- straightforward;
- able to produce results with a qualitative output;
- built on existing methods as appropriate and newly developed methods as needed;
- able to be applied to a variety of site conditions;
- focused on the OE risk (chemical risks have been addressed in the base-wide RI/FS);
- closely related to the OE Sampling and Analysis Plan development; and
- inclusive of public involvement.

The Fort Ord OE Risk Assessment Protocol is not designed to assess absolute risk. The overall OE risk score is an approach for comparing the relative risks between remedial alternatives on an OE-impacted site at the Fort Ord facility. The overall OE risk score determined using this Protocol should not be compared to other OE-impacted facilities because it was developed using site-specific categories. The overall OE risk score will be reevaluated as part of the five-year reviews of Fort Ord.

2.0 EVALUATION AND REVIEW OF EXISTING METHODS

In order to select an OE risk assessment approach for Fort Ord, the Project Team selected 10 existing methods and determined the criteria for choosing a framework (Appendix A). The Project Team requested information on the following methods:

1. Interim Range Rule Risk Methodology (IR3M)
2. Adak Island Explosive Safety Hazard Assessment
3. Risk Assessment Code (EP 1110-1-18)
4. OE Cost Estimating Risk Tool (OECert)
5. Risk Assessment Procedures for OE Sites
6. OE Risk Impact Analysis (OE RIA)
7. Impact Assessment Cooperative Risk Management Framework
8. NAVEODTECHDIV Methodology
9. Kaho'olawe Hazard Assessment Methodology
10. Fort Meade Risk Assessment Methodology

The Project Team outlined the decision criteria and created a series of evaluation questions. These questions focused on the methods' objectives, guidelines, and if they included factors that generally allow CERCLA projects to proceed most efficiently. The evaluation questions were:

- Is the method defensible?
- Are the inputs qualitative or quantitative?
- Are the outputs qualitative or quantitative?
- Was the method developed in a partnered forum with regulatory and public involvement?
- Has the method been applied or tested?
- What is the public and/or regulatory perception of the method?
- Will changes to the method be necessary?
- Can the method be easily modified? Can it accept valuable parts of other methods?
- Is the method flexible enough to meet a variety of site conditions?
- Is the method flexible enough to assess multiple ordnance types and various past operations?
- Can the method be used to measure baseline risk?
- Can the method be used to measure residual risk?
- Does the method provide enough sensitivity to show differences in remedial actions?
- Can the method be used to select Risk Management Actions?
- Is the method straightforward and easy to communicate?
- Does the method complete the CERCLA process?
- What portions of this method could assist Fort Ord?

The evaluation of the 10 existing methods is provided in Appendix A.

Results of the Evaluation of Existing Methods

The analysis of existing methods showed that many of the methods, or portions thereof, meet the technical needs of an OE risk assessment at Fort Ord. The IR3M, Adak, and OE RIA methods provide simple, qualitative analyses of OE risk that meet the specific objectives of the Fort Ord OE Risk assessment. These methods are the newest and rely on the lessons learned from other methods. As demonstrated by the Adak methodology, IR3M's input factors and algorithms can be modified to meet the site-specific conditions at Fort Ord. As a result of its review and analysis, the Project Team agreed to use the IR3M as the basis for the Protocol, drawing on key concepts from the Adak and OE RIA methods.

The IR3M and the OE RIA have been applied and beta tested, at least in concept. The IR3M was used by a mock Base Cleanup Team to test for usability and flexibility. OE RIA was developed based on outstanding comments on the IR3M and is being used at various closed ranges. At the time of the Project Team's evaluation, the Adak approach was still being developed and testing had not been completed. Adak's approach is based on IR3M but changes some of the input factors and algorithms. The IR3M is the only method developed through a nationwide, partnered atmosphere, including groups such as DTSC, EPA, and stakeholders (including Center for Public Environmental Oversight).

IR3M was not finalized at the time of this evaluation; however, stakeholders and developers have agreed on the input factors and general approach of the method. Three major concerns raised during the public comment period and the beta test of the IR3M were as follows:

1. Complexity of the tool – the risk tool may be difficult to understand and explain.
2. Algorithm development – the combination of numbers to obtain final scores is not transparent and based on beta testing, several recommended improvements to the actual combination of variables were identified.
3. Definitions of input factors – the definitions of the input factors were not specific enough to allow their consistent application (e.g., Migration/Erosion – did not include the effects of timing or intensity of natural events).

In addition to the methods evaluation described here, the Army is also conducting a nation-wide evaluation of existing risk assessment methods for their technical basis, implementability, and communication features in measuring explosives safety risk. This evaluation is expected to be completed by Fall 2002; however, the Project Team has tracked this effort to ensure that lessons learned about the methods, specifically on IR3M, could be addressed. At the time this report was prepared (June 2002), the key deficiencies of IR3M identified by this study included: justification for the assumptions used to develop algorithms and scoring procedures are not provided, uncertainty is not addressed, output is not always reproducible, and the instructions are not sufficiently specific.

The Project Team is aware of these concerns and issues and has attempted to resolve these and other issues to create a protocol that is technically sound and straightforward. As described in the following sections, the Protocol was developed considering all of the necessary factors for describing OE risk and is flexible enough to accommodate Fort Ord's and the Army's developing OE program.

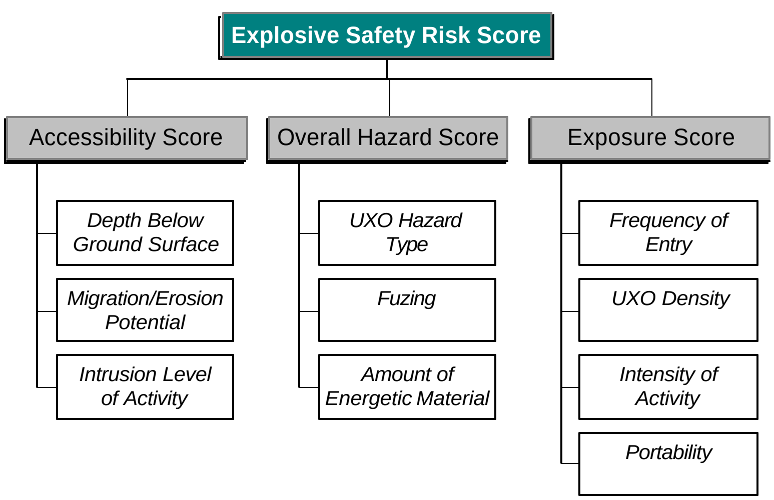
3.0 DEFINING THE PROTOCOL INPUT FACTORS

Review of IR3M As the Selected Framework

IR3M contains several tools to help decision makers assess OE risk and evaluate response alternatives. These tools contain three common elements: input variables, process algorithms, and results. Using these tools, decision makers assign scores to each input variable and use process algorithms to combine the input variables, producing results. For example, a "process algorithm" combines scores for frequency of entry, UXO density, intensity of activity, and portability -- which are all "input variables" in the Explosives Safety Risk Tool -- to generate a "result" for exposure. This result is then combined with other results of the tool to generate an overall result for explosive safety risk.

One of the IR3M's tools is the Explosives Safety Risk Tool. It has ten input variables which are qualitative (e.g., Migration/Erosion Potential) and quantitative (e.g., Depth Below Ground Surface, UXO Density). Three process algorithms combine these 10 input variables into scores for Accessibility, Overall Hazard, and Exposure. A fourth process algorithm combines these 3 scores into a single score for estimating Explosives Safety Risk.

Figure 3-1. IR3M Explosive Safety Risk Tool



IR3M addresses closed, transferring, and transferred military ranges, including Army, Air Force, and Navy sites. Because training activities at military ranges vary widely, some of the IR3M input variables needed to be tailored to adequately address the types of training and site-specific factors at Fort Ord. Therefore, the Project Team reviewed each of the ten input variables' definitions, scores, and relative influence on the resulting risk output. Changes were made to the ranking and definitions of the input variables and to the combination of variables based on Project Team's professional experience and Fort Ord-specific data. The information on the rankings from IR3M is included for comparison. For a complete discussion of IR3M, see Appendix B.

Overview of Changes Between the IR3M and Fort Ord OE Risk Assessment Protocol Methods

The Project Team made changes to IR3M only when necessary based on the validation performed on the IR3M, public comments received on IR3M, the Project Team's professional experience, and site-specific conditions. The most significant change to IR3M was the use of "process algorithms." Because the understanding of these algorithms was of concern, the Project Team used matrices to combine input factors, similar to the Adak approach. In the Protocol, two process matrices combine quantitative input factors into qualitative Accessibility and Exposure scores. A third matrix combines these two scores and the qualitative score for Overall Hazard into a single score for estimating Overall OE Risk.

To simplify the approach, Overall Hazard scoring was changed from the three variables (Ordnance Type, Fuzing, and Net Explosives Weight) as used in IR3M. To simplify the approach, the Team determined that at Fort Ord, OE type clearly drives the overall hazard. Net explosive weight is inherent to OE type and was considered when developing the OE type scoring but was not scored separately. The Fuzing input factor is considered worst-case; therefore, all items were considered fuzed. Of the OE types expected on Fort Ord ranges, over 99% could be picked up and removed (i.e., portable) by a child; therefore, portability is also considered worst-case and portability is not included as a separate factor. In addition, site-specific alterations have been made based on conditions at Fort Ord. The specific changes are discussed in more detail below.

Depth Below Ground Surface

The depth of OE is key to the hazard posed on a site – the deeper an item, the less likely that a person will come in contact with the item. When ordnance is present at a site, in many cases, there will generally be some on the surface (especially when no clearance actions have been completed). In general, the deepest items found to date at Fort Ord were between 3 and 4 feet below ground surface (bgs). The Project Team agreed that if a removal is done on the site, then it is technically appropriate for the depth score to be modified for the post-action risk assessment. The Depth Below Ground Surface categories are given to the right.

Fort Ord Depth Below Ground Surface Ranking

Score	**IR3M**	**Fort Ord OE Risk Assessment**
1	All UXO > 10 feet bgs	100% of detected OE was removed considering the data quality for the site*
2	All UXO > 4 feet bgs	All OE > 5 feet bgs
3	All UXO > 2 feet bgs	All OE ≥ 4 feet bgs
4	All UXO ≥ 1 foot bgs	All OE ≥ 3 feet bgs
5	All UXO < 1 foot bgs	All OE ≥ 2 feet bgs
6		All OE ≥ 1 foot bgs
7		No OE on the surface and OE below surface
8		Any OE on surface

* Detection and removal procedures meeting the DQOs for the site based on clearly defined investigational objectives including reuse and the detection of designated OE. If DQOs have not been established for the sector, the quality of data should be approved by the BCT to score a "1."

Category 7 was included for cases where either a surface removal was completed or where the actual depth of OE is unknown, but OE could be found at any depth bgs.

Category 1 was changed to account for detection and removal procedures. The Team decided that after a removal action which complies with clearly defined Data Quality Objectives (DQOs)[1], there would be sites where 100% of detected OE was removed. Note that a score of 1 can only be reached if the investigational objectives for the site have been met or the data quality was approved by the BCT; scores of 2 and above can relate to situations where actions have taken place but the DQOs were not met due to project limitations, or where no actions have been taken.

Level of Intrusion

Closely related to the depth of an OE item is the depth to which an individual is expected to dig or intrude. When the depth of the OE item and the depth of intrusion overlap, an adverse event is more likely. The Fort Ord Strategic Management, Analysis, Requirements and Technology (SMART)[2] Team has determined that four feet is the maximum expected depth of intrusion and a 25% buffer should be added to the expected intrusion depth giving a five-foot maximum intrusion depth. The Project Team considered the SMART Team's decision and the only change was to make all intrusion types equal (that is, an equal score would be applied when the activity was performed by someone digging with hand tools or with mechanical equipment). Given this change to the IR3M, the type of intrusion will be discussed in a narrative discussion of the overall OE risk. This will ensure that the type of intrusion is considered.

Fort Ord Level of Intrusion Ranking

Score	IR3M	Fort Ord OE Risk Assessment
1	Non-Intrusive: Activity on the ground surface, none below the surface	Non-Intrusive: Activity on the ground surface, none below the surface
2	Minor Intrusions: Activity only on ground surface, ground disturbances with a hand tool to a depth of one foot bgs	Minor Intrusions: Activity on ground surface and ground disturbances to a depth of one foot bgs
3	Moderate Intrusions: Ground disturbances with mechanical equipment to a depth of two feet bgs	Moderate Intrusions: Ground disturbances to a depth of two feet bgs
4	Significant Intrusions: Ground disturbances with mechanical equipment to a depth of four feet bgs	Significant Intrusions: Ground disturbances to a depth of four feet bgs
5	Highly Intrusive: Ground disturbances greater than four feet bgs	Highly Intrusive: Ground disturbances greater than four feet bgs

[1] DQOs for detection and removal procedures used at the site must be based on clearly defined investigational objectives including reuse and the detection of designated OE.

[2] The SMART Team helps ensure the safe and timely transfer of Fort Ord property containing ordnance and explosives (OE) or unexploded ordnance (UXO). The SMART Team is formed by senior members from key decision-making agencies and organizations focus on presenting innovative approaches and solutions to regulatory or technological issues hindering the transfer process. The members are from the Installation, the Environmental Protection Agency Region IX, the California Department of Toxic Substances Control, the Army Training and Doctrine Command, and the Army Secretariat for Installations and Environment.

Fort Ord Migration/Erosion Ranking		
Score	**IR3M**	**Fort Ord OE Risk Assessment**
1	Very Stable: no OE will migrate	Very Stable: OE will not migrate. Erosion is equal to or less than the site-wide average of 3/100 inch per year.
2	Minor Migration: OE not expected to migrate due to recurring natural events; extreme natural events may cause migration	Minor Migration: Recurring and extreme natural events may cause OE to migrate upward, potentially reaching the intrusion level, over a long period of time (more than two five-year reviews). Erosion is greater than the average condition but less than one inch per year.
3	Moderate Migration: OE may surface over a long period of time and/or through recurring natural events	Significant Migration: Recurring and extreme natural events will bring OE to the surface within the first recurring review. Erosion is more than one inch per year.
4	Significant Migration: Recurring and extreme natural events will bring OE to the surface	
5	Highly Dynamic: OE will surface within the first Recurring Review	

Migration/Erosion

Chemical risk assessments consider migration of a chemical by groundwater and by air as possible pathways for exposure. OE items will not migrate these same ways. An OE item instead can migrate vertically from erosion or actual ground movement (e.g., an earthquake). It is unlikely the OE will move laterally on the site, unless erosion occurs on a steep slope. Studies by the U.S. Department of Agriculture Natural Resources Conser-vation Service show that erosion caused by wind and water in the Monterey Bay Area would be on the order of five to eight tons of soil per year per acre, which is equivalent to an average annual maximum rate of approximately three-hundredths of an inch. At this rate, it would take over 33 years to reduce the depth bgs of an OE item one inch. Because of the dense vegetation at Fort Ord, most areas probably erode less than the average for the Monterey Bay Area. Significant erosion would likely only occur in areas disturbed by human activity, such as areas with roads and firebreaks.

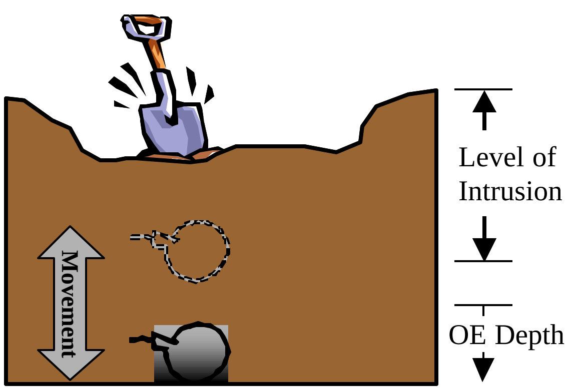


Figure 3-2. Movement of an OE item into the Level of Intrusion

Although significant erosion is unexpected at Fort Ord, the migration/erosion input factor was nevertheless included to capture all potential factors affecting OE risks. Changes were made to the IR3M scoring to account for inconsistencies in how the potential for migration is evaluated, the amount of migration that may occur, and the timing and the consequences of potential migration. In addition, an OE item migrating into the depth of intrusion without moving all the way to the surface is considered in the Fort Ord Migration/ Erosion Ranking.

OE Type

The IR3M uses the Department of Transportation's (DoT) ranking of OE hazards. DoT's approach addresses stockpiling and transporting unused ordnance, and is not appropriate for classifying OE at Fort Ord. The Adak approach is a narrative ranking of OE types; however, Adak was a Navy facility, so some of the items at Fort Ord may not fit into the Adak ranking.

Fort Ord OE Type Ranking

Score	IR3M	Fort Ord OE Risk Assessment
0		Inert OE, will cause no injury
1	Explosive substance or article, very or extremely insensitive (DoT Class 1 Divisions 1.5 and 1.6)	OE that will cause an injury, in extreme cases could cause major injury or death, to an individual if functioned by an individual's activities
2	Moderate fire, no blast or fragmentation (1.4)	OE that will cause major injury, in extreme cases could cause death, to an individual if functioned by an individual's activities
3	Mass fire, minor blast or fragmentation (1.3)	OE that will kill an individual if detonated by an individual's activities
4	Non-mass explosion, fragment producing (1.2)	
5	Mass explosion (1.1)	

A subgroup of the Project Team, including explosive ordnance disposal (EOD)-trained technical experts, reviewed the Adak, DoT, and OE RIA OE hazard rankings. They concluded that (1) the Adak approach is too complex, (2) the DoT ranking does not address unexploded ordnance items, and (3) the OE RIA rankings were established within the Corps of Engineers and have been implemented on other former training sites. For these reasons, the subgroup modified the OE RIA ranking for categorizing OE items at Fort Ord.

In the above table, an "injury" is defined as a flesh wound or minor burn and a "major injury" is defined as the loss of a limb, eyesight, or hearing, and major burns.

On a given site with more than one type of OE, the OE item with the highest score (i.e., worst-case scenario) will drive the OE Type input factor; however, the Project Team has agreed that inconsistent OE Types (e.g., if one OE type is common to the site and a single item of another type is found) will not drive the input factor and will be considered separately. Rare OE items will be addressed when the RI data is compiled and the OE Type factor for a site will be based on the weight of evidence provided in the RI data.

Appendix C is the working group's "Fort Ord Ordnance Hazard Classification." Appendix C must ***only*** be used by ***UXO-TRAINED PERSONNEL*** to determine the OE Type. It is included for completeness and is not intended for use by untrained personnel.

Small arms (0.50-caliber and below) are not considered in the Fort Ord OE Risk Assessment because they pose no explosive risk. Impacts of small arms are being addressed as part of the base-wide range assessment program at Fort Ord.

Fuzing and Amount of Energetic Materiel

These two input factors were considered in conjunction with OE Type input factor. The Amount of Explosive Materiel (or net explosive weight) is inherent to the OE type and was considered when developing the OE Type input factor scoring (above), and was not scored separately. The Fuzing input factor is considered worst-case; therefore, all items were considered fuzed when developing the OE Type input factor. Because the IR3M sensitivity analysis demonstrated that these two factors had minimal impact on the overall OE risk score, they were removed as separate inputs to increase the straightforwardness of the Protocol. The subgroup that developed the OE Type input factor scale ensured that fuzing and amount of energetic material were considered when establishing the OE Type input factor scale.

Portability

Initially, the Project Team kept the IR3M ranking for portability and assumed that many of the items found on Fort Ord will be moderately to easily portable. A subsequent review of the items found on Fort Ord OE sites showed that all but two could be carried by a child (less than 1% of the ordnance types). For this reason, the Team decided to assume that all items could be carried by a child and to leave out the Portability input factor, because it will not allow differentiation between areas or remedial actions.

Frequency of Entry

Fort Ord Frequency of Entry Ranking		
Score	**IR3M**	**Fort Ord OE Risk Assessment**
1	Rare: One or fewer range entries per month	Rare: Is not likely to occur (less than once per year to once per year)
2	Occasional: Two to 8 range entries per month	Infrequent: Will seldom occur (less than once per season to once per month)
3	Often: Nine to 15 range entries per month	Occasional: Will likely occur from time to time (more than once per month)
4	Frequent: Sixteen to 22 range entries per month	Frequent: Will occur frequently (once a week to more than once a week)
5	Very Frequent: More than 22 range entries per month	

The IR3M frequency-of-entry ranking is based on between 1-22 people, or more than 22 people, entering the property per month and does not reflect the frequency of entry expected on some areas within Fort Ord before and after the property is transferred. Considering the Fort Ord Reuse Authority (FORA) reuse plan, the Project Team decided that frequency of entry would be best evaluated with a more qualitative ranking scale that does not consider numbers of people. However, the Team considered quantitative bounds for the Frequency of Entry in terms of the number of entries per year, month, and week based on a person-days-per-year approach. For example, the frequency of entry would be the same if one person visited the site one day each month for a year or if 12 people visited the site for one day during the year, that is, the frequency of entry would be scored as Infrequent ('2').

Exposure duration, as defined in chemical risk assessments, was not explicitly considered for the Protocol. Rather, duration was fixed for all receptors at one year, and the number of exposures during that year evaluated. The "lifetime" exposure of a receptor is to be considered in the associated narrative.

The risk assessment will be run for multiple receptors (construction workers, residents, etc.) to gain a broader understanding of the risk at a given site. However, trained UXO technicians and others covered by OE-specific health and safety plans would not be included in the risk assessment.

OE Density

The density of OE items found at Fort Ord in areas outside of the Multi-Range Area (MRA), to date, has ranged from 0.44 items per acre to 4 items per acre with an average of approximately 0.6 items per acre. The Project Team modified the IR3M scale to be semi-qualitative to better represent the low OE density at Fort Ord. In addition, the OE items of concern are those which are potentially accessible to persons on site; therefore, the OE Density will be determined based on site area (e.g., number of acres) and the Level of Intrusion expected for the given receptor type. Thus, the same site may have different OE Density scores for various receptor types.

Fort Ord OE Density Ranking

Score	IR3M	Fort Ord OE Risk Assessment
1	<2 per acre	100% of detected OE was removed to the Level of Intrusion *
2	2-10 per acre	Low OE Density (< 0.1 items per acre)
3	11-50 per acre	Medium OE Density (0.1 to 1 items per acre)
4	50-100 per acre	High OE Density (> 1 items per acre)
5	> 100 per acre	

* Detection and removal procedures meeting the DQOs for the site based on clearly defined investigational objectives including reuse and the detection of designated OE. If DQOs have not been established for the sector, the quality of data should be approved by the BCT to score a '1.'

Similar to the Depth Below Ground Surface input factor ranking scale, category '1' accounts for OE detection and removal. The Team decided that after a removal action, which complies with the clearly defined DQOs, a site could have all detected OE removed. Note that a score of '1' can be reached only if the investigational objectives for the site have been met or if the data quality was approved by the BCT. Other scores relate to situations where removal actions have taken place but the DQOs were not met or where no removal action has occurred.

Intensity of Contact with Soil

A primary factor affecting the probability of an encounter with an OE item is the intensity of soil contact. For example, a person working at a shopping center developed on the Fort Ord property would be less likely to contact soil than would a construction worker who built the shopping center. The shopping center employee would be less likely to encounter a residual OE item (at any depth) no matter how long they spent on-site because they would only be outside in contact with soil for short periods of time.

Fort Ord Intensity of Contact with Soil Ranking		
Score	**IR3M**	**Fort Ord OE Risk Assessment**
1	Very Low: Less than one hour per day and light activity	Very Low: ≤ 1 hours/day
2	Low: Up to three hours per day and light activity	Low: ≤ 3 hours/day
3	Moderate: Up to six hours per day and moderate or light activity	Moderate: ≤ 6 hours/day
4	High: Up to nine hours per day and moderate activity	High: ≤ 9 hours/day
5	Very High: Greater than nine hours per day or heavy activity	Very High: ≥ 9 hours/day

To address how contact with soil relates to the frequency factor, the IR3M Intensity factor was modified to consider how long an activity puts a person in contact with soil. The Project Team modified the IR3M approach to consider only the duration of the activity that puts a person in contact with soil and to treat all activity types equally (i.e., light activity and heavy activity in contact with soil are given the same importance). In general, a person in contact with soil for a prolonged period would be more likely contact an OE item than during a shorter period. Although the Project Team did not think a difference existed between activity for nine hours and for greater than nine hours on a site, they decided to keep the scale unmodified.

Data Quality

Based on the importance of both data quality and the level of data confidence that is used to make OE decisions (e.g., archival search data, survey percentages or removal data) the Team decided addressing data quality was important in the Protocol.

The IR3M itself does not explicitly address data quality in its scoring, but accounts for it in two ways. IR3M suggests that data quality be determined using the Data Quality Objective (DQO) process before sampling begins and recommends erring on the conservative side when data is less than optimal. The Adak model considers data quality by developing the inputs based on project-specific procedures and requirements in its "Ordnance Search/Removal Status Subfactor." This subfactor relates site status to the search methodologies that will be used according to the site's Final Work Plan. OE RIA does not consider data quality but relies on best professional judgment in during scoring.

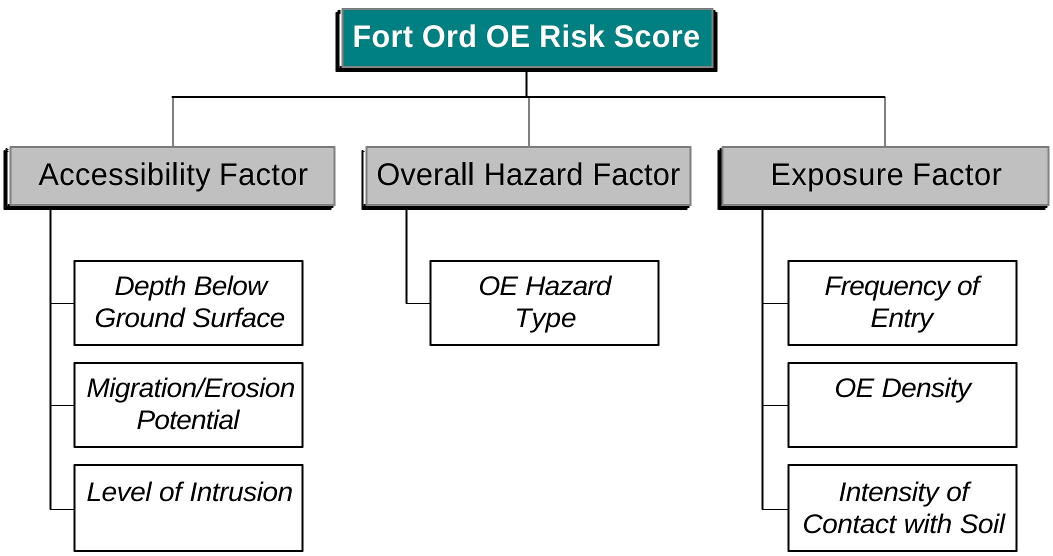
As discussed in Section 5.0, a qualitative discussion will accompany the overall OE risk assessment score. This discussion will assess the strengths and weaknesses associated with scoring the input factors and the effects on the final OE risk score. The Protocol requires users to err on the conservative side when data is less than optimal.

4.0 DEFINING THE PROTOCOL PROCESS MATRICES

This section details how the input factors discussed in the previous section are combined to create the Fort Ord OE Risk Assessment Protocol.

The seven input factors are separated into three factors – Accessibility, Overall Hazard, and Exposure. The associated input factor scores are combined, giving a qualitative score for the category. The scores of the three factors are then combined to determine an overall qualitative risk score. Figure 4-1 is a graphical depiction of each of the factors in these three categories for the Fort Ord OE Risk Assessment.

Figure 4-1. Fort Ord OE Risk Assessment



The Project Team analyzed the weight of the input factors for each category by developing matrices for Accessibility, Exposure, and Overall OE Risk relating all possible combinations of input factors. The matrices are given in Section 5.0. This section details the decisions made when developing these matrices.

Accessibility

Accessibility relates to the ease of access to OE. The Accessibility matrix uses the scores from the Depth Below Ground Surface and the Level of Intrusion factors to develop an Accessibility score. Adjustments are made to reflect the migration or erosion potential (effectively reducing the minimum depth at which the ordnance items may be found). The Accessibility Factor scoring is given below:

Table 4-1. Fort Ord OE Risk Assessment Accessibility Factor

Score	Description
1	Lowest Potential for Accessibility
2	Not Likely to be Accessible
3	May be Accessible
4	Likely to be Accessible
5	Greatest Potential for Accessibility

The three potential accessibility scenarios are shown graphically below:

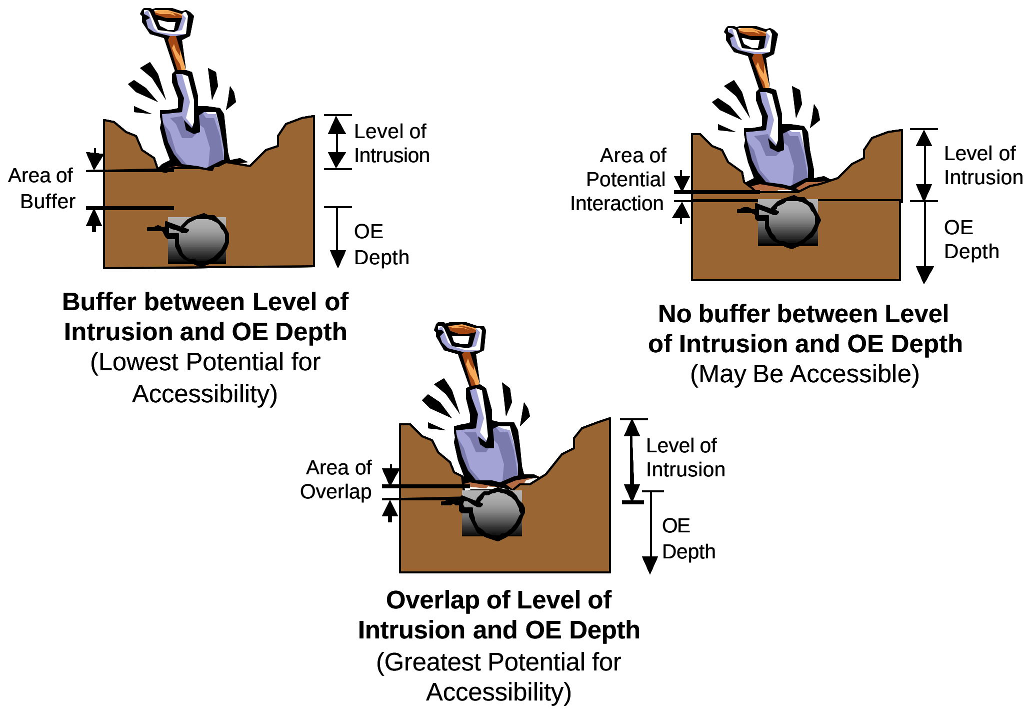


Figure 4-2. Examples of Potential Accessibility Scenarios

As shown in Figure 4-2, the Project Team determined that the Accessibility Factor score depends on the distance between the level of intrusion and the shallowest OE item (i.e., the buffer). The scoring criteria are as follows:

- If the buffer is one foot or more and erosion will not cause the buffer to be less than one foot, the Accessibility Factor score is '1'.If the one-foot buffer can be reduced by erosion or if the intrusion depth increases the potential for access, the Accessibility Factor score is '2'. If the buffer is less than one foot or the buffer can be decreased to less than one foot by erosion, the Accessibility Factor score is '3'. If the buffer approaches zero feet, the Accessibility Factor score is '4'.
- If there is no buffer between the level of intrusion and the depth to the shallowest OE item, the Accessibility Factor score is '5'.

Initially, the Project Team thought that OE Depth should be a primary driver of the Protocol, Level of Intrusion should be a secondary driver, and Migration/Erosion should be a modifier to the overall score. After finalizing the matrix, the relative rankings matched the initial decisions for the overall OE risk (see Appendix D, Figure 6-2).

The Accessibility process matrix is provided as Table 5-4 in the next section.

Overall Hazard

The Overall Hazard factor relates to the type of OE items present. This provides a way to differentiate between situations having similar site access and exposure opportunities but with OE items that present differing risk. The Overall Hazard factor directly relates to the OE Hazard Type Score which considers the amount of energetic material present, assumes that all OE items are fuzed, and the portability of OE items. There is no process matrix for Overall Hazard because of the single factor (OE Hazard Type) which contributes to the score. Table 4-2 shows the Fort Ord OE Risk Assessment Overall Hazard scoring.

Table 4-2. Fort Ord OE Risk Assessment Overall Hazard Factor

Score	Description
0	Inert OE, will cause no injury
1	OE that will cause an injury, in extreme cases could cause major injury or death, to an individual if functioned by an individual’s activities
2	OE that will cause major injury, in extreme cases could cause death, to an individual if functioned by an individual’s activities
3	OE that will kill an individual if detonated by an individual’s activities

Exposure

Exposure to an OE item relates to the likelihood that someone will come in contact with the item, and physically disturb it thereby potentially causing injury or death. The Exposure Factor scoring is given in Table 4-3 below.

Table 4-3. Fort Ord OE Risk Assessment Exposure Factor

Score	Description
1	Lowest Potential for Exposure
2	Not Likely to be Exposed
3	May be Exposed
4	Likely to be Exposed
5	Greatest Potential for Exposure

Initially, the Project Team believed that OE Density should be a primary driver of the Protocol, and the Frequency of Entry and Intensity of Contact with Soil factors should be secondary drivers to the overall score. When finalizing the matrix for Exposure, the OE Density factor was made a primary driver, the Intensity of Contact with Soil factor was made a secondary driver, and the Frequency of Entry factor was used to modify the overall OE risk (see Appendix D, Figure 6-2).

The Exposure process matrix is provided as Table 5-8 in the next section.

Overall OE Risk

The overall OE risk score depends on the potential for access to the OE-impacted area, the potential for exposure to an OE item, and the hazard of the OE type.

Table 4-4. Fort Ord OE Risk Assessment Overall Risk Score

Score	Description
A	Lowest OE Risk
B	Low OE Risk
C	Medium Risk
D	Higher OE Risk
E	Highest OE Risk

The Overall OE Risk process matrix is provided as Table 5-10 in the next section.

Validation of the Process Matrices

Key to the Fort Ord OE Risk Assessment Protocol is a logical combination of the elements of OE risk – Accessibility, Overall Hazard, and Exposure. Before implementing the Protocol, the Project Team conducted a sensitivity analysis and beta test to determine if the input factors and the process algorithms produce an overall OE risk score that fulfills the objectives previously defined for the risk assessment approach. The Sensitivity Analysis determined which input factors significantly affect the OE risk score and which have relatively minor impact. The Beta Test determined the functionality of the Protocol and if the objectives and goals of the OE risk assessment were met using, in part, a questionnaire given to the assessment teams. The results of the validation effort are provided in Appendix D.

Sensitivity Analysis

Sensitivity analysis determines the effects of changes to input factors on results. For quantitative models, sensitivity analysis evaluates the mathematical equations that combine multiple input factors into results. The Fort Ord OE Risk Assessment Protocol produces qualitative results using quantitative inputs. In place of equations, matrices are used to combine input factors which then lead to qualitative results. Thus, the Sensitivity Analysis evaluates how each input variable effects the Overall Risk score (i.e., A through E). See Appendix D, Sections 3.0 and 6.0, for results of the Sensitivity Analysis.

Two techniques were used to conduct the Sensitivity Analysis – deterministic and probabilistic. Deterministic techniques were used to determine all possible results for the Protocol (i.e., how many times that Overall Risk scores of "A" through "E" would theoretically occur). Probabilistic techniques were used to determine how much the Overall OE Risk result changes according to proportional changes to the input factors.

Both techniques are limited by the assumptions used when analyzing the input factors. For the probabilistic analysis, each possible score for each of the input factors were assumed to be equally likely. For example, it assumed a 25% chance for each OE Type outcome (either 0, 1, 2, or 3). But in reality, the OE Type score will depend on the how the site was used. In addition, for both the probabilistic and deterministic analyses, all of the input factors were assumed to be independent. However, this is a simplification, because, for example, in applying the Protocol, OE Density will depend on the Level of Intrusion and may also depend on OE Hazard Type. It is important to note that although some of the input factors may be linked, it does not appear that any of the factors are mutually exclusive. These simplifications were made to provide the Team with a quick assessment of the Protocol.

The deterministic analysis showed that there is theoretically a greater possibility of scoring either an Overall Risk score of "C," "D," or "E," than an "A" or "B." The results of the probabilistic analysis showed that the Overall OE Risk score mostly depends on OE Type with OE Depth, OE Density, and Level of Intrusion influencing the results and Intensity of Contact with Soil, Frequency of Entry, and Migration/Erosion Potential producing more of a modifying influence.

Beta Test

A Beta Test is the final testing stage for new software and is conducted by testers, not the software's developers. A Beta Test of the Protocol determined the functionality of the Protocol and if the objectives and goals discussed in Section 1.0 were met. The criteria for a successful Beta Test was whether or not the Protocol met the objectives outlined in Section 1.0 and if it will help the BCT make decisions on remedial action alternatives during the Feasibility Study.

Three independent assessment teams (Teams A, B, and C) were tasked with running the Protocol on the two data sets. Two problem statements were developed based on information from Fort Ord sites. The independent teams used the Protocol to determine OE risk for baseline conditions and remedial action alternatives, which included no action, institutional controls, surface clearance, and clearance to depth. The problem statements presented two intended receptors based on the proposed reuse for the property as identified in the data set package.

Changes were made to the matrices and Protocol based on the validation effort. The Validation Report is provided as Appendix D. Section 5.0 presents the scoring matrices as revised from the validation effort.

5.0 USING THE FORT ORD OE RISK ASSESSMENT PROTOCOL

The Protocol was prepared through a combined effort of the Army, the DTSC, and the EPA. The purpose of the Protocol is to review OE risks at OE-impacted sites at Fort Ord. As defined in Section 1.0, the Fort Ord BCT will use this Protocol as part of the OE RI/FS to:

- evaluate past, current, and future OE risk;
- help select remedial action and OE risk management actions;
- help communicate OE risks, and
- fulfill the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund).

The OE RI/FS will comprehensively evaluate all OE-related data for the entire Fort Ord. As part of this evaluation, the OE Feasibility Study will evaluate long-term response alternatives for cleaning up managing risk at OE-impacted sites at Fort Ord. The Protocol will also provide the approach for completing the Risk Assessment section in the OE RI/FS Work Plan (USACE, 1999). The Army will apply the Protocol in all areas of Track 2 and Track 3.

The Protocol will be applied to sectors of OE sites as defined in the Remedial Investigation. The OE Risk at a former Fort Ord sector can be determined by answering four questions:

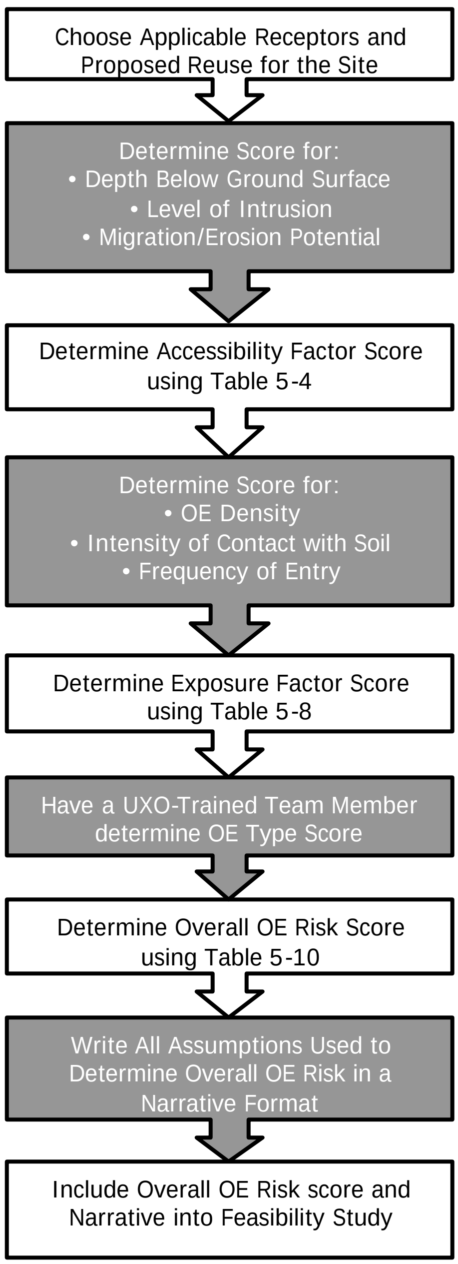
1. How likely is it that the OE items in the sector are ***accessible***?
2. How likely is it that someone will be ***exposed*** to the OE item, if they are in the sector?
3. How ***hazardous*** is the OE item itself?
4. How do the *accessibility* of the OE item, the likelihood of *exposure*, and the level of *hazard* combine to define the ***OE Risk*** for the sector?

The Protocol will be applied during three steps of the OE RI/FS. First, a baseline risk assessment will determine the initial OE risk in a sector prior to any removal work. Second, during the Feasibility Study, the baseline sector risk will be compared to the current OE risk and the potential risk reduction associated with the remedial alternatives determined. The current risk will differ from the baseline risk in sectors where OE removal actions have occurred; otherwise, the current risk will be the same as the baseline risk. Finally, the OE risk assessment will be used to determine the OE risk at the site following remedial action. The result of the OE risk assessment at this final step will be reevaluated as part of the five-year reviews of Fort Ord.

This section guides the user through the application of the Protocol.

Steps for Running the Fort Ord OE Risk Assessment Protocol

Determining Overall OE Risk at a site requires the following nine steps:



1) Determine applicable receptors based on land reuse, which will come from discussions with the BCT, FORA and other appropriate groups.
2) Score the **Depth Below Ground Surface**, **Level of Intrusion**, and **Migration/Erosion Potential** for the sector based on sector conditions and receptor type from previous work and the RI Sampling and Analysis Plan.
3) Determine the **Accessibility Factor** given the scores for Depth Below Ground Surface, Level of Intrusion, and Migration/Erosion Potential.
4) Score the **OE Density**, **Intensity of Contact with Soil**, and **Frequency of Entry** based on the sector conditions, receptor type, and Level of Intrusion from previous work and the RI Sampling and Analysis Plan.
5) Determine the **Exposure Factor** given the OE Density, Intensity of Contact with Soil, and Frequency of Entry.
6) Have an UXO-Trained member determine the **OE Type**. This information will be based on weight of evidence from the RI findings.
7) Determine the **Overall OE Risk** for selected receptor given the Accessibility Factor, the Exposure Factor, and the OE Type.
8) Document all Assumptions to support the Overall OE Risk score in a narrative.
9) Include the Overall OE Risk score and the supporting narrative in the Feasibility Study for use in comparing remedial alternatives.

The following pages describe how to apply this Protocol to each receptor type for baseline, remedial alternatives, and post remedial action.

ACCESSIBILITY FACTOR: How likely is it that the OE items in the sector are accessible?

In order for someone to interact with an OE item, the item must be accessible. Some OE items are found on the surface, others underground. If the OE is on the surface, it is easier for a person to access and potentially be harmed than if it was buried.

To determine an individual's access to an OE item, the following questions need to be answered:

How deep is the OE item?	The answer to this question will determine the **Depth Below Ground Surface** as shown below in Table 5-1.
Will someone be digging in the area and if yes, how deep will they dig?	The answer to this question will determine the **Level of Intrusion** as shown below in Table 5-2.
Can erosion change the depth of the OE item below ground surface?	The answer to this question will determine the **Migration/Erosion Potential** as shown below in Table 5-3.

The information used to answer these questions can be found in the following documents:

- Archive Search Reports
- OE After Action Reports
- Historical Training Maps
- Field Sampling Reports
- The Fort Ord Base Reuse Plan
- Remedial Investigation Results
- Geophysical Data
- Exposure Factors Handbook
- Field Observations of land use, soil type, vegetation, and topography.

Once these three questions are answered, the Accessibility Factor is determined using Table 5-4.

Depth Below Ground Surface

As discussed in Section 3.0, the Depth Below Ground Surface input factor is key to a sector's hazard. To determine the Depth Below Ground Surface score, geophysical and removal data should be used. The maximum depth of OE items depends on the geometry of the item, the angle at which the item impacted the ground, and soil type. Therefore, it is important to understand that if OE sampling was adequate and no items were found from the surface down to a certain depth, then the probability of items being deeper is small.

When scoring Depth Below Ground Surface, the minimum depth of OE items should be used because the shallower an item is, the more likely it will be accessible.

The categories of OE depth and their associated scores are given in Table 5-1.

Table 5-1. Depth Below Ground Surface

Score	**Description** [a] [b] [c]
1	100% of detected OE removed considering data quality for the sector [d]
2	OE > 5 feet bgs
3	OE ≥ 4 feet bgs
4	OE ≥ 3 feet bgs
5	OE ≥ 2 feet bgs
6	OE ≥ 1 feet bgs
7	No OE on the surface and OE below surface
8	Any OE on surface

Notes:
[a] The shallowest OE item found determines the Depth Below Ground Surface for the sector.
[b] If significant uncertainty exists about the depth of the OE item, it may be appropriate to assign the next highest score.
[c] Depth should be based on actual field measurements of OE items found.
[d] Detection and removal procedures meeting the DQOs for the sector based on clearly defined investigational objectives including reuse and the detection of designated OE. If DQOs have not been established for the sector, the quality of data should be approved by the BCT to score a '1'.

A score of '1' for Depth Below Ground Surface is likely to occur in a sector when either (1) a removal action has been completed that meets the BCT's requirements for 100% of detected OE being removed, or (2) when considering remedial alternatives in the feasibility study.

Level of Intrusion

As discussed in Section 3.0, Intrusion Level of Activity should be based on information from the Fort Ord Reuse Plan or data from current activities in similar use areas. However, similar use areas may not necessarily have the same level of intrusion as the sector so all efforts should be made to identify a sector-specific Intrusion Level. In the absence of activity-specific information, information on receptor types (e.g., residents, construction workers, etc.) can be considered. A proposed table of receptor factors is provided in Appendix E. However, receptor data may not always provide a complete understanding of the Intrusion Level of the Activity.

The intrusion level categories and their associated scores are given in Table 5-2.

Table 5-2. Level of Intrusion

Score	Description [(a) (b)]
1	Non-Intrusive: Activity on the ground surface, none below the surface
2	Minor Intrusions: Activity on ground surface and ground disturbances to a depth of one foot bgs
3	Moderate Intrusions: Ground disturbances to a depth of two feet bgs
4	Significant Intrusions: Ground disturbances to a depth of four feet bgs
5	Highly Intrusive: Ground disturbances greater than four feet bgs

Notes:
[(a)] The deepest intrusion level expected for a given reuse determines the Intrusion Level of Activity for the sector.
[(b)] If significant uncertainty exists about the depth of intrusion, it may be appropriate to assign the next higher score.

Migration/Erosion Potential

As described in Section 3.0, the Migration/Erosion Potential input factor considers whether the depth of an OE item will change from soil movement in the sector and is evaluated based on vegetation, terrain, soil type, rainfall, and human activities using the Universal Soil Loss Equation (USLE) and the Wind Erosion Equation (WEQ) (7 CFR Part 610, 1996). The USLE predicts soil losses due to runoff and consists of rainfall and runoff, soil erodibility, slope-length, slope-steepness, cover and management, and support practice factors. WEQ predicts soil losses from wind erosion. These two equations and additional information about their applicability are provided in Appendix F.

In addition to these two methods, the presence of streams, gullies, steep slopes, and man-made roads or trails may indicate a higher potential for erosion and may require a more thorough investigation of the rainfall and soil movement in the sector to determine the appropriate category.

The Migration/Erosion Potential categories and their associated scores are given in Table 5-3.

Table 5-3. Migration/Erosion Potential

Score	Description [(a)]
1	Very Stable: OE will not migrate. Annual erosion is equal to or less than the site-wide average of 3/100 inches.
2	Minor Migration: Recurring and extreme natural events may cause OE to migrate upward, potentially reaching the intrusion level, over a long period of time (more than two five-year reviews). Annual erosion is greater than the average site-wide condition but less than one inch. [(b)]
3	Significant Migration: Recurring and extreme natural events will bring OE to the surface within the first recurring review. Annual erosion is more than one inch. [(c)]

Notes:

[(a)] The Migration/Erosion Factor should consider the potential for change in depth of an OE item due to erosion. The presence of human activities, streams, gullies, or steep slopes in a sector may require a more thorough investigation of the potential for erosion.

[(b)] Average annual site-wide erosion potential is 3/100 inches.

[(c)] Significant erosion at Fort Ord will likely be limited to areas disturbed by human activity, such as roads or firebreaks.

Accessibility Scoring Matrix

As discussed in Section 4.0, the qualitative scoring matrix for the Accessibility Factor is related to the Depth Below Ground Surface, the Intrusion Level of Activity, and the Migration/Erosion Potential factors. After determining the scores for these three factors, the Accessibility Factor is determined from Table 5-4.

To determine the Accessibility Factor score for a given sector:

1. Find the score for Depth Below Ground Surface in the left-most column.
2. Reading across, find the proper row for the Level of Intrusion based on depth.
3. The Accessibility Factor (1-5) is then determined from the appropriate Migration/ Erosion column for the chosen Intrusion Level of Activity row.

Figure 5-1 demonstrates how the Accessibility Factor score should be determined. For this example, Depth Below Ground Surface is scored as OE greater than five feet bgs ('2') and Level of Intrusion is scored as Highly Intrusive ('5'). If the Migration/Erosion Potential is Minor Migration ('2'), then the Accessibility Factor score would be a '3,' that is, the OE item may be accessible to individuals.

Figure 5-1. Using the Accessibility Factor Matrix

Depth Below Ground Surface	**Level of Intrusion**	**Migration/Erosion Potential**		
		1. Very Stable	**2. Minor Migration**	3. Significant Migration
1. 100% of detected OE removed considering data quality for the sector	1. Non-Intrusive (surface only)	1	1	1
	2. Minor Intrusion (≤1 foot bgs)	1	1	1
	3. Moderate Intrusion (≤2 feet bgs)	1	1	1
	4. Significant Intrusion (≤4 feet bgs)	1	1	1
	5. Highly Intrusive (>4 feet bgs)	1	1	1
2. OE > 5 feet bgs	1. Non-Intrusive (surface only)	1	1	1
	2. Minor Intrusion (≤1 foot bgs)	1	1	1
	3. Moderate Intrusion (≤2 feet bgs)	1	1	1
	4. Significant Intrusion (≤4 feet bgs)	1	2	3
	5. Highly Intrusive (>4 feet bgs)	3	**3**	4

Table 5-4. Accessibility Factor Scoring Matrix [a]

Depth Below Ground Surface	Level of Intrusion	Migration/Erosion Potential		
		1. Very Stable	2. Minor Migration	3. Significant Migration
1. 100% of detected OE removed considering data quality for the sector	1. Non-Intrusive (surface only)	1	1	1
	2. Minor Intrusion (≤1 foot bgs)	1	1	1
	3. Moderate Intrusion (≤2 feet bgs)	1	1	1
	4. Significant Intrusion (≤4 feet bgs)	1	1	1
	5. Highly Intrusive (>4 feet bgs)	1	1	1
2. OE > 5 feet bgs	1. Non-Intrusive (surface only)	1	1	1
	2. Minor Intrusion (≤1 foot bgs)	1	1	1
	3. Moderate Intrusion (≤2 feet bgs)	1	1	1
	4. Significant Intrusion (≤4 feet bgs)	1	2	3
	5. Highly Intrusive (>4 feet bgs)	3	3	4
3. OE ≥ 4 feet bgs	1. Non-Intrusive (surface only)	1	1	1
	2. Minor Intrusion (≤1 foot bgs)	1	1	1
	3. Moderate Intrusion (≤2 feet bgs)	1	1	2
	4. Significant Intrusion (≤4 feet bgs)	3	3	4
	5. Highly Intrusive (>4 feet bgs)	5	5	5
4. OE ≥ 3 feet bgs	1. Non-Intrusive (surface only)	1	1	1
	2. Minor Intrusion (≤1 foot bgs)	1	1	2
	3. Moderate Intrusion (≤2 feet bgs)	1	2	3
	4. Significant Intrusion (≤4 feet bgs)	5	5	5
	5. Highly Intrusive (>4 feet bgs)	5	5	5
5. OE ≥ 2 feet bgs	1. Non-Intrusive (surface only)	1	1	3
	2. Minor Intrusion (≤1 foot bgs)	1	2	3
	3. Moderate Intrusion (≤2 feet bgs)	3	3	4
	4. Significant Intrusion (≤4 feet bgs)	5	5	5
	5. Highly Intrusive (>4 feet bgs)	5	5	5
6. OE ≥ 1 foot bgs	1. Non-Intrusive (surface only)	1	2	3
	2. Minor Intrusion (≤1 foot bgs)	3	3	4
	3. Moderate Intrusion (≤2 feet bgs)	5	5	5
	4. Significant Intrusion (≤4 feet bgs)	5	5	5
	5. Highly Intrusive (>4 feet bgs)	5	5	5
7. No OE on the surface and OE below surface	1. Non-Intrusive (surface only)	4	5	5
	2. Minor Intrusion (≤1 foot bgs)	5	5	5
	3. Moderate Intrusion (≤2 feet bgs)	5	5	5
	4. Significant Intrusion (≤4 feet bgs)	5	5	5
	5. Highly Intrusive (>4 feet bgs)	5	5	5
8. Any OE on the surface	1. Non-Intrusive (surface only)	5	5	5
	2. Minor Intrusion (≤1 foot bgs)	5	5	5
	3. Moderate Intrusion (≤2 feet bgs)	5	5	5
	4. Significant Intrusion (≤4 feet bgs)	5	5	5
	5. Highly Intrusive (>4 feet bgs)	5	5	5

Notes:(a) Accessibility Factor scores are defined as:

1. Least Potential for Accessibility
2. Not Likely to be Accessible
3. May Be Accessible
4. Likely to be Accessible
5. Greatest Potential for Accessibility

EXPOSURE FACTOR: How likely is it that someone will be exposed to the OE item, if they are in the sector?

If a person enters a sector with many OE items they have a greater chance of finding an OE item than if they enter another sector with fewer OE items. Similarly, if someone spends a long time in a sector with OE or frequently enters the sector, they are more likely to come across an OE item.

To answer this second question and determine a receptor's potential exposure to an OE item in a given sector, the following questions need to be answered:

How many OE items are present in the sector?	The answer to this question will determine the **OE Density** as shown below in Table 5-5.
How often will someone go to the areas where OE items may be present?	The answer to this question will determine the **Frequency of Entry** as shown below in Table 5-6.
When in the sector, how long will a person spend in direct contact with the ground surface?	The answer to this question will determine the **Intensity of Contact with Soil** as shown below in Table 5-7.

The information used to answer these questions can be found in the following documents:

- Archive Search Reports
- OE After Action Reports
- Historical Training Maps
- Field Sampling Reports
- The Fort Ord Base Reuse Plan
- Remedial Investigation Results
- Geophysical Data
- Field Observations of land use, soil type, vegetation, and topography.

Once these three questions are answered, the Exposure Factor is determined using Table 5-8.

OE Density

As described in Section 3.0, the OE Density factor is based on ordnance and explosive items within the Level of Intrusion as defined in Table 5-2. OE scrap does not pose an OE risk as it is defined for this analysis; therefore, OE scrap should not be used to calculate OE Density. However, the risk assessment team will consider the weight of evidence provided by the RI data, including information on the presence of OE scrap and anomalous items to determine the quality of the data and choose the appropriate OE Density score. When available, actual field measurements should be used to determine OE Density in an area.

OE items of concern are those potentially accessible; therefore, OE Density should be determined based on the area of the sector and the Level of Intrusion expected for the given receptor type.

The categories of OE Density and their associated scores are given in Table 5-5.

Table 5-5. OE Density

Score	Description [a] [b] [c]
1	100% of detected OE removed to Level of Intrusion[d]
2	Low OE Density (< 0.1 items per acre) [e]
3	Medium OE Density (0.1 to 1 item per acre)
4	High OE Density (> 1 item per acre)

<u>Notes:</u>

[a] OE density depends on actual OE items in the Level of Intrusion from Table 5-2. OE scrap should not be considered.

[b] If significant uncertainty exists about OE density, it may be appropriate to assign the next higher score.

[c] Density should be based on actual field measurements of OE items.

[d] Detection and removal procedures meeting the DQOs for the sector based on clearly defined investigational objectives including reuse and the detection of designated OE. If DQOs have not been established for the sector, the quality of data should be approved by the BCT to score a '1.'

[e] As available, the measurement of number of items per acre should be determined from the aerial extent of the sector and the Level of Intrusion.

A score of '1' for OE Density is likely to occur in a sector when either (1) a removal action has been completed for the sector that meets the BCT's requirements for 100% of detected OE being removed, or (2) when considering remedial alternatives in the feasibility study.

Intensity of Contact with Soil

As discussed in Section 3.0, this factor should be based on information from the Fort Ord Reuse Plan or on data from activities in similar reuse areas. These areas may not necessarily have the same soil contact intensity as the sector of interest; so all efforts should be made to develop a sector-specific score. In the absence of activity-specific information, information on receptor types (e.g., residents, construction workers, etc.) can be considered. In the absence of both sector-specific and activity-specific data, a proposed table of receptor factors is provided in Appendix E. However, receptor data may not always provide a complete understanding of the soil contact intensity.

The categories for this factor and their associated scores are given in Table 5-6.

Table 5-6. Intensity of Contact with Soil

Score	Description [a] [b]
1	Very Low: $\leq$ 1 hours/day
2	Low: $\leq$ 3 hours/day
3	Moderate: $\leq$ 6 hours/day
4	High: $\leq$ 9 hours/day
5	Very High: > 9 hours/day

Notes:
[a] Activities involving direct contact with soil should be considered in this category. Direct contact with soil can range from walking on the soil to digging in the soil.
[b] If significant uncertainty exists, in the intensity of contact with soil, it may be appropriate to assign the next higher score.

Frequency of Entry

As discussed in Section 3.0, this factor should be based on information from the Fort Ord Reuse Plan or on data from activities in similar reuse areas. These areas may not necessarily have the same entry frequency as the sector of interest; so all efforts should be made to develop a sector-specific score. In the absence of activity-specific information, information on receptor types (e.g., residents, construction workers, etc.) can be considered. A proposed table of receptor factors is provided in Appendix E. However, receptor data may not always provide a complete understanding of entry frequency.

The categories of the frequency of entry and their associated scores are given in Table 5-7.

Table 5-7. Frequency of Entry

Score	Description [a] [b]
1	Rare: Is not likely to occur (less than once per year to once per year)
2	Infrequent: Will seldom occur (less than once per season to once per month)
3	Occasional: Will likely occur from time to time (more than once per month)
4	Frequent: Will occur frequently (once a week to more than once a week)

Notes:
[a] UXO-trained professionals and others covered by OE-specific health and safety plans should not be considered in the Frequency of Entry categories.
[b] Depending on the areas included in a sector, sectors may have different entry frequencies for the same activity.

Frequency of Entry is a way to consider the number of people entering a sector. As the OE risk is an acute hazard, an entry is based on person-days per year. For example, entry frequency would be the same if one person visited the sector once a month in one year or if 12 people visited the sector for one day during a year, that is, Frequency of Entry would be scored as Infrequent (‘2’).

Exposure Scoring Matrix

As discussed in Section 4.0, the qualitative scoring matrix for Exposure Factor is derived from Table 5-8.

To determine the Exposure Factor score for a given sector:

1. the score for Frequency of Entry is found in the left-most column;
2. reading across, the row for the OE Density score is found for the chosen frequency; and
3. the Exposure Factor is determined from the appropriate Intensity-of Contact with Soil column for the chosen OE Density row.

Figure 5-2 demonstrates how the Exposure Factor is determined. For this example, Frequency of Entry is scored as Infrequent ('2') and the OE Density is scored as Medium ('3'). If the Intensity of Contact with Soil is Moderate ('3'), then the Exposure Factor score would be a '3,' that is, an individual may be exposed to OE in the sector.

Figure 5-2. Using the Exposure Factor Matrix

Frequency of Entry	OE Density	Intensity of Contact with Soil				
		1. Very Low: ≤ 1 hours/day	2. Low: ≤ 3 hours/day	**3. Moderate: ≤ 6 hours/day**	4. High: ≤ 9 hours/day	5. Very High: > 9 hours/day
1. Rare	1. 100% of detected OE removed to intrusion depth	1	1	1	1	1
	2. Low OE Density	1	2	2	3	3
	3. Medium OE Density	2	3	3	3	3
	4. High OE Density	3	3	3	4	4
2. Infrequent	1. 100% of detected OE removed to intrusion depth	1	1	1	1	1
	2. Low OE Density	1	2	2	3	3
	3. Medium OE Density	2	3	**3**	4	4
	4. High OE Density	3	3	4	4	4

Table 5-8. Exposure Factor Scoring Matrix [(a)]

Frequency of Entry	OE Density	Intensity of Contact with Soil				
		1. Very Low: ≤ 1 hours/day	2. Low: ≤ 3 hours/day	3. Moderate: ≤ 6 hours/day	4. High: ≤ 9 hours/day	5. Very High: > 9 hours/day
1. Rare	1. 100% of detected OE removed to intrusion depth	1	1	1	1	1
	2. Low OE Density	1	2	2	3	3
	3. Medium OE Density	2	3	3	3	3
	4. High OE Density	3	3	3	4	4
2. Infrequent	1. 100% of detected OE removed to intrusion depth	1	1	1	1	1
	2. Low OE Density	1	2	2	3	3
	3. Medium OE Density	2	3	3	4	4
	4. High OE Density	3	3	4	4	4
3. Occasional	1. 100% of detected OE removed to intrusion depth	1	1	1	1	1
	2. Low OE Density	2	2	3	3	3
	3. Medium OE Density	3	3	4	4	4
	4. High OE Density	3	4	5	5	5
4. Frequent	1. 100% of detected OE removed to intrusion depth	1	1	1	1	1
	2. Low OE Density	2	2	3	4	4
	3. Medium OE Density	3	4	4	5	5
	4. High OE Density	4	5	5	5	5

Notes:
(a) Exposure Factor scores are defined as:
1. Least Potential for Exposure
2. Not Likely to be Exposed
3. May be Exposed
4. Likely to be Exposed
5. Greatest Potential for Exposure

OVERALL HAZARD: How hazardous is the OE item itself?

As discussed in Section 3.0, OE items at Fort Ord range from small grenades to bombs or flares. Some of the items are just pieces of metal (scrap) that will not explode and others contain explosives that could cause serious injury.

To determine the Overall Hazard of the expected types of OE items, the Project Team reviewed historical reports and removal data for all OE items found to date at Fort Ord.

The OE Hazard Classification Factor depends on the OE type as determined from Appendix C. Appendix C must ***only*** be used by ***UXO-TRAINED PERSONNEL*** to determine the OE Type; however, it is included for completeness but is not intended for use by un-trained personnel.

Also provided in Appendix C are standard operating procedures for classifying any additional OE items found during the investigation.

The qualitative categories for OE Hazard Classification and their associated scores are given in Table 5-9.

Table 5-9. OE Hazard Classification

Score	Description [a]
0	Inert OE, will cause no injury [b]
1	OE that will cause an injury [c], or in extreme cases could cause major injury or death, to an individual if functioned by an individual's activities
2	OE that will cause major injury [d], or in extreme cases could cause death, to an individual if functioned by an individual's activities
3	OE that will kill an individual if detonated by an individual's activities

Notes:
[a] OE Type must only be determined by **UXO-TRAINED PERSONNEL**.
[b] Inert describes the condition of a munition, or component thereof, which contains no explosive, pyrotechnic, or chemical agent.
[c] An injury is defined as a flesh wound or a minor burn.
[c] A major injury is defined as the loss of sight, hearing, or limb, or a major burn.

OVERALL OE RISK: How do the accessibility of the OE item, the likelihood of exposure, and the level of hazard combine to yield an OE Risk at the sector?

As described in Section 4.0, OE Risk on a sector is defined in terms of the potential for accessibility, exposure, and the OE hazard classification. The qualitative scoring matrix for Overall OE Risk is given in Table 5-10. To determine Overall OE Risk for a given sector, the score for OE Type from Table 5-9, the Accessibility Factor score from Table 5-4, and the appropriate Exposure Factor category from Table 5-8 are used as follows:

1. the score for OE Type is found in the left-most column;
2. reading across, the row for the Accessibility Factor score is found for the chosen OE Type; and
3. the Overall OE Risk score is then determined from the appropriate Exposure Factor column for the chosen Accessibility Factor row.

Figure 5-3 demonstrates how the Overall OE Risk score is determined. For this example, assume the OE Type is scored as OE that will cause an injury ('1'). Using the Accessibility Factor score ('3') and Exposure Factor score ('3') from the previous examples, the Overall OE Risk score would be a 'B,' that is, the sector has low OE risk.

Figure 5-3. Using the Overall OE Risk Matrix

		Exposure				
OE Type	**Accessibility**	1. Least Potential for Exposure	2. Not Likely to be Exposed	**3. May Be Exposed**	4. Likely to be Exposed	5. Greatest Potential for Exposure
0. Inert OE	1. Least Potential for Accessibility	A	A	A	A	A
	2. Not Likely to be Accessible	A	A	A	A	A
	3. May Be Accessible	A	A	A	A	A
	4. Likely to be Accessible	A	A	A	A	A
	5. Greatest Potential for Accessibility	A	A	A	A	A
1. OE that will cause an injury	1. Least Potential for Accessibility	A	A	A	B	B
	2. Not Likely to be Accessible	A	B	B	B	B
	3. May Be Accessible	A	B	**B**	C	C
	4. Likely to be Accessible	B	B	C	D	D
	5. Greatest Potential for Accessibility	B	C	D	D	D

Table 5-10. Overall OE Risk Scoring Matrix [a]

OE Type	Accessibility	Exposure: 1. Least Potential for Exposure	Exposure: 2. Not Likely to be Exposed	Exposure: 3. May Be Exposed	Exposure: 4. Likely to be Exposed	Exposure: 5. Greatest Potential for Exposure
0. Inert OE	1. Least Potential for Accessibility	A	A	A	A	A
	2. Not Likely to be Accessible	A	A	A	A	A
	3. May Be Accessible	A	A	A	A	A
	4. Likely to be Accessible	A	A	A	A	A
	5. Greatest Potential for Accessibility	A	A	A	A	A
1. OE that will cause an injury	1. Least Potential for Accessibility	A	A	A	B	B
	2. Not Likely to be Accessible	A	B	B	B	B
	3. May Be Accessible	A	B	B	C	C
	4. Likely to be Accessible	B	B	C	D	D
	5. Greatest Potential for Accessibility	B	C	D	D	D
2. OE that will cause a major injury	1. Least Potential for Accessibility	A	A	B	B	B
	2. Not Likely to be Accessible	A	B	B	C	C
	3. May Be Accessible	A	B	C	D	D
	4. Likely to be Accessible	B	C	D	D	E
	5. Greatest Potential for Accessibility	B	C	D	E	E
3. OE that will kill	1. Least Potential for Accessibility	A	B	B	C	C
	2. Not Likely to be Accessible	B	B	C	D	D
	3. May Be Accessible	B	C	D	E	E
	4. Likely to be Accessible	C	C	D	E	E
	5. Greatest Potential for Accessibility	C	D	E	E	E

Notes: (a) Overall OE Risk scores are defined as:
A. Lowest Risk
B. Low Risk
C. Medium Risk
D. High Risk
E. Highest Risk

The Fort Ord OE Risk Assessment Protocol is not designed to assess absolute risk. Rather, the Overall OE Risk score is used to compare the relative risks among remedial alternatives on an OE-impacted sector at Fort Ord. This score should not be compared to risks from other OE-impacted facilities, because the Protocol was developed using site-specific categories.

Overall OE Risk Score Narrative

A complete narrative should be provided which explains the assumptions used to determine the Overall OE Risk Score. The Project Team recognized that the risk score itself and an explanation of the meaning of the risk score with assumptions are equally important.

Each explanation should describe the information to support the Overall OE Risk score and any assumptions made when determining the score. The following outline should be used as a minimum requirement for the qualitative discussion of the overall explosive safety risk score.

1) Explanation of Score
   a) Sector Status
      i) Baseline vs. Post Remediation
      ii) Planned Reuse
   b) Definition of Score (lowest risk to highest risk)
   c) Type of Expected Receptor
2) Explanation of Input Factors
   a) Accessibility
      i) OE Depth
      ii) Level of Intrusion and Type of Intrusion
      iii) Migration/Erosion Potential
   b) Exposure
      i) Frequency of Entry
      ii) Intensity of Contact with Soil
      iii) OE Density
   c) Overall Hazard
      i) OE Type
3) Data Quality/Uncertainty Discussion
   a) Basis of Data Used
   b) Quality of Data Used
   c) Proposed Land Use

The following paragraph is given as an example of the qualitative narrative. The italicized parenthetical text contains choices for filling in the provided blanks:

"The ____ (*baseline / post-remediation*) Overall OE Risk Score for Sector XYZ is __ (*A / B/ C / D / E*) meaning it has a _____ (*lowest / low / medium / high / highest*) potential of posing a risk to the public. The proposed land use of this sector is _________ (*e.g., residential, commercial*) and the receptor type used to determine this score is ______ (*e.g., resident, commercial worker*). This score was determined by considering the accessibility of the sector, the potential for exposure at the sector, and the overall hazard of the OE type in the sector. OE on Sector XYZ ___ (*is / is not*) currently accessible because the depth of the OE items is ______ (*e.g., greater than 5 feet below ground surface*) and the level of intrusion is ______ (*e.g., only between 0 and 1 foot below ground surface*) using ______ (*e.g., mechanical or non-mechanical means*). Sector XYZ is on _____ (*e.g., flat, steeply sloping*) terrain and erosion _____ (*is / is not*) expected to significantly affected the sector. The Frequency of Entry is ___ (*rare / infrequent / occasional / frequent*) and the Intensity of Contact with Soil is ____ (*very low / low / medium / high / very high*); therefore, the potential exposure to Sector XYZ is ____ (*lowest / not likely / may be likely / likely / highest*) because of the expected OE density within the Level of Intrusion is _______ (*e.g., high*). The OE density below the Level of Intrusion may be higher or lower than the reported density. The types of OE expected in Sector XYZ are _____ (*e.g., anti-tank practice mines*), which could ____ (*e.g., cause an injury to, in extreme cases could cause a major injury to or kill, an individual if functioned by an individual's activities*). All items identified at Fort Ord are assumed to be fuzed (if not inert) and portable. The data used in this analysis (*was / was not*) consistent with the Data Quality Objectives established for the investigation. This Overall OE Risk score is for Sector XYZ to be reused as _____ (*e.g., residential*) and the proposed receptors are _____ (*e.g., construction workers, residents*). If the land use for the site differs from this proposed land use, the OE Risk Assessment must be reevaluated to ensure the scoring of the input factors and the Overall OE Risk score has not been altered."

Table 5-11 shows how a similar description could be given in a tabular format. Again, italicized parenthetical text contain choices for filling in the provided blanks:

Table 5-11. Narrative Explanation of Overall OE Risk in Tabular Format

Sector	XYZ		
Proposed Property Reuse			
Receptor Type			
OE Risk Score	____	*Accessibility*	• Sector _____ *(is / is not)* currently accessible because the depth of the OE items is ______ *(e.g., greater than 5 feet below ground surface)* and the level of intrusion is ______ *(e.g., only between 0 and 1 foot below ground surface)* using ___ *(e.g., a shovel)*. • On _____ *(e.g., flat, steeply sloping)* terrain and _____ *(is / is not)* expected to be significantly effected by erosion
		Exposure	The Frequency of Entry is ___ *(rare / infrequent / occasional / frequent)* and the Intensity of Contact with Soil is ____ *(very low / low / medium / high / very high)*; therefore, the potential exposure to Sector XYZ is ____ *(lowest / not likely / may be likely / likely / highest)* because of the expected OE density is ______ *(e.g., high)*.
		OE Type	The types of OE expected in Sector XYZ are _____ *(e.g., anti-tank practice mines)*, which could ____ *(e.g., cause an injury to, in extreme cases could cause a major injury to or kill, an individual if functioned by an individual's activities)*. All items identified at Fort Ord are assumed to be fuzed (if not inert) and portable.
		Data Quality	The data used in this analysis was consistent with the Data Quality Objectives established for the investigation.

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