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DEVELOPMENT OF INTEGRATED CONCEPTUAL SITE MODELS FOR ENVIRONMENTAL AND ORDNANCE AND EXPLOSIVES (OE) SITES

WORKING REVIEW DRAFT

This document is a working draft and for discussion purposes only. It does not represent official CoE, Army or DoD Policy.

PLEASE NOTE: Based on pending Department of Defense guidance, the terms ordnance and OE will be replaced by munitions response and MEC (munitions and explosives of concern) in future versions of this document.

ENGINEER PAMPHLET

Distribution Statement

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Series Title
DEVELOPMENT OF INTEGRATED CONCEPTUAL SITE MODELS FOR ENVIRONMENTAL AND ORDNANCE AND EXPLOSIVES (OE) SITES

1. Purpose. This pamphlet provides U.S. Army Corps of Engineers (USACE) and other personnel with procedural guidance to develop Conceptual Site Models (CSM) at sites potentially containing environmental contamination or ordnance and explosives (OE) hazards. The CSM will provide a planning tool to integrate site information from a variety of sources, evaluate the information with respect to project objectives and data needs, and respond through an iterative process for further data collection or action. The target audience is the project delivery team involved in decision-making for the site.

2. Applicability. This pamphlet applies to all Headquarters, U.S. Army Corps of Engineers (HQUSACE) elements, USACE Major Subordinate Commands, USACE geographic districts, and field operating activities having responsibilities for civil works and/or military programs with environmental and OE-related issues. This guidance is provided to assist any organization or PDT involved in evaluation and decision-making at a site. The CSM development process in this pamphlet is applicable to any phase of a project, including investigation, design, remediation, construction, operation, and maintenance phases.

3. Distribution Statement. *Statement Pending*

4. References. Required related references are at Appendix A.

FOR THE COMMANDER:

4 Appendices
(See Table of Contents)

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Chapter 1
Introduction

1-1. Purpose of the Guide. This pamphlet provides U.S. Army Corps of Engineers (USACE) and other personnel with procedural guidance to develop Conceptual Site Models (CSM) at sites potentially containing environmental contamination or ordnance and explosives (OE) hazards. The CSM will provide a planning tool to integrate site information from a variety of sources, evaluate the information with respect to project objectives and data needs, and respond through an iterative process for further data collection or action. The target audience is the Project Delivery Team (PDT) involved in decision-making for the site.

a. A primary objective of this guide is to bring synergy to the OE and environmental programs at a site. There are numerous closing and formerly used military sites in this country that have both OE and environmental chemical issues. These issues have typically been addressed through separate programs within USACE, with one program focusing exclusively on OE hazards and another on Hazardous, Toxic, and Radiological Waste (HTRW) contamination. A common goal for each program, however, is to achieve site closeout in a safe, environmentally responsible, and economical manner. It is critical for both programs to coordinate efforts to obtain this goal. The USACE district Project Manager must ensure that site data collection supports both programs and is utilized in the most efficient manner. Sites are commonly addressed in a sequential fashion beginning with OE hazards before focusing on environmental contamination. Rarely are both programs implemented at the same site at the same time, mostly due to differing priorities for hazards and budgets. However, knowing the distribution of OE at a site and any recorded observations of spills, stains, or buried waste can be a critical first layer of data to build an environmental CSM. Development of an OE CSM should assist the PDT in designing the environmental data collection and removal activities, resulting in more efficient use of resources in both programs and faster closeout at sites. Additional benefits include better understanding and appreciation of the coordinated process from regulatory personnel and other stakeholders.

> Environmental and OE issues at a site are typically addressed under separate programs within the USACE organization. Development of guidance for an integrated CSM will facilitate communication and sharing of data between programs, resulting in faster closeouts and less duplication of effort.

b. This guidance should be used together with existing USACE guidance for project execution. Development of a CSM is an integral component of planning and data collection activities described in the USACE Technical Project Planning (TPP) Process (EM 200-1-2). The TPP Process provides a framework for identifying the site information and project objectives, determining data needs to meet those objectives, evaluating the options for data collection, and finalizing the data collection program for optimum results. The TPP Process is equivalent to the Systematic Planning Process recommended by the U.S. Environmental Protection Agency. A systematic planning process encourages the PDT to determine data gaps and to ensure data collected are appropriate for the objectives of the investigation. This prompts the PDT to consider the end use of data before it is collected, resulting in more efficient and cost-effective investigation, cleanup, and monitoring.

c. CSM guidance is also consistent with USACE guidance publications ER 1110-1-263, Chemical Data Quality Management for Hazardous Waste Remedial Activities, and with EP 1110-1-18, Ordnance and Explosives Response. The CSM provides a visualization tool for planning data acquisition activities or response actions at a site, and documents the current status of a site following sampling or response. Users are urged to review these existing guidance documents to determine the applicable integration of CSM guidance.

1-2. Scope of this Guide. The CSM development process in this pamphlet is applicable to any phase of a project, including investigation, design, remediation, and construction phases and during operation/maintenance with recurring review, and may be applied under any regulatory framework. This guidance addresses environmental and OE-related issues at closing, non-operational, or former used defense sites. The specific focus of this guidance for OE sites is directed at conventional ordnance. While certain aspects of CSM development are also applicable to non-stockpile chemical warfare materiel (CWM) or non-conventional (i.e., nuclear or biological) issues, the user should be aware of hazards, responses, and processes specific to these issues that may govern the application of this guide.

1-3. How to Use this Guide. This guide is intended to provide the user with basic information necessary to develop or review a conceptual model at a site. The objectives of each chapter and appendix are listed below:

Chapter 1:	Introduce the guide, including purpose, scope, and use.
Chapter 2:	Provide background information on CSMs, including the definition, components, presentation, steps in development, and PDT responsible for development.
Chapter 3:	Describe environmental CSM development from source, pathway, and receptor network analysis.
Chapter 4:	Describe OE CSM development from source, pathway, and receptor network analysis.
Chapter 5:	Describe integrated CSM development.
Appendix A:	Glossary of Terms
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Appendix C:	Example OE Profiles
Appendix D:	Example of an Integrated CSM

Chapter 2
Description of a Conceptual Site Model

2-1. Introduction. This chapter presents an overview of what a CSM is and how it may be used, how it is depicted, when CSM development begins, and who is involved in the development process. It also discusses the refinement and iterative nature of the CSM process.

2-2. Conceptual Site Model Defined. The CSM is a description of a site and its environment that is based on existing knowledge. The CSM describes sources of environmental contaminants or OE hazards at a site, actual or potential pathways, current or proposed use of property, and potential receptors to contaminants or hazards. The source-pathway-receptor relationship is a descriptive output of a CSM. The CSM serves as a planning instrument, a modeling and data interpretation aid, and a communication device among the PDT, the decision-makers, and the stakeholders. The CSM can be viewed as a tool to assist PDTs with integration of information and decisions. Data are not collected simply to create a CSM, but instead the CSM provides a standard means to summarize and display what is known about the site, and identifying what additional information must be known to develop defensible data quality objectives objectives.

> The CSM is a description of a site and its environment that is based on existing knowledge. It describes sources, pathways, and receptors, and it assists the project delivery team, decision-makers, and stakeholders in their planning, data interpretation, and communication. The CSM is an iterative tool that changes over time to help focus objectives throughout the life of the project.

a. The CSM is an iterative tool that evolves as site work progresses and data gaps are filled. Although there are no rules for how many iterations of a CSM are required, typical refinements (following the initial model) are appropriate after implementation of any characterization phase, removal or stabilization measures, or site closeout. CSM development is best viewed as a process that is used throughout the duration of project activities, from initial characterization to response action and recurring review to project closeout. The initial CSM may be used to identify potential OE use areas, source areas, and media of concern. Later iterations of the CSM may be used to evaluate effectiveness of sampling or focus design efforts. Analysis of the CSM can help focus general regulatory objectives to more site-specific project objectives.

> CSM development is best viewed as a *process* that reflects the progress of activities at a site from initial assessment through site closeout.

2-3. Conceptual Site Model Team Composition. The size of the PDT will vary with the complexity of the site and contaminants present. In general, the team should consist of a complementary mix of government and contractor technical members, regulatory personnel, and affected stakeholders. An effort should be made early in the process to identify special challenges or interests that require input from specific disciplines or groups. These personnel represent various planning perspectives, including decision-makers, data users, and data implementers.

a. One aspect of developing a CSM for a site potentially having both environmental contamination and OE hazards is the importance of early and ongoing coordination between technical experts on the PDT. Each group will have a set of data needs to meet specific requirements, and these data needs may contain differences and overlaps due to the perspective of the user. The data needed to evaluate potential risk at an environmental site include impacts to human health and the environment associated with site conditions, site investigations, and site remediation. The data needed to evaluate risk at an OE site focus more on current and future impact to public safety and present and future human use of the site. By coordinating the needs of all data users, the sampling or characterization program can focus on data collection that satisfies multiple requirements.

2-4. Information Needed for a CSM. An effective CSM will present what is currently known or suspected at a site, at a particular point in time, about the sources, pathways, and potential receptors. Depending on the complexity of the investigation, typical information needs include:

- Facility Profile that describes all man-made features at or near the site;
- Physical Profile to describe factors that may affect release, fate and transport, and potential receptors;
- Release Profile to describe the extent of contaminants or hazards in the environment;
- Land Use and Exposure Profile to provide information used to identify and evaluate the applicable exposure scenarios and receptor locations; and
- Ecological Profile to describe the physical relationship between developed and undeveloped portions of the site, use of the undeveloped portion, and ecological receptors in those areas.

Profile information may be collected from a variety of sources. The PDT should review all relevant historical and current documentation, conduct interviews, and perform a site visit as needed to gather profile information. Typical information associated with each profile is presented in Table 2-1. These information needs are presented only as guidance. Keep in mind that other information may be relevant to specific sites.

a. Historical and current information can be obtained from maps, aerial photographs, operational records, and previous reports. The quality of the information must be evaluated before use in the CSM.

b. Local government offices are a source of documents and records for many facilities. If the facility had a point source discharge outfall, this likely operated under permit with the local regulatory agency and periodic monitoring data may be available. Construction permits can also indicate process changes over time. Local law enforcement or emergency response personnel are often called to respond to OE items found outside installation boundaries.

Profile Type	**Typical Information Needs**
Facility Profile	• All structures, sewer systems, process lines, firing points, underground utilities, boundaries and fencing, etc. • Current and historical process areas • Ordnance activity areas • Any waste disposal or potential source areas from routine and systematic release of hazardous constituents • Historical features that indicate potential release areas (i.e., landfills or lagoons, ground scars, impact craters)
Physical Profile	• Topographic and vegetative features • Surface water features and drainage pathways • Surface geology, including soil type and properties • Meteorological data • Geophysical data • Hydrogeologic data for depth to groundwater and aquifer characteristics • Soil boring or monitor well logs and locations
Release Profile	• Identification of source material • Contaminants of concern from source material • Impact of chemical mixtures and co-located waste on transport mechanisms • Locations and delineation of confirmed releases with sampling locations • Migration routes and mechanisms • Modeling results
Land Use and Exposure Profile	• Land use on and near the facility (residential, agricultural, industrial, public forest, single- or multi-family homes, etc.) • Beneficial resource determination (aquifer classification, natural resources, wetlands, cultural resources, etc.) • Resource use locations (water supply wells, recreational swimming, boating, or fishing areas, hiking trails, grazing lands, historic burial grounds, etc.) • Subpopulation types and locations (schools, hospitals, day care centers, site workers, etc.) • Applicable exposure pathway scenarios (residential well water use, ingestion of fish, agricultural crop consumption, excavation of OE items, etc.)
Ecological Profile	• Description of the undeveloped property at the facility, including habitat type (wetland, forested, desert, pond, etc.) • Primary use of the undeveloped property and degree of disturbance, if any • Identification of any ecological receptors in relation to habitat type (endangered or threatened species, migratory animals, fish, etc.) • Relationship of any releases to potential habitat areas (locations, contaminants or hazards of concern, sampling data, migration pathways, etc.)

Table 2-1. Typical CSM Information Needs

c. A site visit provides critical information on the location, layout, and physical characteristics of the site. Adjacent land use may be verified through observation at the site.

2-5. Steps in Development of a CSM. The CSM is developed through analysis of the available profile information collected by the PDT. Most existing guidance (e.g., American Society for Testing and Materials (ASTM), 1995 or EPA, 1986) typically focuses on development of a risk exposure networks as the CSM. A risk model is often needed during characterization to both guide data collection activities and to inform stakeholders of the site conditions. The steps in development of a risk model, while appropriate to environmental sites, do not always readily apply to OE sites. However, there are similar activities in current guidance that may be applied to assessing risk at both environmental and OE sites, namely:

(1) Identify the types and locations of known or suspected **sources** of environmental contaminants or OE hazards, and the expected concentrations or these,
(2) Identify **pathways** for release, migration, or potential exposure to the contaminants or hazards, and
(3) Identify **receptors**, both human and ecological, and the exposure route by which receptors may contact the contaminant or hazard.

a. Source-pathway-receptor relationships may differ between environmental and OE sites but the process for developing these networks remains the same. The development of source-pathway-receptor relationships is a primary goal of the risk exposure CSM process and must be performed during characterization phase for all projects. This is where the PDT links all cumulative knowledge of contaminants or hazards and sources, pathways, and receptors to evaluate potential for risk at a site. From this evaluation, the PDT will determine what response actions or data, if any, are still needed.

Risk from an OE site differs from that usually found at an HTRW site. Environmental contaminants generally present a threat to human health and the environment through repeated and accumulated exposures to **contaminants** above acceptable exposure limits. OE sites present a **hazard** of physical injury from explosion resulting from accidental or unintentional detonation.

b. Data collection or response actions are focused on complete or potentially complete relationships that represent actual risks. Only those data that support gaps in the current model or contribute to understanding of future networks should be collected. Several iterations of development-data collection/assessment-development may occur before the CSM satisfies all data user needs. However, continued focus will speed the process and ensure the most economic path is taken. Complete exposure networks usually indicate the need for further investigation at a site and should receive priority for project resources over incomplete or improbable networks.

2-6. Initial CSM Development. An initial CSM is an integral component of the Technical Project Planning guidance of EM 200-1-2. In the first stage of this process, a project delivery team is established. The PDT should consist of technical experts from multidisciplinary backgrounds. A team information package, prepared from existing site information, is analyzed to develop working hypotheses for the site. The team uses this information to identity a site approach used to define project objectives.

a. The PDT integrates available information to develop a CSM. The PDT, using logic, experience, and available data uses the CSM to illustrate how the site conditions function as a system. As more data are generated, the understanding of the system becomes more refined. This understanding allows greater focus for subsequent investigations or for design and cleanup activities. The importance of early involvement of project team members and recognition of the long-term project goals is emphasized during the development process.

b. Even if a CSM was not developed at project inception, it is advantageous to develop one at a later phase. The planning team should summarize all available information and compare this to the objectives for the next phase of the project. The benefits to focusing the data collection or design decision will still be realized if all system inputs and outputs are considered. An example of this would be if OE were discovered during investigation of an environmental site. Although not considered during the initial phase of the investigation, an OE component to the CSM should now be developed, along with a review or revision to the objectives for the project if warranted.

2-7. Representation of the CSM. The CSM can vary in content and complexity depending on available or needed information. A simple diagram may depict a CSM for simple sites. However, a CSM for most sites is more complex and typically documented by written narrative and supported by maps, cross-sections, pictorial network diagrams, or other graphics to form the entire model. On environmental sites, the risk exposure CSM focuses on contaminant sources, pathways through environmental media, and exposure to receptors. A CSM for an OE site is structured in a similar manner, yet differences exist in the hazards and the potential exposure mechanisms. Whatever format is chosen to depict the model, all risk exposure CSMs should provide an accurate representation of the source-pathway-receptor networks present at the site. These networks show the relationships between contaminants or hazards at a site and how these may affect humans or ecological organisms, and are an important component of any CSM.

a. Narrative Description. This format includes a written description of the CSM with supporting photographs, maps, figures, and tables. Detail will vary with complexity and available information of the site. Narrative descriptions should attempt to include all components of the CSM listed previously, but at a minimum shall include a summary of information on sources, pathways, and receptors.

b. Pictorial Description. A pictorial CSM is shown in Figure 2-1. This illustration, often in simplistic form, includes the necessary elements of a CSM, including the sources, pathways,

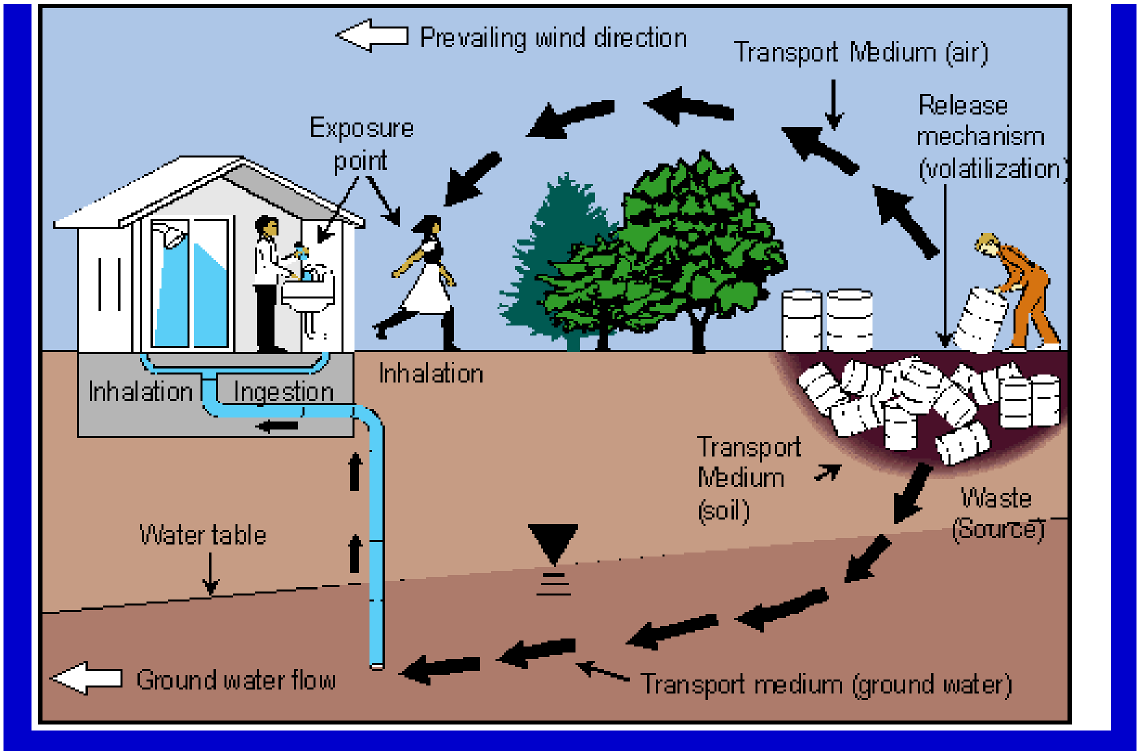

Figure 2-1. Pictorial Representation Component of a Conceptual Site Model

and receptors for a simple site. This format is most useful for presenting the CSM in the least technical manner. This illustration will become more detailed and complex as more data regarding the site becomes available, and the CSM is revised.

c. Graphical Presentation. A graphical format of an environmental CSM is shown in Figure 2-2. This format is most useful for planning, conducting, and illustrating the baseline human health or ecological risk assessment. It also is provides a concise summary of complete or incomplete source-pathway-receptor networks. Note that more complexity can be added to the model as the situation dictates. Secondary sources or secondary pathways may be identified, and can be represented by the addition of these components to the diagram. Similar network diagrams may also be developed for ecological risk assessments.

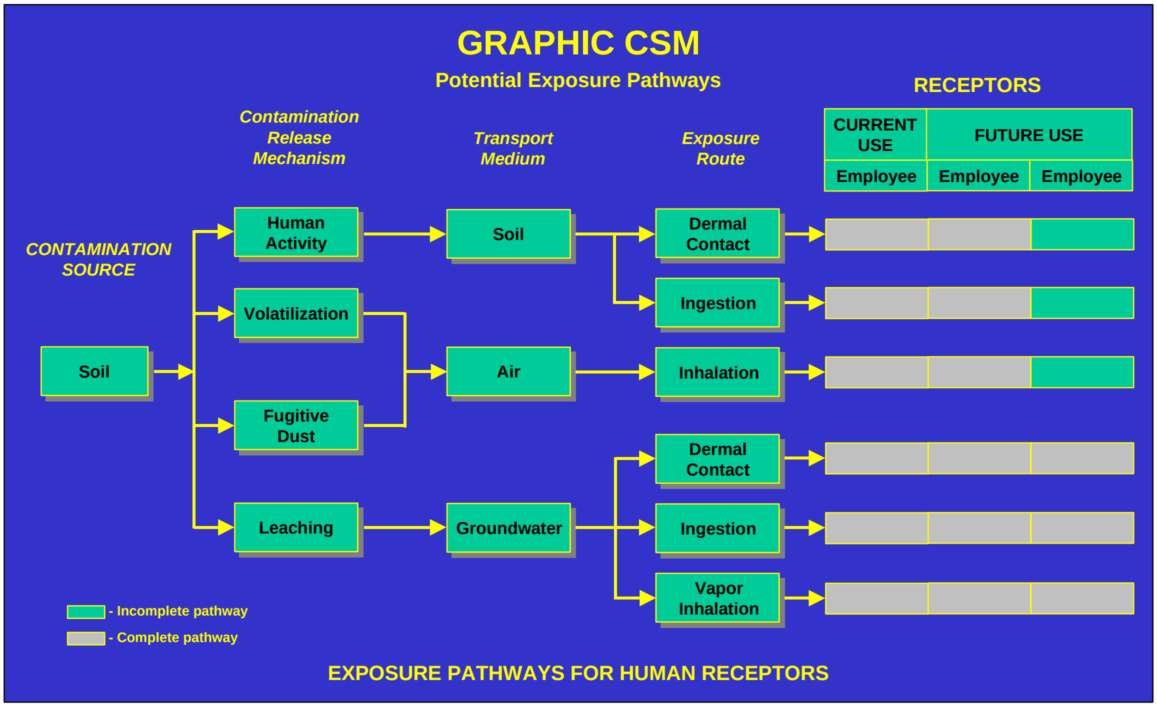

Figure 2-2. Graphic Presentation Component of an Environmental Conceptual Site Model

d. Although often represented by the simple graphical or pictorial formats described above, the CSM is actually the entire body of knowledge that is presented in one or more graphic illustrations or narratives. The focus of the risk exposure CSM is to illustrate the source-pathway-receptor networks at a site to a target audience. The PDT should present the CSM with consideration of the data users. For instance, a hydrogeologist may prefer a cross-sectional subsurface diagram to conceptually view the source areas and possible groundwater impacts. A risk assessor or land use planner may prefer the graphic representation to consider present or future risk issues. A person more interested in OE issues might opt for a range map in plan view depicting firing points and impact areas, and the potential for human interaction with these. Any of these formats could be components of the CSM, but no single format should be viewed as a complete representation of the model.

> Whenever possible, one component of the CSM should depict the source-pathway-receptor relationship.

2-8. Iterative Development of the CSM. A CSM requires continual refinement. Just as knowledge and understanding of a site will change over time, the model used to represent that understanding should also change. The CSM identifies gaps in data that help to guide future activities at the site. CSM development may be compared to a geographical information system process where a core data set of existing information is expanded using additional layers of information. Each additional layer or subset of information adds to the overall completeness and understanding of the site. It is the responsibility of the PDT to focus data collection to those data that are relevant to project objectives.

a. Later revisions of a CSM will be the result of numerous iterations of data reviews and validation. As shown in Figure 2-3, physical profiles for the site are first identified from the existing data to create an initial CSM. This information includes all available data from the CSM profiles list. The PDT must then create reasonable hypotheses regarding potential for contaminant migration or exposure to OE items. These hypotheses must consider the present or future impact to a resource or receptor. For example, analysis of the groundwater pathway will usually entail some hypotheses with respect to groundwater flow direction or soil permeability. If these parameters are not currently known, they can be measured through sampling or interpreted through modeling or professional judgement. If the results from data collection confirm the predicted model, the source-pathway-receptor relationship is established. However, if results do not support the predicted outcome, it may indicate the hypothesis was incorrect and should be revised. In some cases, existing data may suffice, or the resulting knowledge gained does not justify the expense in time or costs. If so, the data needs may be modified for better application to the CSM.

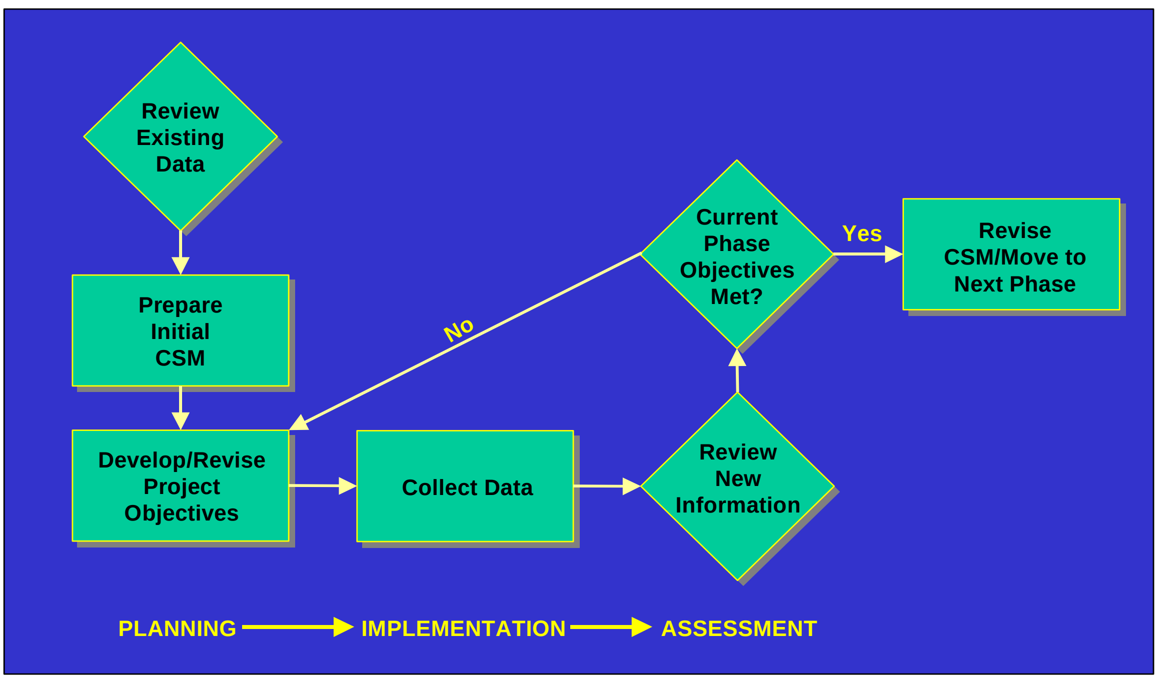

Figure 2-3. CSM Iterative Flow Process

b. Newer accelerated approaches to site characterization allow faster processing, reduction, and use of site data. This in turn allows more rapid incorporation into the CSM for that site. New data are analyzed and integrated continually, usually daily or weekly, so that the CSM evolves constantly during all phases of the work. Consequently, work plans and sampling plans for accelerated approaches are dynamic. Fieldwork is modified based on the integration of contaminant and physical data into the developing CSM.

Chapter 3
Development of a Conceptual Site Model for an Environmental Project

3-1. Introduction. The CSM for a site with environmental contaminants must clearly illustrate the source-pathway-receptor relationships present. This can be accomplished by following the TPP process and applying five simple steps. This chapter describes the steps in CSM development for a project addressing environmental contaminants. Relevant terms are defined, and examples are provided.

3-2. Review Existing Information.

a. Identifying sources and types of information available for a site is one of the most critical steps in developing the initial CSM. Historical and current site information may be obtained from maps, aerial photographs, existing reports, cross-sections, land surveys, environmental studies, or laboratory analytical data. Procurement or inventory records provide information about what items or materials were purchased and used by various departments. Operational manuals or procedures are also essential sources of information relating to how an activity was performed in the past. Landfill or burial pit disposal records, when available, offer invaluable data on what wastes may be present.

> The quality of existing data must be evaluated before inclusion in the CSM. The decision to use the data should be based on its applicability to meeting the data objectives. All data sources should be described, copied, and archived for future reference.

b. Interviews with current or former site personnel will provide anecdotal information or process knowledge about the site or specific activity. For military installations, the base historian, real property manager, and range managers should also be contacted. Local officials with the fire or law enforcement offices would typically have information if ordnance has been found at a site, or if there have been responses to chemical spills or incidents. Local military museums may also contain information on ordnance hazards at a site.

c. Site visits are highly recommended. Local archives often the best source of information, and a site visit allows the opportunity to verify much of the written information. Visual evidence of craters, soils stains, ordnance items, or fragments provide the most direct indication that ordnance hazards are present. A site visit is essential when initiating any field sampling program. The PDT should visually inspect the site to identify significant features for inclusion in the initial CSM, evaluate logistical concerns that may affect field mobilization (e.g., location or availability of utilities, access to sampling locations), and identify site conditions that may affect choice of sampling methods, such as soil conditions or excessive topographic relief.

3-3. Identify Sources.

a. The source area should be identified based on the presence of an environmental contaminant or an OE hazard. A "contaminant" is usually defined as any substance that is potentially hazardous to human health or the environment and is present at concentrations above background levels. Contaminants may also be defined by regulatory concentrations, regardless of background levels. Examples of chemical contaminants at environmental sites include chlorinated solvents, pesticides, or petroleum products.

b. Sources include those areas from which a contaminant or hazard has entered (or may enter) the physical system described by the source-pathway-receptor relationships of the CSM. At environmental sites, source areas typically include landfills, surface impoundments, fire training areas, or underground storage tanks. Investigators should be familiar with the historical operations at a site in order to recognize potential unauthorized disposal sites or areas with a likelihood for incidental spills. Sufficient information must be obtained to determine the location, boundaries, and volume of each source area. Source areas should be marked clearly on a site map, including the relationship to property boundaries and sensitive environments.

> Sources of environmental contaminants should be described in terms of locations where the contamination exists, the types of contaminants present, and the expected concentrations of these.

c. Environmental contamination sources may be primary or secondary. Secondary sources include those separate areas or media directly impacted by the primary source, which in turn may release the contaminant to a physical system. Contaminated soils beneath a surface impoundment or leachate from impact area residues are examples of secondary sources. Each secondary source should also be characterized and located on a map for inclusion in the CSM and evaluation in the source-pathway-receptor network.

d. Sampling data are typically the most reliable indicator of contamination at a site. In the absence of sampling data, or if the data are suspect, other methods may be used to develop reasonable hypotheses regarding potential sources. Known burial sites, soil stains, or stressed vegetation are signs of potential source or pathway areas, and should be included in the CSM information. Background concentrations must be established in order to determine the environmental impact from the source area of interest.

3-4 Identify Pathways.

a. A pathway is the environmental medium or matrix through which a contaminant migrates or contacts a receptor. A pathway must be present to link contaminants with receptors for a complete exposure pathway. Due to the tendency of explosive hazards to remain in place rather than migrate, pathway analysis for environmental sites often differs from that for an OE site. Environmental pathways typically correspond to the media where the contaminant is released, and to fate and transport processes following the release. Examples of environmental pathways are groundwater, surface soil, subsurface soil, sediments, surface water, and air. The biotic pathway occurs through uptake, accumulation, or concentration of contaminants by organisms, and subsequent transport of that contaminant through the food chain.

b. A contaminant is rarely immobile in the physical environmental system; therefore pathway analysis for environmental contaminants will usually require identification of a release mechanism. Release mechanisms include those physical processes that contribute to the introduction and distribution of a contaminant in the environment. This often leads to migration from the source area to an environmental medium. Multiple releases may exist for the same primary or secondary source. A liquid contaminant may be released through percolation or infiltration through the soil column or directly to surface water, sediments, or groundwater. Volatilization of that contaminant may occur, which adds a separate release mechanism from the primary source. Contaminated soil or sediment (which form a secondary source) may become airborne or migrate through erosional processes through entirely different release mechanisms. Careful evaluation must be made of all potential release mechanisms and resultant pathways.

> Pathways and release mechanisms should be identified for each source present at the site. Multiple pathways may exist for each source area.

c. The soil pathway is important where there is potential for receptor contact with contaminated soil. The PDT must determine the depth of contamination and the potential for human or biotic contact with the contamination. Certain activities, such as soil excavation, can create an exposure path where one does not currently exist.

d. The groundwater pathway must consider depth to the groundwater, permeability of the overlying strata, transmissivity of the water-bearing unit, and aquifer classification and use. The fate and transport properties of the contaminant are also important in determining rate of dispersion and migration properties.

e. The air pathway is important when evaluating particulate dispersion of contaminated soils or sediments or volatile gas release from contaminants. Prevailing wind directions should be determined to measure potential for receptor risk from this pathway.

f. The biotic pathway is important when considering potential transfer of contaminants along the food chain. Bioaccumulation and bioconcentration in plants or animals can result in exposure of other receptors to harmful concentrations of contaminants. Movement of the contaminated biota results in transport of the contaminant.

g. Pathway analysis for human and ecological receptors is performed for each source. The potential for both current and future migration from the source area should be determined and represented in the CSM, requiring the PDT to consider the effect of time and future land use at the site.

3-5. Identify Receptors.

a. A receptor is a person or population that is or may be adversely affected by a release. Receptors are both human and ecological. Ecological receptors may include individual organisms, populations, communities, or habitats and ecosystems. A receptor completes the source-pathway-receptor network; therefore, a receptor must be identified for each pathway and exposure route. Both current and potential receptors must be identified during this evaluation.

b. Multiple receptors may be, and typically are, exposed through a single route. Ingestion of contaminated surface water is as much a concern for terrestrial or aquatic wildlife as for humans. In addition, human receptors are often subdivided into several categories to represent varying degrees of potential exposure. These may include residents, site workers, recreational users, researchers, or trespassers. The probability, frequency, and duration of each receptor's exposure to the contaminant are assessed in this manner.

> If a receptor is not identified for each pathway or exposure route, that network is incomplete and no risk is assigned. The effort to document that network must be documented to demonstrate that potential risk has been evaluated.

c. Identification of receptors is usually enhanced by use of maps that show the ecological profile and land use surrounding the facility and the migration pathways from the facility. On-site and off-site receptors must be assessed for both current and future scenarios.

d. Identification of receptors usually requires an evaluation of the exposure route. Exposure routes are those processes by which a contaminant or hazard in the environment contacts a receptor. For most environmental contaminants, these processes include direct contact, ingestion, inhalation, and dermal exposure. Chemical contaminants may migrate through environmental pathways through various fate and transport mechanisms. The method of uptake of these contaminants from the environment represents an exposure route.

e. More than one exposure route may exist for any single pathway. For example, a receptor may be exposed to contaminants in surface water through dermal contact or ingestion while swimming. Inhalation of volatile compounds released from water is also a potential exposure route in this scenario, depending on the properties of the contaminant.

3-6 Documentation of the CSM. Careful analysis of the profile information should allow the PDT to identify the source-pathway-receptor network for a project site. This network may be presented in any format deemed appropriate for the complexity of the site. However, the CSM does not consist only of the pictorial or graphical diagram illustrating the network analysis. The complete CSM will consist of detailed evaluation and analysis of potential pathways through environmental media, which clearly explains the fate and transport properties of the contaminants. Detailed geological and hydrogeological analyses should be included, especially for larger and more complex sites. The PDT must rely on all components of the CSM, not just a simple box diagram. This will apply for both environmental and OE projects.

> The complete CSM must include the entire summary of sampling data, modeling results, and detailed analysis of the project site. Box diagrams are only a single component of the complete CSM.

CHAPTER 4
Development of a Conceptual Site Model for an Ordnance and Explosives Hazards

4-1. Introduction. CSM development for OE hazards follows the same TPP process as that for environmental sites, but data needs often differ. The primary focus of the OE CSM is to represent the safety hazards associated with ordnance and explosives. Often, historical records are incomplete or old maps do not show the installation range dimensions accurately. Former range areas may have become re-forested or even undergone residential, commercial, or industrial development. The OE team must be able to find and illustrate the potential hazards in areas that may no longer be recognizable as former ranges. In recent years, attempts to make analogies between OE investigations and environmental studies have met with misunderstanding and frustration. This chapter describes the CSM development process for sites with OE hazards, defines key terms, and provides examples specific to these sites for each step of the development process to help promote better understanding between project personnel and stakeholders.

4-2. Review Existing Information.

a. As with environmental sites, information gathering for OE sites should focus on the profile information that forms the CSM. When available, the Archive Search Report (ASR) for a site should provide a summary of OE activities to date. Additional records search, a site walkthrough, and personnel interviews are other recommended sources of information.

An **Archives Search Report** is an evaluation of past OE activities at an installation. The purpose of an Archives Search Report (ASR) is to assemble historical records and available data, assess potential ordnance presence, and recommend follow-up actions based on risk. However, the ASR alone should not be viewed as presenting a comprehensive understanding of site conditions.

b. If the current available information is poor, the PDT may need to conduct initial investigations at the site in order to make recommendations for further actions. Historical ground and aerial photographs may be obtained from installation or military archives. A detailed military photogrammetric study is recommended, followed by sampling or geophysical surveys. The CSM should be updated with new information throughout this process.

Historical photographs should be reviewed for indications of past range activity.

4-3. Identify Source.

a. Source areas at OE project sites are typically defined by hazards rather than by contaminants. A "hazard" is an explosive safety risk presented by OE present at the site. OE sites often contain a variety of ordnance with differing properties that define the type of hazard present. OE may present an environmental contamination potential, a safety hazard potential, or both. Each potential should be evaluated and addressed.

OE consists of either: (1) ammunition, ammunition components, chemical or biological warfare materiel or explosives that have been abandoned, expelled from demolition pits or burning pads, lost, discarded, buried, or fired (i.e., unexploded ordnance) and that are no longer under accountable record control of any Department of Defense organization or activity or (2) explosive soil, where any mixture of explosives in soil, sand, clay, or other solid media is at such concentrations that the mixture itself is explosive, or (3) buildings with explosive residues that present explosive hazards.

b. Source area identification for an OE site may be accomplished by following a three-step process. First, determine the type and number of OE area(s) present. Second, determine the weapons and ammunition used at the OE area. Third, determine the orientation and dimensions of the OE area. Each of these steps is further explained in the following sections.

1. Determine Type and Number of OE Areas. Sources at OE sites may include those areas where ordnance hazards are known or suspected. These areas may include firing points, range fans, impact areas, ordnance handling or storage areas, maneuver/bivouac areas, defensive positions, and both authorized and unauthorized ordnance disposal and burial sites. The use and activities that occurred at the site over time will provide an indication of the OE hazards and distribution, and helps the PDT define the potential hazard areas. Table 4-1 lists some common OE areas and the typical uses associated with each. Additional information regarding range operations is provided in Appendix C. Source areas should be marked clearly on a site map, including the relationship to property boundaries and sensitive environments. Identification of each OE area type is a necessary step in developing the facility profile. This information can then help guide the determination of the probable weapon system and ammunition used at the area.

2. Determine the Weapons and Ammunition Used at the OE Area. Weapons and ammunition used at an OE area form the basis for determining the potential OE hazards and source items at the site. Delineating the boundaries of a source area requires knowledge of the type, density, condition and depth of ordnance found in each area. At most OE sites, there exists a potential for dud-fired rounds that present an unexploded ordnance (UXO) safety hazard. The relative severity of that hazard depends on the type and amount of ordnance used or remaining at the site. One factor critical to this determination is the age or time frame for area use. Weapons systems change over time, but performance specifications for these systems are available from

Unexploded ordnance (UXO) is a specific type of OE that presents a significant safety hazard. **UXO** is defined as military munitions that have been primed, fuzed, armed, or otherwise prepared for action, and that have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installation, personnel, or material and that remain unexploded either by malfunction, design, or any other cause.

military archives. Even though documentation of use at a particular range or other OE area may be poor, knowledge of the range type and time frame can narrow the potential number of systems and help focus further investigation. For example, a PDT has documentation that an area is a former artillery range that was used within the World War I era from 1905 to 1919. From this information, the team can hypothesize that the weapons used at that artillery range might include a 3-in. field rifle Model 1905, a 4.7-inch field gun Model 1906, and a 155-mm Howitzer Model 1918. This information further serves as a basis for determining the dimensions of the range fan and safety danger zone.

OE Area Type	Activity/Potential Ordnance
Small Arms	Skeet, rifle, machine gun, anti-aircraft, pistol
Rifle Grenade, Anti-Tank	Live and practice HE rounds
Grenade Courts	Live and practice grenades
Artillery	Anti-aircraft, barrage rockets, tank (main gun), recoilless rifle
Bombing	Live and practice, smoke, submunitions
Air to Air	Live and practice guns, rockets
Air to Ground	Strafing, aerial rockets
Ground to Air	Live and practice missiles
Ground to Ground	Live and practice missiles
Multiple/Combined Use	Small arms, mortars, rifle grenades, hand grenades, rockets, bombs
Training/Maneuver Areas	Vehicle and troop maneuvers, combat cities, jungle village, pill boxes, live and practice rounds, pyrotechnics
OB/OD Units	Permitted disposal of OE by burning or detonation
Army Ammunitions Plant	High explosives, explosive soils, process residuals
Bivouac Areas	Live and practice small arms rounds, smokes, pyrotechnics

Table 4-1. Common OE Areas and Hazards

3. Determine the Orientation and Dimensions of the OE Area. The OE area dimensions determine the boundaries of the source area at a site, particularly for explosive hazards. Range dimensions are not limited to the standard layouts that may exist for a particular weapon system. Dimensions are also a function of the ordnance use over time, from both the limits of fire from the weapons system used and the placement of the firing points and impact areas over the years. An example of how dimensions may change over time is illustrated in Figure 4-1. Firing points and target areas were moved sometime between 1951 and 1956 at this range, altering the layout and increasing the overall acreage of the OE area. Similar effects are found when two or more adjacent ranges overlap. Terrain features are also important when assessing the dimensions or potential hazards of a range. Natural or man-made barriers will produce a "shadow effect" on ordnance distribution fired at the feature. An illustration of this is provided in Figure 4-2. The standard layout for an artillery range is shown at a location on level ground and intersecting a hill that cuts across a range at another location. The backdrop of the hill substantially foreshortens the second range. A PDT planning to evaluate ordnance density at both ranges could expect a lesser density behind the hill and develop a larger grid spacing for geophysical survey.

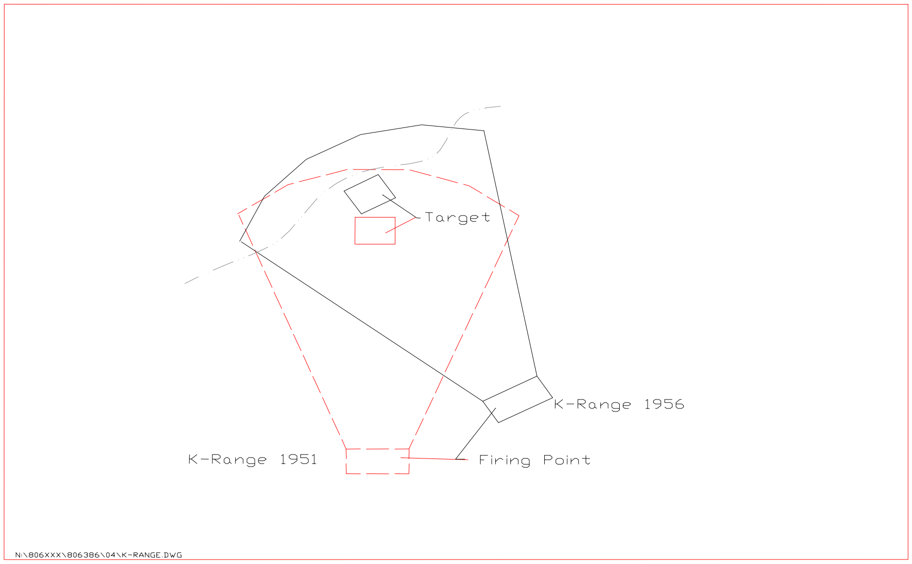

Figure 4-1. Range Dimensions over Time
(Note: Concept drawing for review. Final will include background color)

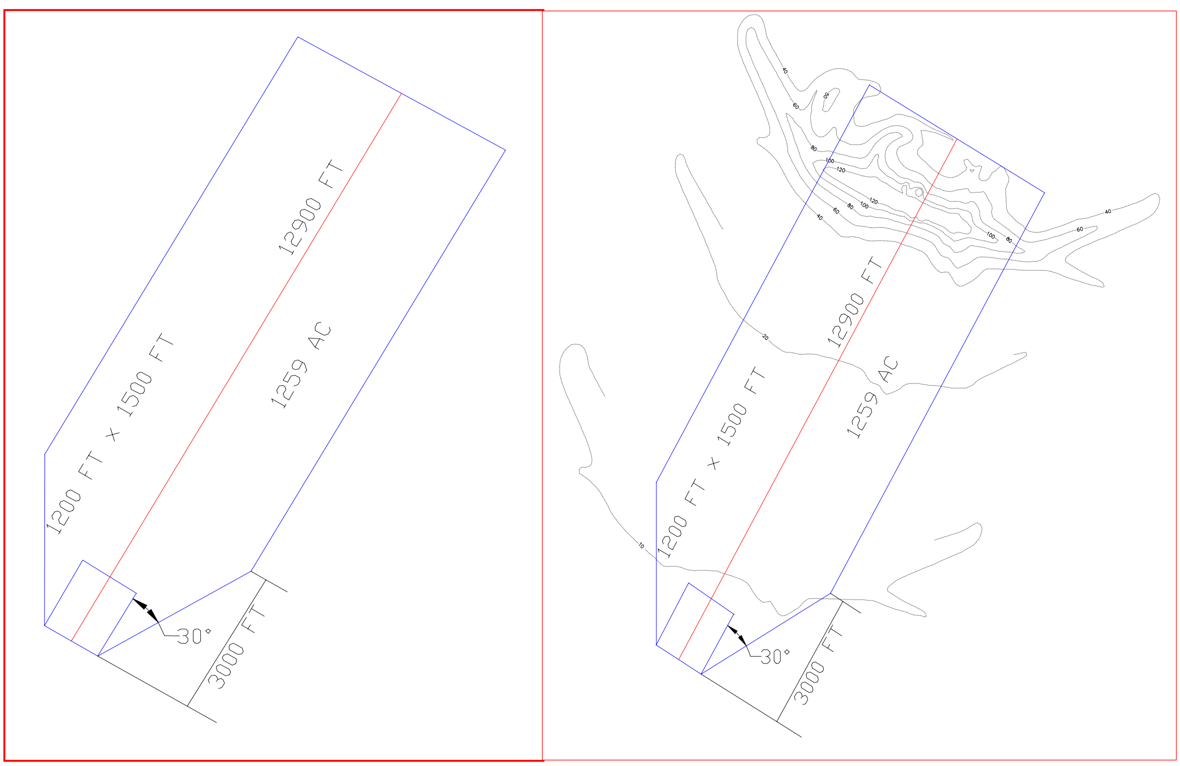

Figure 4-2. Terrain Effects on Range Dimension and Use
(Note: Concept drawing for review. Final will include background color, and change to artillery range dimensions.)

c. Potential source areas at OE sites may be determined from the presence or absence of indicators common to many OE areas. Some indicators for presence or absence of OE are presented in Table 4-2. Examples of some indicators are also illustrated in the photographs shown in Figures 4-3a through 4-3g.

Indicators of Presence of OE	Indicators of Lack of OE
• Scarring of land	• No scarring of land
• OE scrap present	• No OE scrap present
• Historical records of OE use	• No historical OE use documented
• Land features indicating OE related use	• No land features indicating OE use
• Vegetation features indicating OE related use	• No vegetation features indicating OE related use
• OE found	• No OE found
• Eyewitness accounts of OE use	• No eyewitness accounts of OE use

Table 4-2. Indicators for Presence or Lack of OE

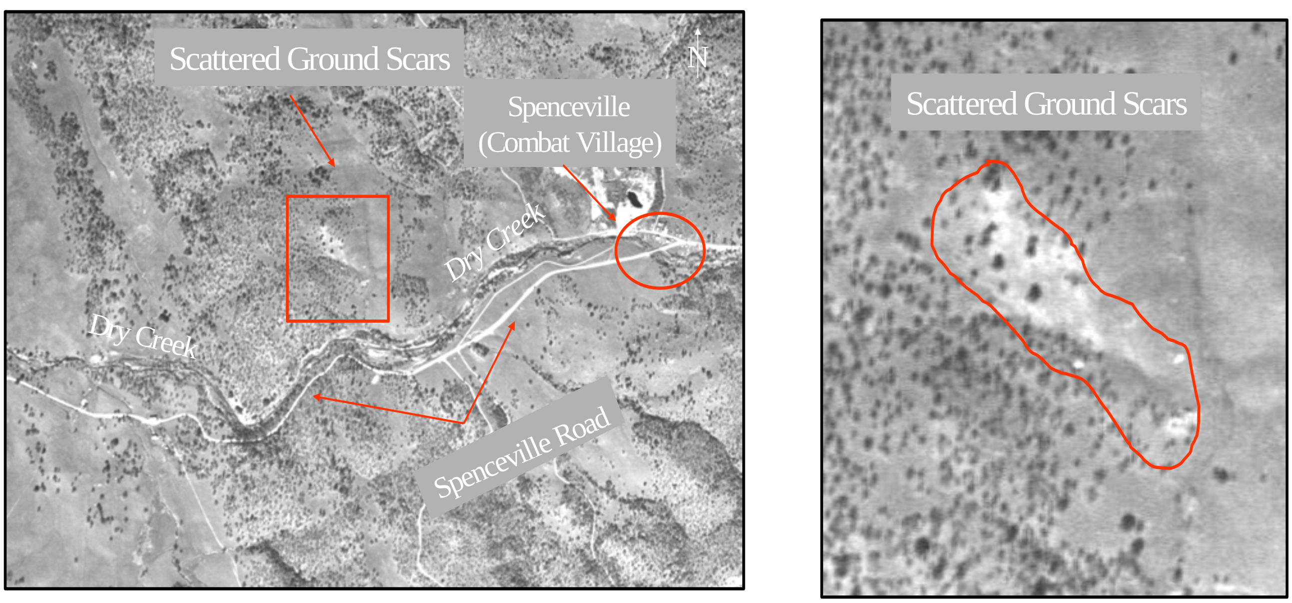

Fig. 4-3a. Ground scars indicating potential OE use.

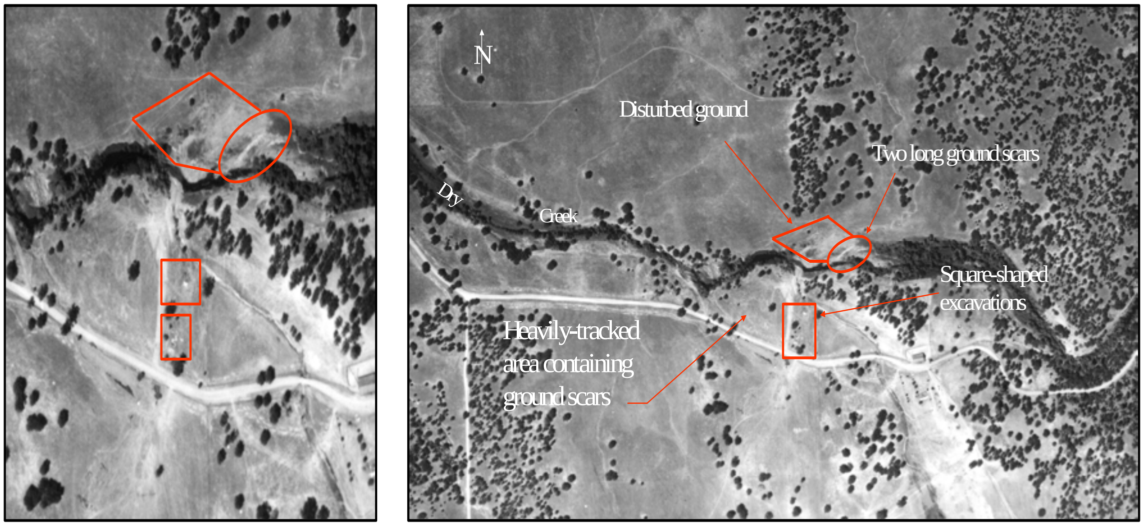

Figure 4-3b. Tracked areas and ground scars indicating past range activities.

4-4. Identify Pathways.

a. As with environmental sites, a pathway must be present to link OE hazards with receptors for a complete exposure pathway. Due to the tendency of explosive hazards to remain in place rather than migrate, the pathway for these materials will usually be the source area where the OE activity occurred. The pathway can be land surface, shallow subsurface, underwater, or buried in sediment. For impact areas the pathway will be the ground surface or subsurface soils. At water ranges, the OE pathway will be the bottom of the water body and shallow sediments. Determination of the range dimensions will usually result in identification of the pathway for OE hazards.

b. When evaluating the subsurface pathway, the PDT should attempt to determine the probable depth of penetration by the ordnance. This information is important to determination of safety hazard from OE and the cost of detection or cleanup. Site-specific information includes soil type, soil moisture, topography, and vegetation. Weapons system information includes ordnance geometry and weight, striking velocity, and angle of entry. Even with this information, investigators should be aware that there may exist dramatic differences in penetration depth from the same ordnance. For example, loose, sandy soil will typically allow less penetration of similar ordnance than will dense clay. The depth or location of OE is an important factor when developing clearance objectives for future land use.

c. Care must be taken to evaluate physical processes that may affect movement of an OE hazard. These processes may be either natural or result from human activities.

1. Erosion, scouring, or flooding of surrounding soil or sediment, frost heave, or tidal currents can cause movement of ordnance items from their original depth or location. The geology, geomorphology, and hydrology of the source area should be assessed for this potential.

2. "Re-deposition" of OE items can occur through construction activities that change the properties or location of a source area. Ordnance that was once deeply buried may become more accessible, and subsequently more hazardous, following removal of overlying material. The PDT should be aware of the potential for an existing source area to be buried, or OE items relocated from earth-moving or dredging activities. Draining a pond that contains UXO also results in a change in the pathway that can impact risk. Both current and potential future pathways must be evaluated, requiring the PDT to always consider the effect of time and future land use at the site.

4-5. Identify Receptors.

a. The exposure route for OE explosive safety hazards to a receptor is primarily direct contact as a result of some human activity. An OE item tends to lie in place unless disturbed, either by a natural or human process. Some processes such as frost heaving or erosion may change the location or distribution of OE items but do not necessarily result in exposure. However, this movement can increase the potential for direct contact from human activities.

b. Identification of OE receptors should focus on current or future human activities that bring humans into contact with the hazard. Human receptors for OE hazards may be categorized by the activity that potentially causes direct contact. Construction workers, ranchers, explosive ordnance disposal personnel, or investigators all may be potential receptors, if these activities are consistent with the current or future land use.

c. Access controls and future land use are two important considerations for determining OE receptors. Ease of entry and adjacent population can present trespasser scenarios, either intentional or accidental. Future use of OE land may result in construction for development or agricultural uses that increase potential for exposure. Depth of buried OE items becomes very important when considering limitations for future use. Clearance depths for OE items will vary according to the planned use as unrestricted, public access, limited public access, or restricted.

> The presence of access controls will help determine whether the exposure network to a receptor is complete. Fences or natural barriers can prevent human access to a source area or pathway. Interim measures, including access controls, source removals, or contaminant isolation methods, also interrupt the exposure pathway and should be considered in the network analysis.

4-7. Documentation of the CSM. The CSM developed for the OE project site must also include detailed analysis of how the source-pathway-receptor network was developed. Calculations of range dimensions, ordnance properties, and site soil properties must be defensible and effectively presented for review. Changes to the project site over time, such as completion of a removal action or implementation of recurring review, must also be documented within the CSM.

CHAPTER 5
Integration of the Conceptual Site Model for OE and Environmental Projects

5-1. The Need for Integration. Numerous closing, non-operational, or formerly used defense sites are currently under investigation or are scheduled for investigation in the near future. The historical use of these properties, documented or not, creates a potential for OE hazards and environmental contaminants that will require assessment and response. Until an area has been certified as "range-free" or undergone appropriate clearance actions, the CSM will always include an OE component. Early and ongoing coordination between environmental and OE project personnel is critical to safe and efficient planning and execution of differing phases of the project at these sites. In order for hand-offs of project activities to be as seamless as possible, data collection programs must be designed to meet multiple objectives for both OE and HTRW projects.

5-2. Data Needs Common to OE and Environmental CSM Development. The overall approach to developing the CSM is the same for an environmental site as an OE site. CSM development is a result of the TPP process implementation, regardless of the problem that may exist. The PDT must collect and analyze existing profile information, prepare an initial CSM, develop project objectives for that phase of the project, and collect necessary data specific to fulfilling those objectives. Once those objectives have been met, new objectives are developed for the next phase of work. Both the OE and HTRW project phases have needs common to both, but may be unaware of the other's efforts or objectives. The information needs described in the following sections represent some areas where the OE and HTRW phases may overlap. This summary is not specific to any project or site, but provides a general guide to data needs that may be shared by different groups.

a. A primary data need common to CSM development for OE and HTRW projects is delineation of the source area, contaminant or hazard type, and expected amount or concentration. Many OE areas have potential not only for explosive hazard but also OE residue or filler that results in environmental contamination. Chemical fillers and propellants from low-order detonations, dud-fired munitions, or prolonged use have been shown to impact soil, sediment, and groundwater media at some locations. Other areas have potential for buried munitions with low explosive hazard, but high environmental risk from chemical releases from the munitions. A CSM for such a site would include an environmental component and potential OE hazard component. For example, investigation at an artillery range would typically be initiated as an OE project. The OE PDT would, in the course of their investigation, define the range boundaries and use areas in order to focus the investigation. The team may "sectorize" the range based on known or anticipated density of ordnance fired at the target impact area over the years (Figure 5-1). This information would be critical to an environmental CSM as well, allowing that project phase to focus investigations in those areas most likely to be a source of chemical contamination.

b. Pathway analysis is a common data need for integrated sites. Any location with OE explosive hazard also has a potential for chemical contamination, and the pathway is defined to

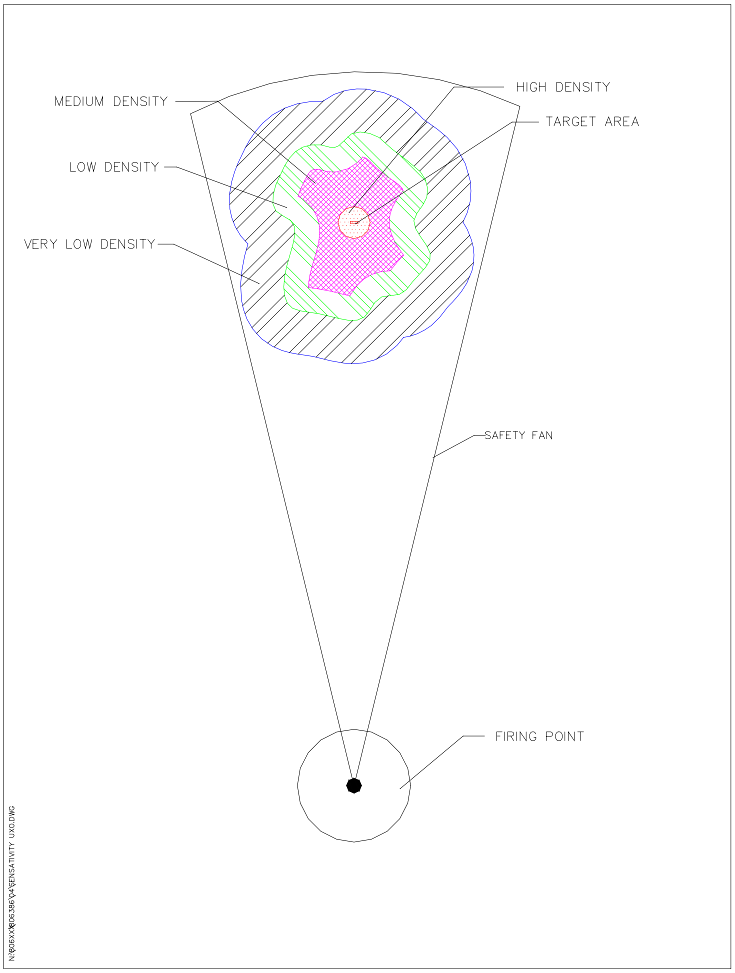

Figure 5-1. Density Distribution of Projected Ordnance
(Note: Concept drawing for review. Final will have color background.)

evaluate risk from both. Pathway identification is especially important at OE sites where activities generate significant quantities of mobile contaminants. Open Burn units often used fuels as an accelerant when burning excess ordnance. During the manufacturing process of explosives, ammunition plants sometimes generated large quantities of explosive waste in impoundments of "pink water". The actual mechanism for release to pathways may differ for OE hazards and environmental contaminants, but the locations of these areas can aid investigators in determining the appropriate source-pathway-receptor relationships to meet their project objectives.

> Release mechanisms typically do not apply to OE explosive safety hazards such as UXO, but may apply to potentially mobile contaminants released by OE items.

d. Receptor information is common to both OE and environmental projects. Although the method for contacting the receptor may differ, the presence of human or ecological populations is necessary for either investigation. The PDT must consider reasonable current and future scenarios when evaluating exposure routes.

e. Fate and transport characteristics of the OE material are a common data need for an integrated project. Changes in the chemical composition of the filler are also possible once exposed to the environment. Explosive D (ammonium picrate), for instance, degrades to picric acid and other constituents when exposed to moisture, and can produce explosive picric salts. In this instance, the explosive hazard co-exists with the environmental contaminant.

f. OE and environmental projects can share most physical and environmental profile data. Site topography, geology, meteorology, and hydrology data are examples of common data needs. Soil properties (moisture content, corrosivity, pH, etc.) are important for evaluation of chemical and OE item fate. Soil property measurements should include parameters for common data needs.

5-3. Major Differences in OE and Environmental CSM Development. Completing exposure networks for OE or environmental sites requires linking a source to a pathway and to a receptor. In most cases, exposure networks for OE sites are easier to determine than for environmental sites. OE hazards typically are not subject to secondary releases and thus have fewer pathways to consider and fewer receptors to contact. The tendency for OE hazards to remain in place where dropped, placed, propelled, or thrown results in a different approach to determining the pathway as well as how the receptor comes into contact with the source.

a. In order for a receptor to be exposed to an OE hazard, the receptor must actively interface with the item in some manner. Since the receptors to OE explosive hazards are usually human, the direct interface is typically due to some human activity. This represents a fundamental difference in the way contaminant exposures and OE explosive hazards exposures are viewed. Contaminants are typically evaluated as migrating in the environment to a passive receptor. Conversely, OE hazards remain passive and are contacted by a receptor.

b. Receptors for OE hazards should be identified from the activity that provides a link to the source. For example, recreational users (as a receptor group) must engage in some activity such as hiking or horseback riding that puts them into direct contact with the OE hazard at the source location. This differs from the traditional way of viewing source-pathway-receptor networks associated with environmental contaminants. In the environmental network analysis, a receptor may be passive and far removed from the source area, yet become exposed to a contaminant through various pathways and exposure mechanisms. From an OE safety hazard perspective, a receptor must actively engage in some activity that places them in contact with the hazard. This relationship may be represented in a network diagram by arrows from the receptor to the pathway. A comparison of the source-pathway-receptor relation ship between OE and environmental sources is illustrated in Figure 5-2.

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It does not represent official CoE, Army or DoD Policy.

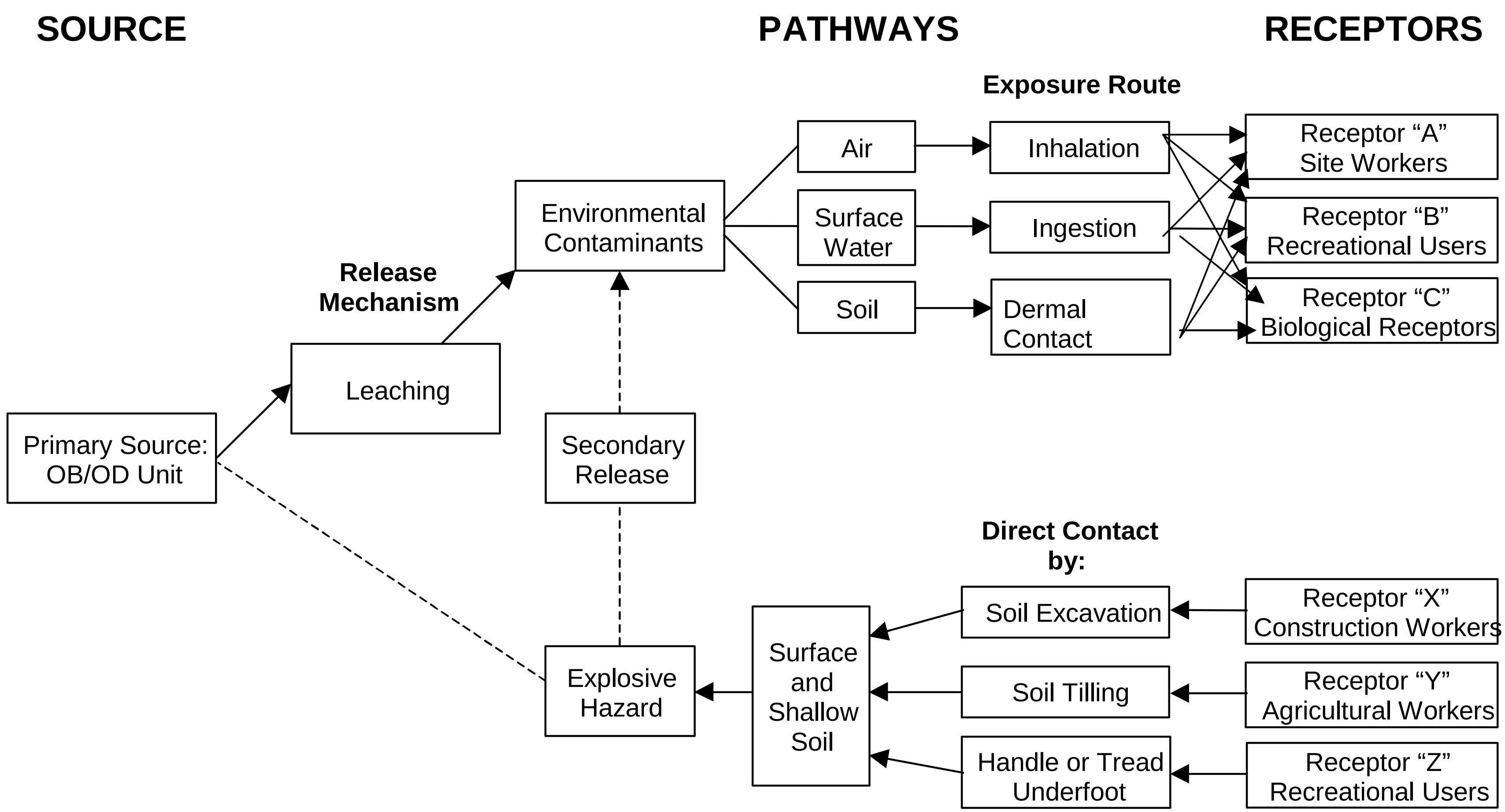

Figure 5-2. Source-Pathway-Receptor Relationships for OE and Environmental Sites

5.4 Safety Issues for OE Sites.

The relative risk from OE hazard sites is difficult to assess. There is no proven and accepted method of estimating the amount of OE at a site, evaluating the fuzing system(s) that may be present, evaluating the sensitivity and yield of the particular explosives used, evaluating the exposure pathways, and converting these and other factors into a quantitative statement of risk. The recommended approach to OE investigation is to include OE experts in the entire process so that all hazards are understood and adequately planned for. The degree of risk from direct contact with UXO is dependent on several factors. Ordnance type, net explosive weight (NEW), filler substance, fuzing, fragmentation radius, orientation, and depth should be considered as data needs for hazard evaluation. Table 5-1 summarizes some common ordnance types with fuzing and filler information as a guide for evaluating the explosive hazard potential at an OE site.

<table>
<tr><th>Method of Delivery</th><th>Ordnance Type</th><th>Possible Fuze Actions</th><th>Possible Fillers</th></tr>
<tr><td rowspan="2">Dropped</td><td>Bombs</td><td>• Impact
• Proximity
• Delay</td><td rowspan="2">• Explosive
• Chemical
• Incendiary</td></tr>
<tr><td>Submunitions (includes dispensers)</td><td>• Impact
• Antidisturbance
• Self-destruct
• Magnetic</td></tr>
<tr><td rowspan="4">Projected</td><td>Projectiles</td><td rowspan="2">• Impact
• Proximity
• Delay</td><td rowspan="2">• Explosive
• Chemical
– Riot control agent
– White phosphorus
• Illumination flares
• Submunitions</td></tr>
<tr><td>Rockets and missiles</td></tr>
<tr><td>Mortars</td><td>• Impact
• Proximity
• Delay</td><td rowspan="2">• Explosive
• Chemical
– Riot control agent
– White phosphorus
• Illumination flares
• Obscurants</td></tr>
<tr><td>Rifle Grenades</td><td>• Impact</td></tr>
<tr><td rowspan="3">Thrown (Hand Grenades)</td><td>Fragmentation
Offensive
Illumination</td><td rowspan="2">• Burning delay</td><td>• Explosive
• Incendiary (illumination)</td></tr>
<tr><td>Smoke</td><td>• White Phosphorus
• Riot control agent
• Obscurants</td></tr>
<tr><td>Antitank</td><td>• Impact</td><td>• Explosive</td></tr>
</table>

Table 5-1. Guide to Common Ordnance Types and Characteristics

APPENDIX A
BIBLIOGRAPHY

ASTM, 1995. *Standard Guide for Developing Conceptual Site Models for Contaminated Sites,* ASTM E 1689-95, American Society for Testing and Materials, Philadelphia, PA.

Department of the Army, U.S. Marine Corps, 1994. *Unexploded Ordnance (UXO) Procedures,* Field Manual No. 21-16, Fleet Marine Force Manual 13-8-1.

Department of Defense (DoD) Instruction 6055.14, "Unexploded Ordnance Safety on Ranges", January 23, 1998.

Manthey, James P., 2001. *Site Characterization for Sites Containing Ordnance,*

Report of the Defense Science Board Task Force on Unexploded Ordnance (UXO) Clearance, Active Range UXO Clearance, and Explosive Ordnance Disposal (EOD) Programs. Office of the Undersecretary of Defense for Acquisition and Technology. April 1998.

Tetra Tech Em, Inc., 2001. *Appendix A Draft Report on the Development of a Conceptual Model for the Characterization of Military Munitions at Camp Edwards Massachusetts,* prepared for National Guard Bureau, Army Environmental Division, Arlington, VA.

Unexploded Ordnance (UXO): An Overview. Naval Explosive Ordnance Disposal Technology Division. October 1996.

U.S. Army Corps of Engineers, 2000. *Ordnance and Explosives Response,* EP 1110-1-18.

U.S. Army Corps of Engineers, 1998. *Technical Project Planning Process,* EM 200-1-2.

APPENDIX B
ACRONYMS and DEFINITIONS

ASR Archives Search Report. An Archives Search Report is an evaluation of past OE activities at an installation. The purpose of an Archives Search Report (ASR) is to assemble historical records and available data, assess potential ordnance presence, and recommend follow-up actions based on risk.

ASTM American Society for Testing and Materials

CSM Conceptual Site Model. The CSM is a description of a site and its environment that is based on existing knowledge. It describes sources, pathways, and receptors, and it assists the project delivery team, decision-makers, and stakeholders in their planning, data interpretation, and communication. The CSM is an iterative tool that changes over time to help focus objectives throughout the life of the project.

CWM Chemical Warfare Materiel. An item configured as a munition containing a chemical that is intended to kill, seriously injure, or incapacitate a person through its physiological effects.

DoD U.S. Department of Defense

HQUSACE Headquarters U.S. Army Corps of Engineers

Military Range A designated land or water area set aside, managed, and used to conduct research on, i.e., develop, test, and evaluate military munitions and explosives, and other ordnance or weapon systems, or to train military personnel in their use and handling. 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.

Military Munition. 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 the Department of Defense, 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, grenades, 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 devices thereof. However, the term does include non-nuclear components of nuclear devices, managed under DOE's nuclear weapons program after all required sanitization operations under the Atomic Energy Act of 1954, as amended, have been completed.

NEW Net Explosive Weight

OB Open Burn

OD Open Detonation

OE	Ordnance and Explosives. **OE** consists of either: (1) ammunition, ammunition components, chemical or biological warfare materiel or explosives that have been abandoned, expelled from demolition pits or burning pads, lost, discarded, buried, or fired (i.e., unexploded ordnance) and that are no longer under accountable record control of any Department of Defense organization or activity or (2) explosive soil, where any mixture of explosives in soil, sand, clay, or other solid media is at such concentrations that the mixture itself is explosive, or (3) buildings with explosive residues that present explosive hazards.
PDT	Project Delivery Team
RPM	Remedial Project Manager
TPP	Technical Project Planning
USACE	U.S. Army Corps of Engineers
UXO	Unexploded Ordnance. UXO is defined as military munitions that have been primed, fuzed, armed, or otherwise prepared for action, and that have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installation, personnel, or material and that remain unexploded either by malfunction, design, or any other cause.

APPENDIX C
RANGE OPERATIONS OVERVIEW

When developing a CSM for a former military site it is important for the team to understand the basics of design, operation and maintenance of training ranges. Different parts of ranges were used for different operations with distinctly different hazards existing at each of these locations. This section presents only an overview of the most important elements of range operations. The interested reader should refer to AR 385-63 for a complete description,

Storage areas are typically located near, but not within, a range. Types of storage areas include permanent or temporary facilities for stockpiling munitions and munitions components. These facilities can include warehouses, bunkers, magazines or vehicles. Munitions stored in these facilities were normally in their shipping containers or configurations and are seldom fuzed. They represent very little hazard of inadvertent detonation. Though not a normal practice, unwanted or unserviceable munitions were occasionally buried in or near storage areas.

Firing Points are fixed locations or areas where munitions are prepared for use, and then fired. Munitions come in many different configurations, but normally include the filler (typically explosive) and a fuzing system to initiate the explosive. In addition, many munitions include a propellant charge designed to propel the munitions to its target. For most munitions, at least two, and often all three of these main components were stored separately. They were only combined and configured for use at the firing point. In many instances there were excess components, especially propellant, resulting from the use of munitions at firing points. Excess propellants were typically burned near the firing point, and other excess components were either returned to storage, destroyed through burning or detonation, or buried.

Targets are particular locations within a larger impact area where munitions are intended to land and function. Targets can consist of almost anything, including excess military or civilian vehicles, old appliances, wooden or cardboard structures, geographic features, or map coordinates with no defining features. Most munitions fired at a target functioned as intended, and therefore represent no further hazard. However, a significant percentage - typically from 1% to 20% - did not function as intended. Either the munitions did not explode at all, or only a part of the filler was consumed when the munitions functioned. When munitions were fired but inadvertently did not function as designed, they are categorized as unexploded ordnance (UXO). UXO can be extremely dangerous and must never be touched by anyone other than trained personnel. Impact areas containing UXO should be regarded as extremely hazardous sites. At many larger range complexes, several ranges may share a common impact area (Figure C-1). As indicated by this example, determination of the OE hazards in an impact area can be quite complex. Numerous weapons systems firing a variety of ammunition over a time have resulted in an impact area that is difficult to characterize. Both OE hazards and environmental contaminants must be evaluated for this site. UXO (armed or fuzed) and residual OE compounds are likely to be present.

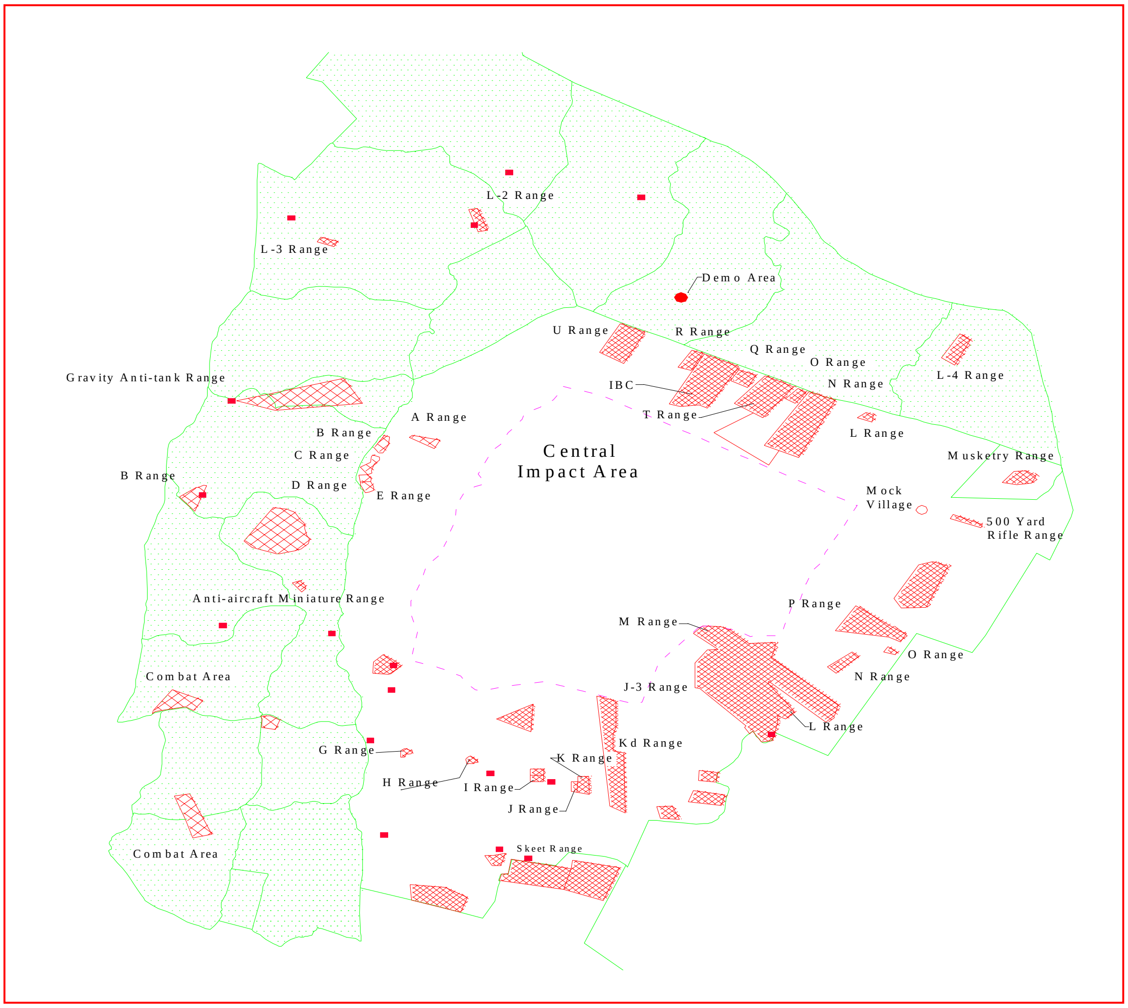

Figure C-1. Range Complex Impact Area

Open Burning/Open Detonation (OB/OD) Areas are locations where munitions are destroyed, usually within a permitted facility. Typically, excess stockpile munitions were destroyed at OB/OD areas. However UXO from target and impact areas are sometimes moved to OB/OD areas for destruction as well. Basically UXO can be divided into two groups; those that trained personnel determine are "Safe to Move", and those that are "Unsafe to Move." Those that are unsafe to move are destroyed where they are found by Blowing in Place (BIP). UXO and other munitions that are determined to be safe-to-move can be either detonated in place or moved to another location, often an OB/OD facility, for destruction. Because of safety concerns, UXO whether "safe to move" or not, are never disassembled and their components recovered. Demolition operations are not always effective. Entire munitions, as well as dangerous components, can remain. Like target areas, demolition areas should be regarded as extremely hazardous sites.

APPENDIX D
EXAMPLE OF AN INTEGRATED CSM

This example is still under development and will be finalized pending receipt of comments on the text of this guidance document.