CONCEPTUAL SITE MODELS FOR ORDNANCE AND EXPLOSIVES (OE) AND HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW) PROJECTS

ENGINEER MANUAL

CECW-ET	**DEPARTMENT OF THE ARMY** **U.S. Army Corps of Engineers** **Washington, DC 20314-1000**	EM 1110-1-1200

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Engineering and Design
CONCEPTUAL SITE MODELS FOR ORDNANCE AND EXPLOSIVES (OE) AND HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW) PROJECTS

1. Purpose. This Engineer Manual (EM) provides U.S. Army Corps of Engineers (USACE) and other personnel with procedural guidance to develop Conceptual Site Models (CSMs) at sites potentially containing ordnance and explosives (OE) and/or hazardous, toxic, and radioactive waste (HTRW) environmental contamination. The CSM is a description of a site and its environment that is based on existing knowledge. It describes sources and receptors, and the interactions that link these. It assists the team in planning, interpreting data, and communicating. The CSM will provide a planning tool to integrate information from a variety of resources, to evaluate the information with respect to project objectives and data needs, and to respond through an iterative process for further data collection or action. The target audience is the project delivery team (PDT).

2. Applicability. This manual 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 OE and HTRW-related issues. This guidance is provided to assist any organization or PDT involved in evaluation and decision-making. The CSM development process in this manual is applicable to any phase of a project, including investigation, design, response, and operation and maintenance of remedial systems with recurring review.

3. Distribution Statement. Approved for public release; distribution is unlimited.

4. References. Related bibliographic materials are at Appendix A.

ER 5-1-11
U. S. Army Corps of Engineers Business Process

ER 1110-1-263
Chemical Data Quality Management for Hazardous Waste Remedial Activities

EM 200-1-2
Technical Project Planning Process

EP 1110-1-18
Ordnance and Explosives Response

FOR THE COMMANDER:

4 Appendices
(See Table of Contents)

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CECW-ET

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Table of Contents

Chapter 1
Introduction

1-1. Purpose

a. This Engineer Manual (EM) provides U.S. Army Corps of Engineers (USACE) and other personnel with procedural guidance to develop Conceptual Site Models (CSMs) at sites potentially containing ordnance and explosives (OE) or hazardous, toxic, and radioactive waste (HTRW), or both. The CSM is an integral part of the Technical Project Planning (TPP) process. The target audience is the Project Delivery Team (hereinafter referred to as the team).

b. A primary objective of this guide is to bring synergy to the OE and environmental projects at a site. There are numerous closing and formerly used military sites in this country that have both OE and HTRW issues. These issues have typically been addressed as separate program categories within USACE, with one focusing exclusively on OE and another on HTRW. A common goal for each program category, however, is to achieve site closeout in a safe, environmentally responsible, and cost-effective manner. It is critical to coordinate efforts to obtain this goal of site closeout. The USACE District Project Manager (PM) must ensure that site data collection supports both program categories and is utilized efficiently. Sites are commonly addressed sequentially, beginning with OE before focusing on HTRW. Rarely are both implemented at the same time, often as a result of differing safety priorities or 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 a CSM for an HTRW project. Development of an OE CSM should assist the team in designing the environmental data collection and response actions, resulting in more efficient use of resources and faster closeout at sites. Additional benefits include better understanding and appreciation of the coordinated process required by regulatory personnel and other stakeholders.

> Pursuant to the Corps' Project Management Business Process, the District Project Manager is the leader of the project delivery team (PDT) who must seamlessly integrate USACE efforts to deliver the best possible solution for the customer. The OE and HTRW team members must coordinate with each other to ensure that data collection is complementary and meets project objectives.

c. This guidance should be used together with other USACE guidance for project execution. Development of a CSM is an integral component of planning and data collection activities described in the USACE TPP Process (EM 200-1-2). The TPP process provides a framework for identifying project objectives to achieve site closeout, determining data needs to meet those objectives, evaluating the options for data collection, and finalizing the data collection program for optimum results. It also fulfills the requirements of the systematic planning process endorsed by the U.S. Environmental Protection Agency (USEPA). The TPP process allows for development of Data Quality Objectives (DQOs) through a step-wise series of problem identification, analysis, and response. It encourages the team to determine data gaps, to ensure data collected are appropriate for the project objectives, and to consider the end use of data before they are collected. This process results in more efficient and cost-effective investigation, cleanup, and monitoring.

d. This manual is also consistent with USACE Engineer Regulation (ER) 5-1-11, U.S. Army Corps of Engineers Business Process; ER 1110-1-263, Chemical Data Quality Management for Hazardous Waste Remedial Activities; and EP 1110-1-18, Ordnance and Explosives Response. Users are required to review these other guidance documents to determine the applicable integration of CSM guidance.

1-2. Scope

The CSM development process in this manual is applicable to any phase of an OE or HTRW project. These include investigation, design, response phases, and during operation/maintenance of remedial systems with recurring review. The CSM is not a separate deliverable, but a component of existing documents such as work plans, sampling and analysis plans, site characterization reports, final removal reports, or similar documents as determined by the team. This process may be applied under any regulatory framework.

Chapter 2
Description of a Conceptual Site Model

2-1. Introduction

This chapter presents an overview of what a CSM is and how it should 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.

2-2. Conceptual Site Model Defined

> The **CSM** is a description of a site and its environment that is based on existing knowledge. It describes sources and receptors, and the interactions that link these. It assists the team in planning, data interpretation, and communication.

a. The CSM is a description of a site and its environment that is based on existing knowledge. It describes sources of OE or HTRW at a site; actual, potentially complete, or incomplete exposure pathways; current or reasonable proposed use of property; and potential receptors. The source–receptor interaction 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 team (see Paragraph 2-3). It can be viewed as a tool that aids communication with the general public and also assists the team with integration of information and decisions. The CSM provides a standard means to summarize and display what is known about the site, and to identify what additional information must be known to develop technically sound DQOs.

> CSM development is an ***iterative process*** that reflects the progress of activities at a site from initial assessment through site closeout. The CSM evolves over time to help focus objectives throughout the life of the project.

b. The CSM is a tool that evolves as site work progresses and data gaps are filled. CSM development should be 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. Potential source areas, media of concern, and OE use areas are documented in the initial CSM. Later versions of the CSM may be used to evaluate the effectiveness of sampling or to help focus design efforts. The CSM can help focus general regulatory objectives to more site-specific project objectives. Data collection should be focused on complete or potentially complete exposure pathways, based on both current and reasonably anticipated future land use.

> The threats presented by OE and HTRW are different, and in this document are differentiated by the terms “hazard” and “risk.” OE presents a **hazard** of direct physical injury resulting from the blast, heat, fragmentation, or acute chemical effects of a munition or munition component. Environmental contaminants present a **risk** to human health and the environment through exposures. The degree of risk posed by HTRW is usually proportional to the toxicity of the contaminants, as well as the amount and duration of exposure. A single site may have threats of both OE hazards and HTRW risks that must be considered.

c. The basic process in the development of a CSM applies to both OE and HTRW sites. The CSM is developed through analysis of site profile information collected by the team. The team integrates this information to illustrate relationships between the potential sources and receptors that may be affected. Through this illustration, the team conducts a pathway analysis to show how site conditions, including the exposure pathways, function as a system. As more data are generated, the understanding of this system becomes more refined. This understanding allows greater focus for subsequent investigations or for design and response activities.

2-3. Team Composition

> "The **Project Delivery Team** (PDT) will include the customer(s), the PM, technical experts within or outside the local USACE activity, specialists, consultants/contractors, stakeholders, representatives from other state or federal agencies, and vertical members from division and headquarters that are necessary to effectively develop and deliver the project." U.S. Army Corps of Engineers (ER 5-1-11)

Team composition will vary with the complexity of the site and the nature of the OE hazards or HTRW contaminants present. The PM leads a team that consists of technical experts, regulatory personnel, and other 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, as described in the TPP Process manual (EM-200-1-2). Each group will have a set of data needs, and these may contain differences and overlaps. One aspect of developing a CSM for a site potentially having both OE and HTRW is the importance of early and ongoing coordination between technical experts on the team.

2-4. Profiles Needed to Develop a CSM

An effective CSM presents known or suspected conditions about sources and potential receptors, and the interactions between them. The team must be able to recognize those types of information relevant to developing the CSM. In most cases, the needed information may be categorized into five "profile types" that address specific yet overlapping types of information. These profile types include:

- Facility Profile—describes man-made features and potential sources at or near the site.
- Physical Profile—describes factors that may affect release, fate and transport, and access.
- Release Profile—describes the movement and extent of contaminants in the environment.
- Land Use and Exposure Profile—provides information used to identify and evaluate the applicable exposure scenarios, receptors, and receptor locations.
- Ecological Profile—describes the natural habitats of the site and ecological receptors in those areas.

> Early involvement of team members and identification of project goals and objectives (culminating in site closeout) are important during the CSM development process.

Profile information may be collected from a variety of resources. The team 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 type is presented in Table 2-1. These information needs are not comprehensive, and each site may require different or additional information as determined by the team.

Table 2-1. Profile Types and Information Needs

Profile Type	Typical Information Needs
Facility Profile	• All structures, sewer systems, process lines, underground utilities • Physical boundaries (past and current), fencing, administrative controls, etc. • Current and historical process and manufacturing areas • Ordnance activity areas (firing points, impact areas, storage areas, munitions manufacturing, or disposal areas) • Storage and waste disposal • Historical features that indicate potential source areas (landfills or lagoons, ground scars, impact craters)
Physical Profile	• Topographic and vegetative features or other natural barriers • Surface water features and drainage pathways • Surface and subsurface geology, including soil type and properties • Meteorological data • Geophysical data • Hydrogeological data for depth to ground water and aquifer characteristics • Other physical site factors that affect site activities • Soil boring or monitoring well logs and locations
Release Profile	• Determination of contaminant movement from source areas • Contaminants and media of potential concern • Impact of chemical mixtures and co-located waste on transport mechanisms • Locations and delineation of confirmed releases with sampling locations • Migration routes and mechanisms (HTRW and OE constituents) • Modeling results
Land Use and Exposure Profile	• Receptors associated with current and reasonable future land use on and near the facility (residential, recreational, commercial, agricultural, industrial, public forest, etc.) • Zoning • Types of current or future activities at the facility, including frequency and nature of activity (intrusive or non-intrusive) • 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, historical burial grounds, etc.) • Demographics, including subpopulation types and locations (schools, hospitals, day care centers, site workers, etc.)
Ecological Profile	• Description of the property at the facility, including habitat type (wetland, forest, desert, pond, etc.) • Primary use of the 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.)

2-5. Pathway Analysis

Source–receptor interaction for an OE CSM requires two components: **Access** and **Activity**.

The team uses information from the profiles to identify all actual, potentially complete, or incomplete source–receptor interactions for the site, for both current and reasonably anticipated future land use. An exposure pathway is the course a chemical or physical agent takes from a source to a receptor. For OE projects, each pathway must include a source, access, activity, and a receptor. Each pathway for an HTRW project must include a source, an exposure medium, an exposure route, and a receptor. An HTRW pathway may also include a release mechanism (e.g., volatilization) and a transport medium (e.g., air), if the point of exposure is not at the same location as the source. The CSM will illustrate all complete exposure pathways, current and future. The pathway analysis, represented by the CSM, will guide data collection activities and can be used to inform stakeholders of site conditions.

Source–receptor interaction for an HTRW CSM requires two components: an **Exposure Medium** and an **Exposure Route**. A release mechanism and transport medium may also be present.

a. Source. Sources are those areas where OE or HTRW has entered (or may enter) the physical system. Information on sources and source areas is collected when the Facility, Physical, and Release Profiles are generated. Even though a source may be easily labeled, such as an impact range or a landfill, it is extremely important that the entire team completely understand as much about the source as possible, including probable munitions or contaminants. Early in the project, many of the details of the source may not be known. It is necessary for the team to determine what is known and what is assumed about the source.

b. Interaction. Interaction describes ways that receptors come into contact with a source. Information from all profiles will assist in identifying source–receptor interactions. Typically, movement of OE is not significant, and interaction will occur only at the source area, limited by access and activity. However, there can be some movement through natural processes, such as frost heave, tidal action, and erosion, or from human activity. Environmental contaminants often undergo various processes (e.g., volatilization, migration) such that media other than the source area can become contaminated. Therefore, the team must consider all potentially contaminated media (exposure media) as well as all exposure routes (ingestion, inhalation, and dermal contact) in evaluating the source–receptor interactions at HTRW sites.

c. Receptors. A receptor is an organism (human or ecological) that contacts a chemical or physical agent. The pathway evaluation must consider both current and reasonably anticipated future land use, as receptors are determined on that basis. Appropriate human and ecological receptors are identified in the Land Use and Exposure, and Ecological Profiles. Human receptor subcategories can include residents, site workers, construction workers, recreational users, and trespassers.

2-6. Representation of the CSM

The CSM can vary in content and detail, depending on complexity of the site as well as available or needed information. A simple figure or narrative may depict a CSM for a simple site. However, a CSM for most sites is more complex and typically documented by written narrative and supported by maps, cross-sections, diagrams, or other graphics to form the entire model. On HTRW sites, the risk exposure CSM focuses on the contaminant source, exposure routes through environmental media, and exposure of receptors. A hazard exposure CSM for an OE site is structured in a similar manner, depicting the OE source, access to the source by a receptor, and the activity performed by the receptor. Whatever format may be chosen to illustrate the model, all hazard exposure or risk exposure CSMs should provide an accurate representation of the source–receptor interactions present at the site.

> The CSM will illustrate the sources and receptors present at the site, and the interactions that may result in exposure. For OE projects, the CSM will aid in determining whether hazards from OE are present. Similarly, for HTRW projects, the CSM will help determine whether risk from chemical contamination exists.

a. Narrative Description. A narrative is a written description of the site conditions, based on profile information. Detail will vary with complexity and available information for the site. Narrative descriptions must include a summary of information on sources, receptors, and interactions. For very simple sites, a narrative may be all that is needed to document the CSM.

b. Pictorial Presentation. A pictorial presentation includes the necessary elements of a CSM, including the sources, receptors, and interactions between them. This format is useful for presenting the CSM to a wide range of stakeholders. An example of a pictorial CSM for an HTRW site is shown in Figure 2-1, and one for an OE site is shown in Figure 2-2.

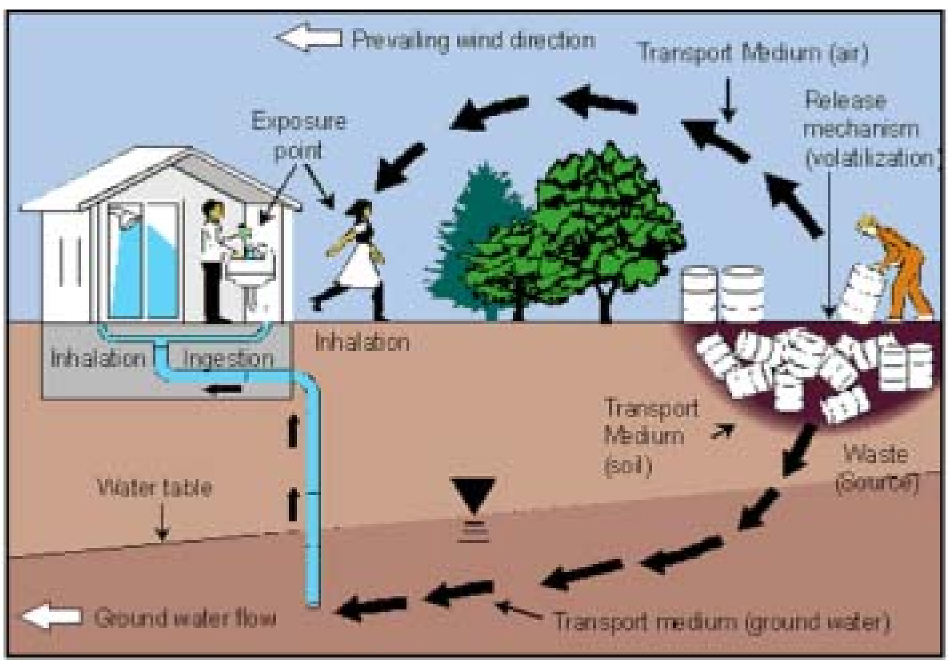

Figure 2-1. Pictorial Presentation of an HTRW CSM

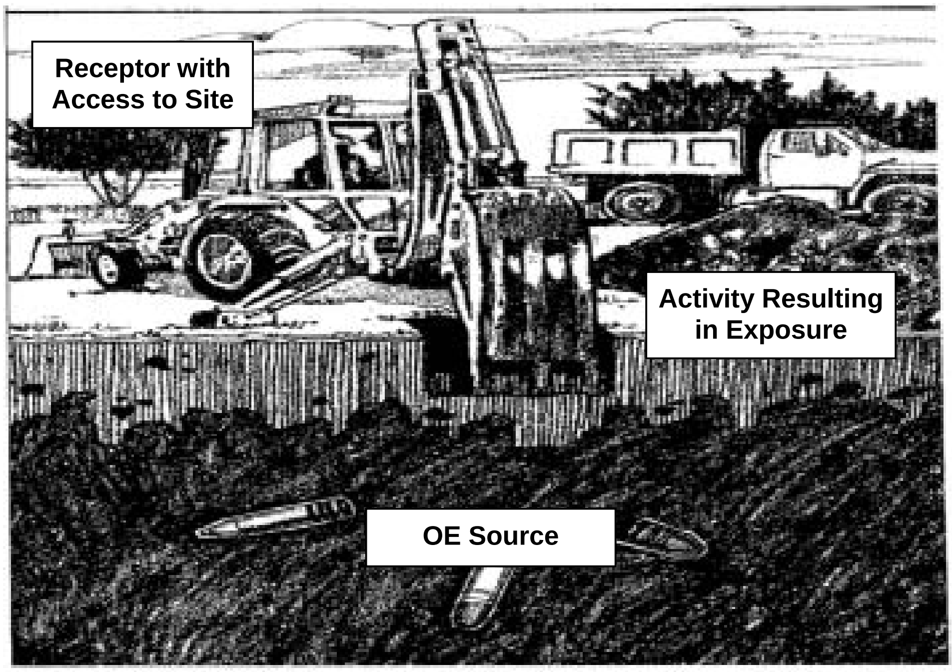

Figure 2-2. Pictorial Presentation of an OE CSM

c. Graphical Presentation. The graphical presentation provides a concise summary of complete or incomplete exposure pathways. It is commonly used for HTRW projects and may also be used for OE projects. However, the potential interactions between the source and receptors are assessed differently, as described below.

(1) A graphical presentation of a CSM for an HTRW project is shown in Figure 2-3. This example focuses on a single contamination source in soil. Secondary sources or secondary pathways may also be identified, and can be represented by the addition of these components to the diagram. Interaction between the source and receptors involves a release mechanism for the contaminant, an exposure medium that contains the contaminant, and an exposure route that places the receptor into contact with the contaminated medium. Additional pathways can be added to the model as necessary. For example, for sites with a radioactive source area, an exposure pathway could be added for external radiation for both the soil pathway and the inhalation pathway.

(2) A graphical presentation of a CSM for an OE project is shown in Figure 2-4. This example focuses on an impact area as the OE source. Interaction between the potential receptors and an OE source has two components. The receptor must have access to the source and must engage in some activity that results in contact with individual OE items within the source area.

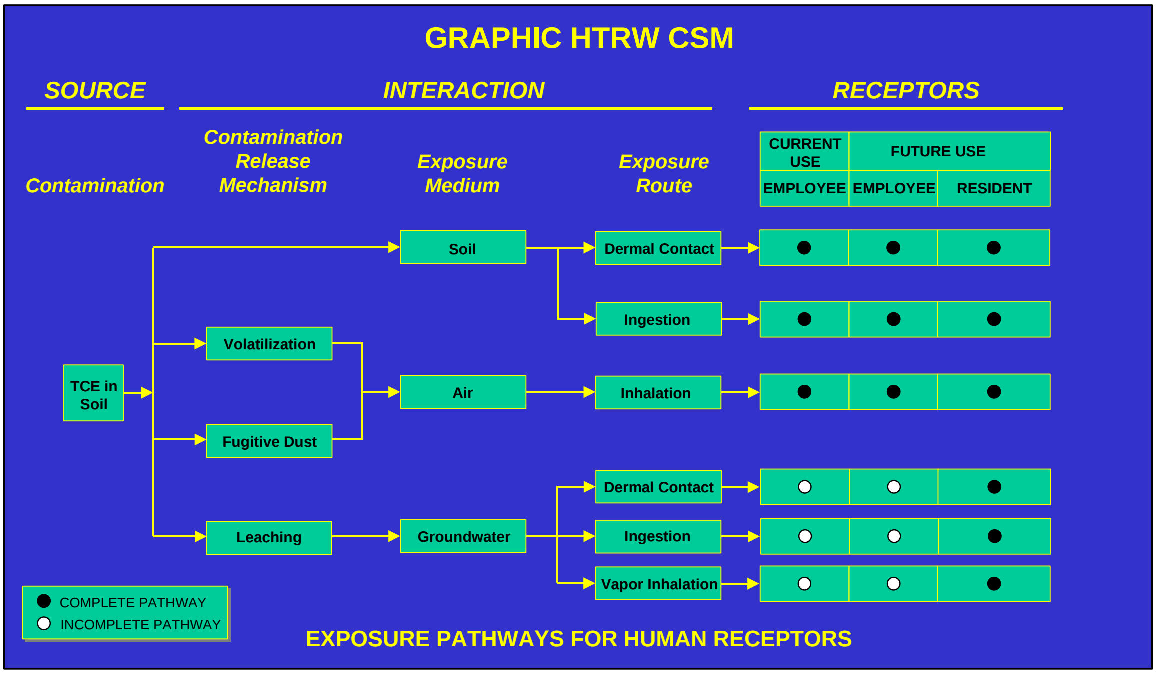

Figure 2-3. Graphic Presentation Component of an HTRW Conceptual Site Model

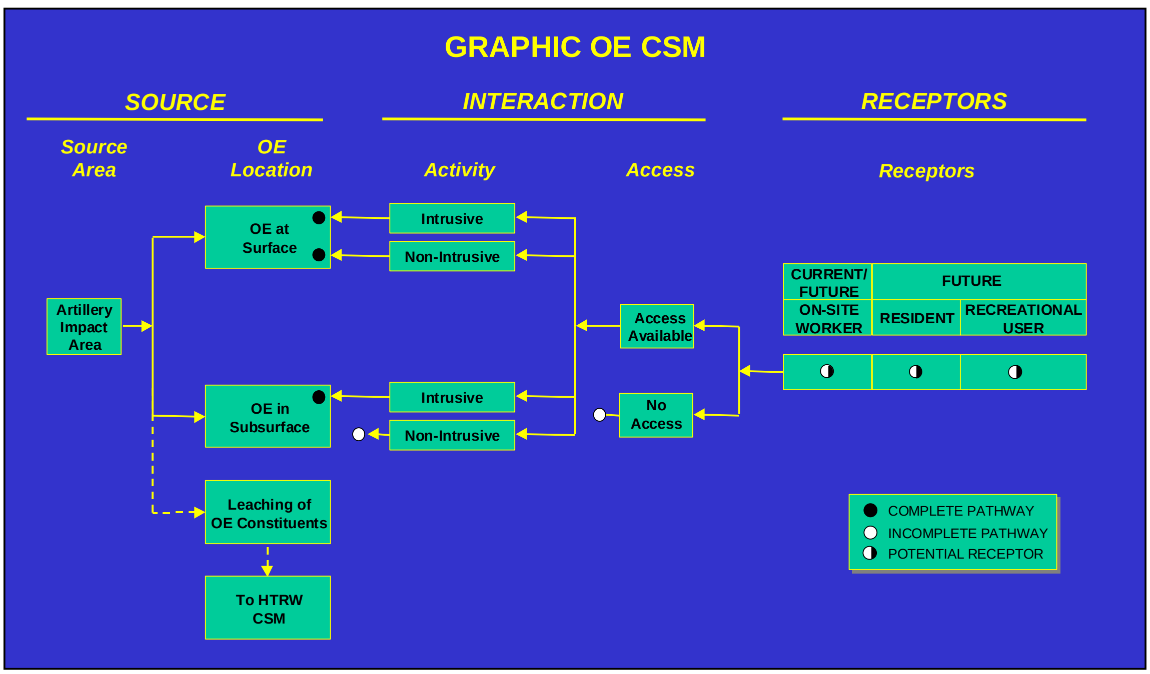

Figure 2-4. Graphic Presentation Component of an OE Conceptual Site Model

Additional detail regarding access and type of activity may be included. In this example, the OE in the subsurface would not present a hazard if left undisturbed. The concept of a secondary source does not apply to OE. However, a release of chemical constituents is possible and should be considered as a potential HTRW source in an integrated CSM.

d. Other Presentations. The CSM is a summary of the existing body of knowledge for a project presented in one or more illustrations or narratives. Specific data users may require this information to be presented in different formats. For instance, a hydrogeologist may prefer a cross-sectional subsurface diagram to conceptually view the source areas and possible ground water 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 depicting firing points and impact areas and the potential for human interaction with these.

e. Geographical Information Systems (GIS). The data collected and stored for a project may be complex and immense. The team is strongly encouraged to use GIS as a tool to store, manipulate, and present these data for the CSM.

2-7. Iterative Development of the CSM

a. A CSM requires continual refinement. Just as knowledge and understanding of a site will change as additional data are collected, the model used to represent that information should also change. The CSM helps the team to identify gaps in data in each phase of the project. In addition, completion of project phases will also be reflected in the CSM.

b. As shown in Figure 2-5, site profiles are developed from the existing data to document an initial CSM. The team must then create reasonable hypotheses regarding potential for exposure. For example, analysis of the ground water pathway will usually entail some hypotheses about ground water flow velocity or direction relative to potential receptors. If these parameters are not 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 CSM is updated to show that the hypothesis is correct. However, if results do not support the predicted outcome, it may indicate the hypothesis was incorrect and should be restated. This will require revision to the existing CSM.

c. A CSM can be developed at any phase of a project, even if one had not been prepared previously. In addition, site characterization or response actions may reveal unanticipated contaminants or sources. As an example, OE may be discovered during investigation of an HTRW site. Although not expected during the initial phase of the investigation, an OE component to the CSM should now be developed, along with review or revision to the objectives for the project as needed.

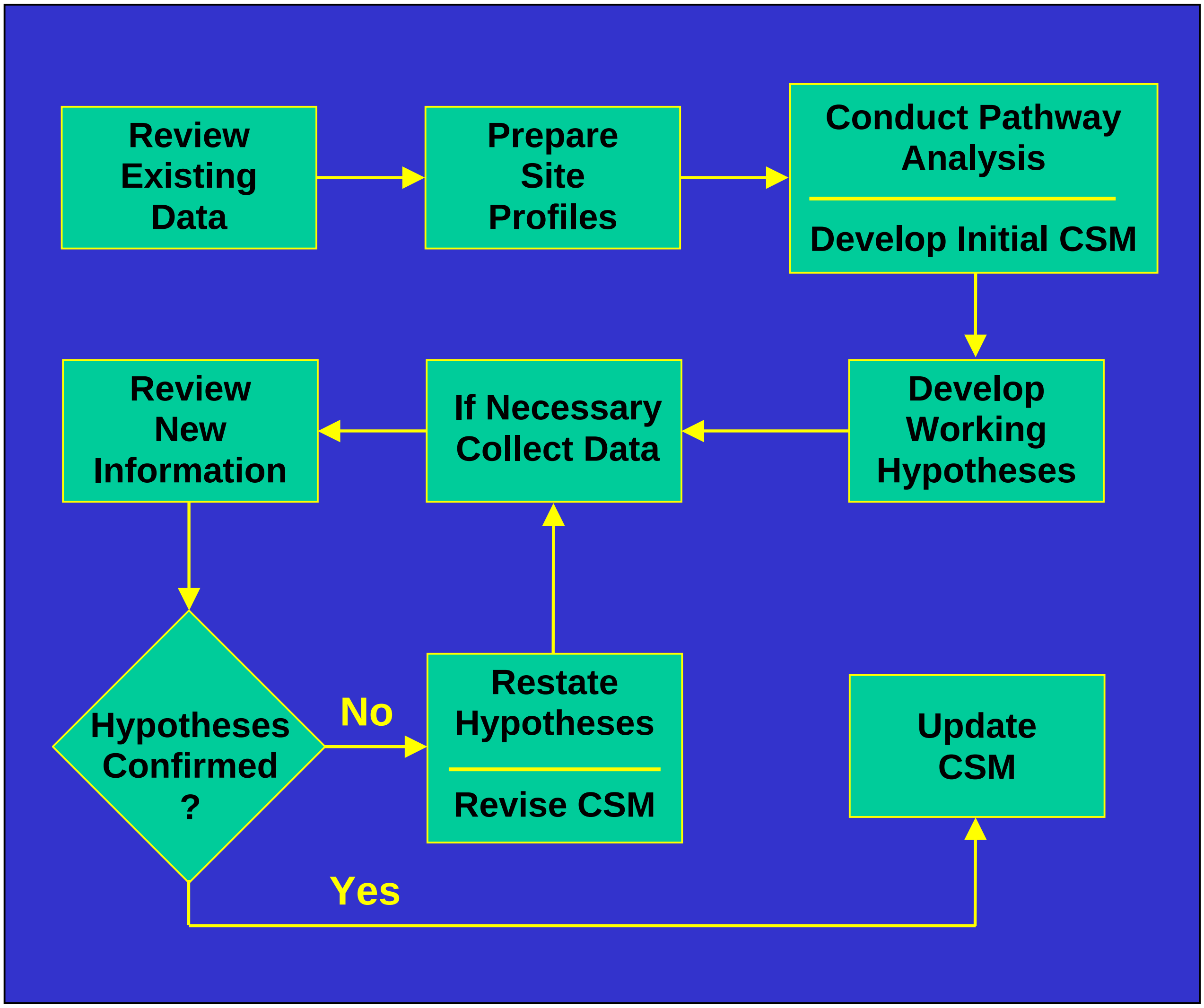

Figure 2-5. CSM Development Process

Chapter 3
Development of a Conceptual Site Model for OE Projects

3-1. Introduction

This chapter describes the CSM development process for sites with OE, defines key terms, and provides examples specific to these sites for each step of the development process. Some military lands containing OE have been transferred to other government agencies and civilian ownership, and out of military control. Current and reasonably anticipated future land use may not be compatible with the hazard posed by OE at these sites. The primary focus of the OE CSM is to illustrate the interaction between OE sources and receptors. Interaction between the receptor and an OE source has two components: access and activity. The CSM is developed through collection of the profile information (see Paragraph 2-4) and subsequent pathway analysis.

> **OE** consists of either (1) ammunition, ammunition components, chemical or biological warfare material or explosives that have been abandoned, expelled from demolition pits or burning pads, lost, discarded, buried, or fired (e.g., UXO) 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.

3-2. Profile Information Resources

The initial step in OE CSM development is to collect profile information for the site. For most sites, an Archives Search Report (ASR) or similar document provides useful profile information. However, the ASR alone should not be viewed as presenting a comprehensive understanding of site conditions. Additional records searches, a site visit, and personnel interviews are other recommended resources. Local officials with the fire or law enforcement offices would typically have information if there have been responses to OE discoveries. Historical ground and aerial photographs may be obtained from installation or military archives. In addition, a detailed military photogrammetric analysis should be conducted if this has not already been done.

> An **Archives Search Report** is an evaluation of past OE activities at an installation. The purpose of an ASR is to assemble historical records and available data and assess potential ordnance presence.

3-3. Facility Profiles

Facility Profiles for OE sites are focused on identification of OE source areas. An OE source area is the location where ordnance or explosives are expected to be found based on available information. The OE may be present as a result of direct military activities or placed there at some later time.

a. OE source areas include grenade courts/ranges, air-to-ground gunnery ranges, maneuver areas, etc. Table 3-1 lists OE area types, the possible activities that took place there, and the potential OE items for each area.

Table 3-1. Common OE Area Types, Activities, and Potential OE

OE Area Type	Possible Activity	Potential OE[1]
Small Arms	Pistol, rifle, machine gun and skeet firing ranges	Small arms ammo .50 caliber and less
Grenade	Hand grenade range Rifle grenade range	Hand or rifle grenades
Artillery	Anti-aircraft, tank, recoilless rifle ranges	Projectiles and submunitions
Bombing	Aircraft bombing	Bombs and submunitions
Air-to-Air	Air-to-air firing	Small arms rounds, projectiles, rockets, and guided missiles
Air-to-Ground	Strafing and other air to ground firing	Small arms rounds, projectiles, rockets, and guided missiles
Ground-to-Air	Anti-aircraft firing	Small arms rounds, projectiles, rockets, and guided missiles
Ground-to-Ground	Rocket and missile firing	Rockets and guided missiles
Multiple/Combined Use	Multiple training activities	Small arms rounds, projectiles, grenades, rockets and bombs
Training/Maneuver Areas	Tactical training	Small arms rounds, signals, booby traps, trip flares and other pyrotechnics, and other training devices
OB/OD Areas	Disposal of munitions	Various OE items surplus to operations
Ammunition Plants	Production of explosives and munitions	High explosives, explosive soils, process residuals
Storage Areas/Transfer Points	Storage and handling of munitions	Various munitions and explosives in approved storage configuration
Firing Points	Preparation and firing of authorized weapons systems	Unfired or abandoned munitions and explosives
Burial Pits	Mass burial of large quantities of OE	Unfired or abandoned munitions and explosives
Bivouac Areas	Troop encampments	Probably few or no OE items

[1]Potential for both live and inert munitions types listed. Inert items are considered OE scrap.

b. Source areas at OE sites may be determined from indicators common to many OE areas. Some of these indicators are as follows:

- Scarring of land.
- OE scrap present.

- Historical records of OE use.
- Land features indicating OE related use.
- Vegetation features indicating OE related use.
- OE found.
- Eyewitness accounts of OE use.

These indicators can help the team focus on areas where the probability of OE is greatest; however, absence of the indicators may not indicate lack of OE. Figures 3-1 and 3-2 are photographic examples of some OE indicators.

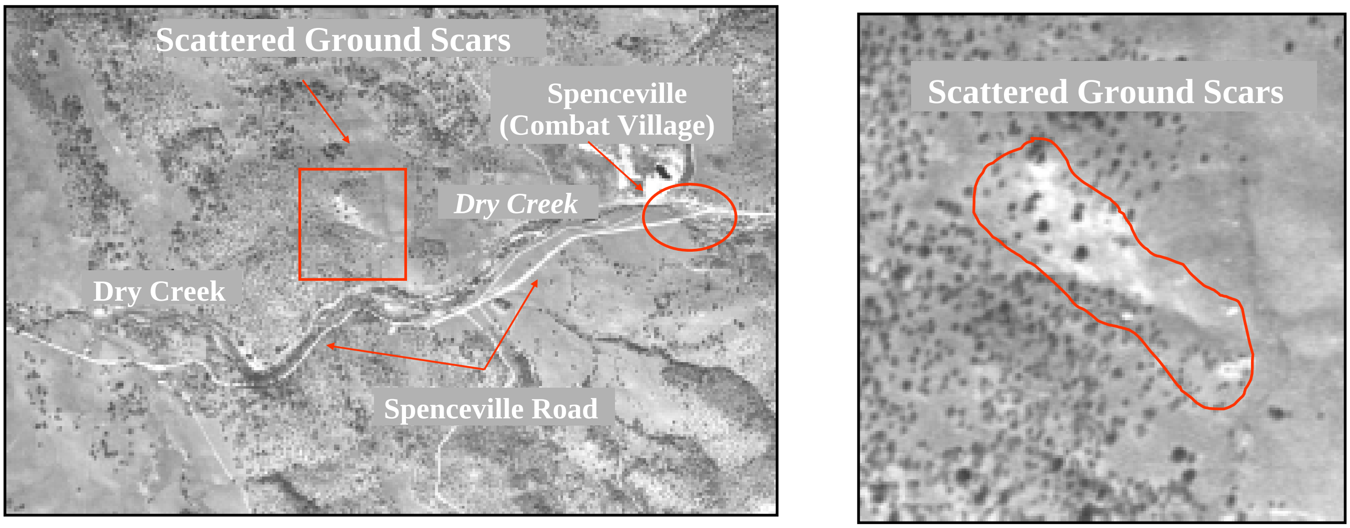

Figure 3-1. Ground Scars Indicating Potential OE Use

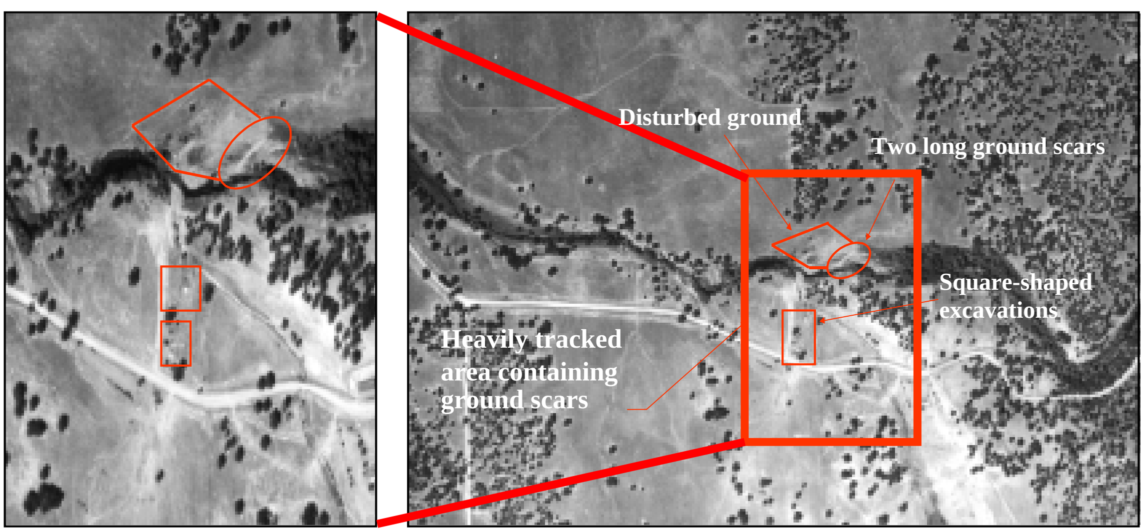

Figure 3-2. Tracked Areas and Ground Scars Indicating Past Range Activities

c. Military use of a site may change over time. The same range may be used for several different activities and therefore contain a variety of OE items. Range dimensions and orientations may change as a result of target relocation (Figure 3-3). The team must consider the potential for changing use at each OE site.

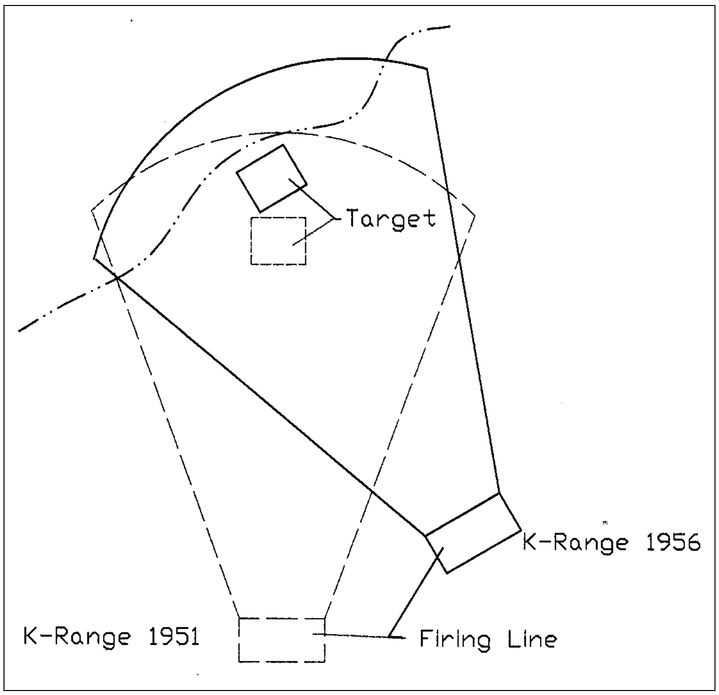

Figure 3-3. Range Orientation over Time

3-4. Physical Profiles

Physical properties of a site that affect the location, movement, detection, and recovery of OE are described in the Physical Profile for a site.

a. Location of OE. Location refers to both the areal (horizontal) extent as well as the vertical extent (depth) of OE.

(1) *Areal Extent of OE*. This is related to the distribution of OE items from the use that occurred at that site. Usually, the type or limits of fire of a weapon system or a munition will provide a basis for areal distribution of the OE. Standard layouts for range boundaries may be used to help determine the probable location of OE. Terrain features are important when assessing the dimensions or potential hazards of some ranges, as these can limit the areal extent of OE. Natural or man-made barriers will produce a “shadow effect” on the distribution of ordnance fired at a target with a terrain feature as a backstop. An illustration of this is provided in Figure

3-4. The standard layout for a range is shown in both design and as-built drawings for a former military installation. As shown on the as-built, the total area of the range is reduced by the terrain feature. Note this effect is more applicable to direct fire weapons (e.g., bazooka) rather that indirect fire systems such as mortar or artillery.

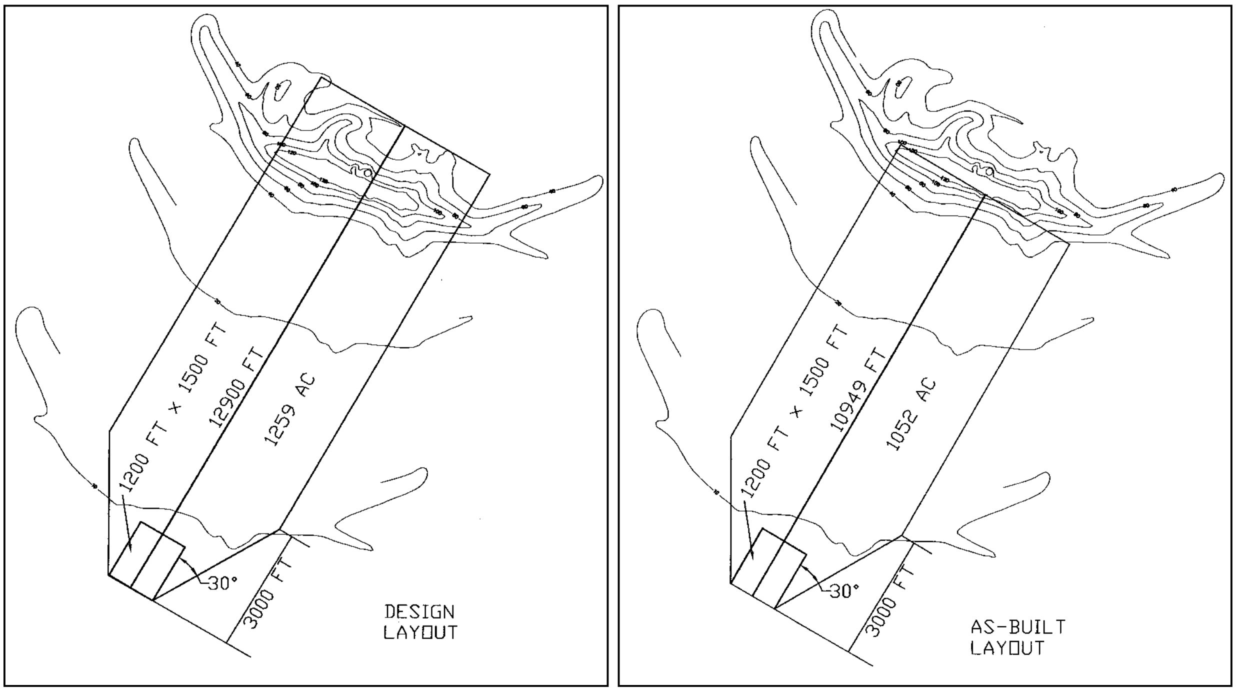

Figure 3-4. Terrain Effects on Range Dimensions

(2) *Vertical Extent of OE*. Subsurface conditions can affect the vertical extent of OE. For instance, soil type, soil moisture, and vegetation are important physical factors in determining the penetration depth of certain ordnance. The team should attempt to determine the probable depth of penetration by the ordnance. This information is important to determining both the 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.

b. Movement of OE. The team must evaluate physical processes that may affect movement of OE items. Erosion, scouring, or flooding of surrounding soil or sediment, frost heave, or tidal currents are natural processes that can cause movement of ordnance items from their original depth or location. The geology, geomorphology, and hydrology of the OE source area should be collected to assess this potential.

c. Detection of OE. Many naturally occurring site conditions affect the detection of subsurface OE. Physical characteristics affect specific detection instruments in different ways. Terrain and geology features may introduce electronic noise into the process, making detection difficult. Dense vegetation may affect the ability to get an instrument's sensor close enough to the surface, thereby limiting its effectiveness. Terrain, vegetation, and soil composition are key data elements to be collected. These data will be used in the selection of appropriate geophysical instruments and methods.

d. Recovery of OE. Certain physical features affect the ability to access and recover OE at a site, and this information should be collected. These features can include excessive relief, rough terrain, wetlands and water bodies, and difficult vegetation.

3-5. Release Profiles

Release mechanisms include those physical processes that contribute to the relocation of OE in the environment, after initial placement. An OE item tends to lie in place unless disturbed by either a natural process, as noted previously, or human activity. Construction, excavation, plowing or tilling, and surface soil or vegetation removal are examples of human activities that may relocate OE. Ordnance that was once deeply buried may become more accessible by removing overlying material. Any possibility of release of chemical constituents from OE items should be identified, considered as a source in an HTRW CSM, and addressed in an integrated CSM.

3-6. Land Use and Exposure Profiles

The Land Use and Exposure Profiles are used to identify on-site and surrounding off-site land use and associated receptors. The Land Use Profile must identify the means of access or potential activities. The Exposure Profile identifies the available receptors at and near a site, and the activities whereby they may contact OE. Demographic information should also be included. This process will also be performed for any reasonably anticipated future land use. These profiles will assist in determination of the appropriate receptors to be evaluated in the pathway analysis.

3-7. Ecological Profiles

The on-site or surrounding property should be described and its primary use documented. OE projects typically consider humans as the primary and often the only receptor to OE, because ecological receptors typically do not engage in activities that expose them to OE hazards. However, site activities in support of OE projects, particularly vegetation removal and detonation of recovered OE, may significantly affect ecological receptors and should be evaluated.

3-8. Pathway Analysis

Careful analysis of the profile information should allow the team to identify all source–receptor interactions for an OE project. The CSM will illustrate all potential exposure pathways (see Paragraph 2-6 for various CSM representations). For OE, an exposure pathway must include a **source**, **access**, **activity**, and a **receptor**. Interim measures, including access controls, source removals, or isolation methods, may interrupt the exposure pathway and should be considered in the analysis.

a. Sources. An OE source area is the location where ordnance or explosives are expected to be found, based on available information. The OE may be present as a result of direct military activities or placed there at some later time. Source areas were identified during generation of the Facility, Physical, and Release Profiles from available documentation or from direct evidence compiled during a site visit, or both. OE source areas are described by the following three components: the number and type of OE areas, the location and dimensions of each area, and the type and distribution (including depth) of OE within each area. Some processes such as frost heaving or erosion may change the location or distribution of OE items. This movement can increase the potential for direct contact.

b. Interaction. Information from all profiles will assist in identifying source–receptor interactions. Interaction is the means by which receptors come in contact with OE. This interaction requires two closely connected elements: access and activity. Access is the ability of a receptor to enter the source area. Activity is any action by a receptor that may result in direct contact with individual OE items.

Interaction between the receptor and an OE source has two components: access and activity. **Access** is the ability of a receptor to enter a source area. **Activity** is any action by a receptor that may result in direct contact with individual OE items in the source area.

(1) *Access*. The presence of access controls will help determine whether an exposure pathway to a receptor is complete, as fences or natural barriers can limit human access to a source area. The depth of OE items in subsurface soils may also limit access by a receptor. Additionally, the team must consider the effect that future land use can have on site access. Access may be unlimited for explosive ordnance disposal (EOD) personnel or construction workers, but may be restricted for nearby residents or other potential receptors. Ease of entry for adjacent populations (e.g., lack of fencing) can facilitate trespassing at the site, either intentional or accidental.

Access and Activity at an OE Site

(2) *Activity*. The hazard presented by OE is caused by direct contact as a result of some human activity. Site access without such activity does not present a hazard. Identification of OE exposure pathways should focus on current or future activities that bring humans into contact with the OE. Future use of OE land may result in intrusive activities (e.g., construction or agriculture) that also increase the potential for contact.

c. *Receptors*. The receptors evaluated in the OE CSM were identified in the Land Use and Exposure Profile. Both current and future receptors must be considered for OE sites, and access controls are critical to this determination. Human receptors are categorized by their ability to access the site combined with the activities that potentially allow contact with OE. Construction workers, ranchers, EOD personnel, recreational users, trespassers, and residents are examples of potential receptors.

Chapter 4
Development of a Conceptual Site Model for HTRW Projects

4-1. Introduction

This chapter describes the steps in CSM development for an HTRW project addressing environmental contaminants. As with an OE project, CSM development follows the TPP process with establishment of project objectives and DQOs. The primary focus of the HTRW CSM is to illustrate the interaction between contaminant sources and receptors. This is accomplished through development of the profile information (see Paragraph 2-4) and subsequent pathway analysis.

4-2. Profile Information Resources

a. Identifying profile information available for an HTRW 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 contracts or inventory records provide information about what items or materials were purchased and used by various departments. Operational manuals or procedures are also essential resources for 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. Some data may not meet quality standards for all uses. For example, data that are inadequate to evaluate risk may be acceptable to design a remedy. The decision to use the data should be based on their applicability to the project objectives. However, 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 there have been responses to chemical spills or incidents.

c. Site visits are highly recommended to identify significant features from all profile types for inclusion in the initial CSM. Local archives are often the best resource for information, and a site visit allows the opportunity to verify much of the written information. Visual evidence, such as soil stains or stressed vegetation, can directly indicate that HTRW contaminants are present.

> **Sources** of environmental contaminants should be described in terms of locations where the contamination exists and the types of contaminants present.

4-3. Facility Profiles

a. Facility Profiles provide information to determine the source areas at a site. The source area for an HTRW project should be identified based on the presence of an environmental contaminant. The team should be familiar with the historical operations at a site to recognize potential unauthorized disposal sites or areas with a likelihood for incidental spills or releases. At HTRW sites, source areas typically include landfills, surface impoundments, fire training areas, process buildings, and underground storage tanks. All suspected source areas should be marked clearly on a site map, including the relationship to property boundaries.

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.

b. Sampling data are typically the most reliable indicator of contamination sources at a site. In the absence of adequate sampling data, 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 areas and should be included in the profile information.

4-4. Physical Profiles

a. The factors that affect the fate and transport of the contaminants are identified in the Physical Profile. This information includes soil type, soil properties, precipitation data, surface and ground water characteristics, and topography.

b. Physical profiles also describe site conditions important in determining exposure potential. Excessive topographic relief, dense vegetation, water bodies, or other physical characteristics may prevent or deter access to some sites, which limits potential for exposure.

c. Physical profiles are also important for identifying constraints to field activities and evaluating potential response actions.

4-5. Release Profiles

a. A contaminant is rarely immobile in the physical 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 another exposure medium.

Release mechanisms should be identified for each source present at the site. Multiple release mechanisms may exist for each source area.

b. Multiple release mechanisms may exist for the same source. A drum of liquid contaminant may leak to soil as a primary release, then create a secondary release through percolation or infiltration. Volatilization of that contaminant from the soil may also occur, which adds another release mechanism from the primary source. Contaminated soil or sediment may become airborne or migrate through erosional processes to contaminate another medium. All potential release mechanisms and resulting contaminated media must be carefully evaluated.

c. Exposure media contain the source or become contaminated through migration of the contaminant from the source area. Examples of exposure media are surface soil, subsurface soil, ground water, sediments, surface water, and air. The biotic medium can exist through uptake, accumulation, or concentration of contaminants by organisms and subsequent transport of that contaminant through the food chain.

4-6. Land Use and Exposure Profiles

a. The Land Use and Exposure Profiles are used to identify on-site and surrounding off-site land use and associated receptors. These profiles should also include locations of natural resources and how they are used.

b. The team should determine current use of the property and surrounding land. Demographic as well as sensitive subpopulation information is included in this profile. Any beneficial resources at the site must also be identified. This will aid in determining the appropriate receptors to be evaluated in the pathway analysis.

c. The exposure profile identifies the available receptors at and near a site. A receptor is a person or population that is or may be exposed to a release. Both current and potential future receptors must be identified.

4-7. Ecological Profiles

The Ecological Profile for an HTRW project includes a description and use of the natural habitats at and surrounding the site. Identification of receptors is usually enhanced by use of maps that show the ecological profile and land use surrounding the facility and contaminant migration routes from the source. Ecological receptors may include individual organisms, populations, communities, or habitats and ecosystems. Threatened and endangered species, as well as migratory species, must be identified if they are present.

4-8. Pathway Analysis

Careful analysis of the profile information should allow the team to identify all source–receptor interactions for an HTRW project, for both current and reasonably anticipated future land use. The CSM will illustrate all potential exposure pathways (see Paragraph 2-6 for various CSM representations). An exposure pathway is the

> An HTRW **exposure pathway** requires a source, an exposure medium, an exposure route, and a receptor. If any one of these is absent, that pathway is incomplete and no risk can be assigned. This effort must be documented to demonstrate that the potential for risk from this pathway has been evaluated.

course a physical or chemical agent takes to contact a receptor. Each pathway must include a **source**, an **exposure medium**, an **exposure route**, and a **receptor**. The pathway may also include a release mechanism (e.g., volatilization) and a transport medium (e.g., air), if the point of exposure is not at the same location as the source. It is important to remember that certain activities, such as soil excavation, can create a complete exposure pathway where one does not currently exist.

a. Sources. Source areas are identified when the Facility, Physical, and Release Profiles are generated, and will be used for the pathway analysis.

b. Interaction. For HTRW sites, the source–receptor interaction requires that exposure media and exposure routes be evaluated. Information from all profiles will assist in identifying these interactions.

(1) *Exposure Media*. Exposure media are those that contain the source, or those media that become contaminated through migration of the contaminant from the source area.

(*a*) Exposure to soil (surface and subsurface) is important where there is potential for receptor contact with contamination or for contaminant migration into another medium. The team must determine the depth of contamination, the potential for human or biotic contact with the contamination, and the migration potential of the contaminant.

(*b*) Exposure to ground water is important when contaminated ground water is used for domestic purposes. Contaminants are rarely released directly into ground water. Typically, ground water is contaminated by migration from another medium. The team must consider factors that affect the likelihood of a contaminant reaching ground water, such as depth to the aquifer and permeability of the overlying strata. Contaminant migration within the aquifer must consider transmissivity of the water-bearing unit as well as fate and transport properties of the contaminant.

(*c*) Exposure to sediments is most important to ecological receptors, as sediment-dwelling organisms typically serve as a food source for higher trophic level organisms. Human receptors can be exposed under certain conditions, such as through wading or swimming.

(*d*) Exposure to surface water is important when contamination is released directly to the surface water body, or through contaminant migration from another medium (e.g., surface soil or ground water). Human receptors can be exposed through recreational activities (e.g., swimming, wading, or fishing) or domestic uses of the surface water.

(*e*) Exposure to air is important when particulate dispersion of contaminated soils or sediments, release of volatile compounds from soils or sediments, or volatilization of contaminants from surface water is possible. Prevailing wind directions should be determined to measure potential for receptor exposure to this medium.

(*f*) The biotic medium is important when considering the potential for transfer of contaminants through the food chain. Additionally, bioaccumulation and bioconcentration of some contaminants in plants or animals can result in exposure of other receptors to harmful contaminant concentrations.

(2) *Exposure Routes*. Exposure routes are those processes by which a contaminant or physical agent comes in contact with a receptor. For most environmental contaminants, these processes include ingestion, inhalation, and dermal contact. 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 and incidental ingestion while swimming. Inhalation of volatile compounds released from water is a third potential exposure route in this scenario, depending on the properties of the contaminant. Multiple receptors may be, and typically are, exposed through a single exposure route. Ingestion of contaminated surface water is as much a concern for terrestrial or aquatic wildlife as for humans.

c. *Receptors*. The receptors evaluated in the HTRW CSM were identified in the Land Use and Exposure Profile, as well as the Ecological Profile. The team must consider both human and ecological receptors. Evaluation of actual and potential receptors will consider both current and reasonably anticipated future land use. In addition, human receptors are typically subdivided into several categories to represent varying degrees of potential exposure. These may include residents, site workers, construction workers, recreational users, and trespassers. The probability, frequency, and duration of each receptor's exposure to the contaminant are assessed in this manner.

Chapter 5
Development of an Integrated Conceptual Site Model for OE and HTRW Projects

5-1. Introduction

a. This chapter describes the steps in CSM development for properties whose historical military use creates a potential for OE and HTRW that may require assessment and response. When the potential for OE and HTRW exists on a site, then an integrated CSM should be developed. An integrated CSM addresses all source–receptor interactions for both OE and HTRW from all sources at a site. Typically, the HTRW project will follow the OE project phase. In such cases, data needs for the HTRW project must be communicated early on to ensure that OE project efforts support those needs when possible. As noted in Paragraph 2-3, the PM should assemble a team to address both OE and HTRW issues, and oversee the integration of overlapping data needs. An integrated CSM will facilitate concurrent OE and HTRW data collection.

Early and ongoing **coordination** between OE and HTRW personnel is critical to efficient planning and execution of an integrated project. Ideally, during the early stages of the project, OE personnel will coordinate with the HTRW team members to ensure data collected will meet their DQOs.

b. The overall approach to developing the CSM is the same for an integrated project as for an OE site and an HTRW site: profile information is collected and pathways are subsequently analyzed. CSM development is a tool in the TPP process. The team must collect and analyze existing profile information, prepare an initial CSM, develop project DQOs for that phase of the project, and collect necessary data specific to fulfilling those objectives.

5-2. Profile Information Resources

OE and HTRW project phases have distinct information needs and some that are common to both. The information needs described in the following sections represent some areas where OE and HTRW data needs may overlap. These summaries are not specific to any project or site, but provide a general guide to information needs that may be shared by the team members. Profile information resources for OE and HTRW sites described in previous chapters will be used, and need to be shared by all team members.

5-3. Facility Profiles

a. Facility Profiles provide information to help determine the source areas at a site. When both OE and HTRW may be present, the team needs to gather and sort facility profile information that supports both OE and HTRW projects.

b. A primary information need common to CSM development for OE and HTRW projects is delineation of the OE use areas, OE area type, and the type and distribution of OE in each area. Many OE areas have the potential not only for OE, but also explosives constituents that may result in environmental contamination. Explosives and propellants from low-order detonations or prolonged use of an area have been shown to affect soil, sediment, and ground water media at some locations.

c. For example, investigation at an artillery range would typically be started as an OE project. The team would, in the course of their investigation, define the range boundaries of this OE use area to focus their investigation. They may divide the range based on known or anticipated density of ordnance fired at the target area over the years (Figure 5-1). This information would be critical to an HTRW CSM as well, allowing that project phase to focus investigations in those areas most likely to be a source of subsurface chemical contamination from the OE constituents (Figure 5-2).

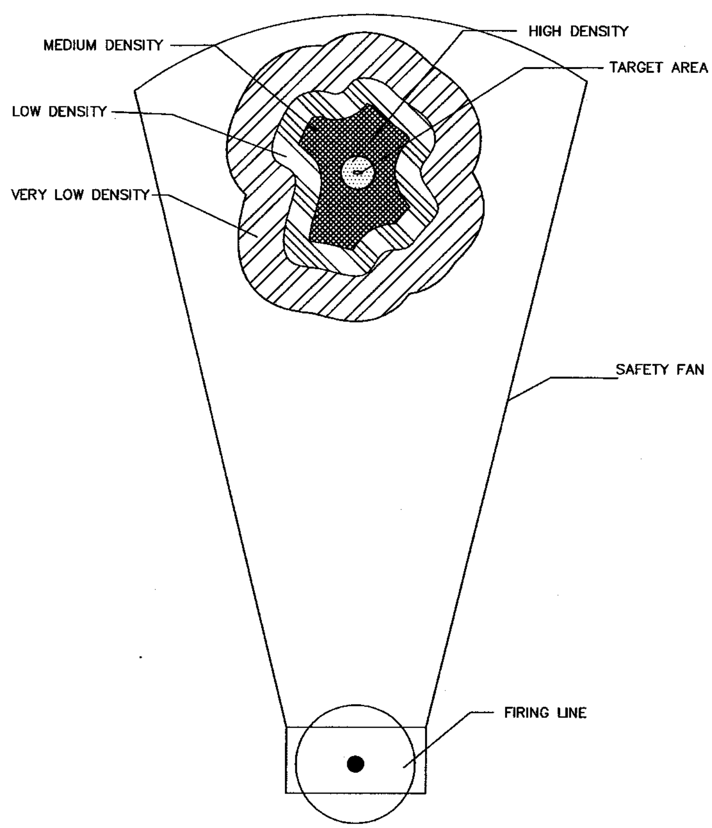

Figure 5-1. Density Distribution of Projected Ordnance

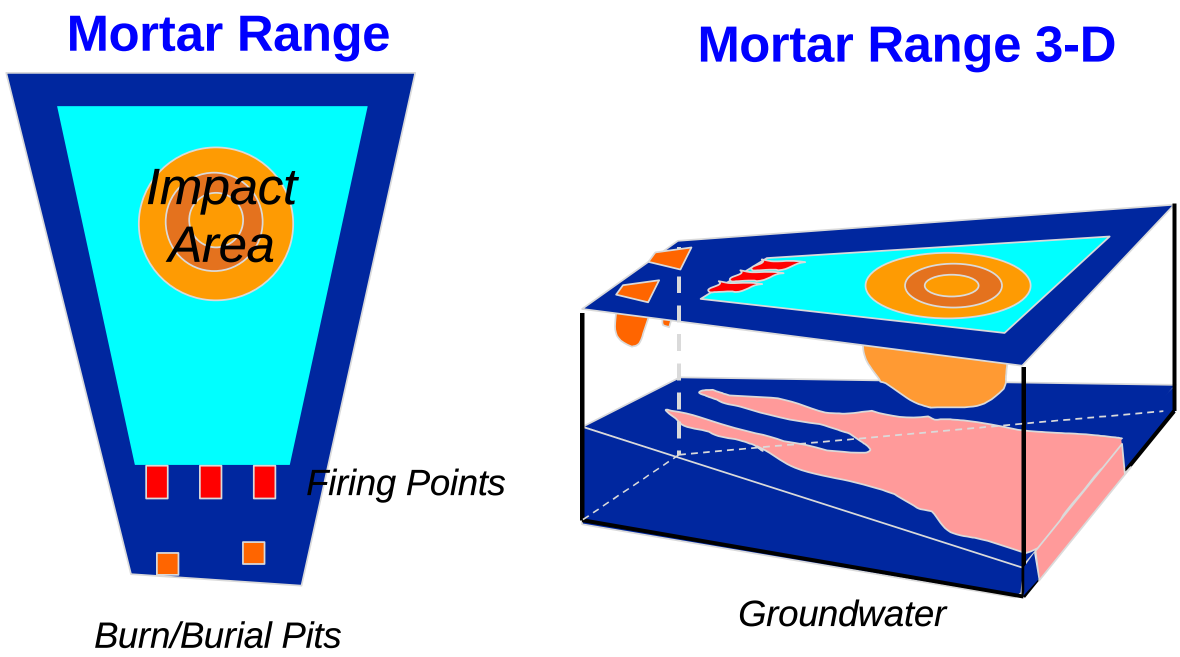

Figure 5-2. Areas of Potential OE and HTRW Distribution at a Mortar Range

d. Many locations with OE also have a potential for chemical contamination. For example, open burn (OB) units often used fuels as accelerants when excess ordnance is destroyed. Similarly, the manufacture of explosives at ammunition plants generated large quantities of waste rinse water that was retained in impoundments and often releases contaminants to other media.

e. The type of OE used at a site is an important information need for an integrated project. This information is critical to understanding the explosive hazards and the possible chemical contamination resulting from OE constituents. All team members will need to work together to identify explosives and propellants by their precise composition. Changes in the chemical composition of constituents occur over time and from exposure 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 that are extremely shock sensitive.

5-4. Physical Profiles

OE and HTRW projects can share most physical profile information. Site topography, geology, meteorology, and hydrology data are examples of common data needs. Soil type and soil properties (moisture content, corrosivity, pH, etc.) are important for evaluation of depth of OE and the fate and transport of chemical contamination. The same type of OE use area in a different physical setting will present different environmental challenges. Because physical profiles also affect access to OE, this information must be clearly presented.

5-5. Release Profiles

Release mechanisms include those natural processes or human activities that relocate OE or introduce and distribute an HTRW contaminant in the environment. For HTRW, this often leads to migration from the source area to another exposure medium.

5-6. Land Use and Exposure Profiles

Land use and receptor information is common to both OE and HTRW projects. The team must consider both current and reasonably anticipated future land use so that all source–receptor interactions can be evaluated. Although the source–receptor interactions may differ, understanding receptor populations and their activities is necessary for either investigation.

5-7. Ecological Profiles

The Ecological Profile will identify surrounding land and habitats and will aid the team in determining potential ecological receptors. Special use areas (e.g., fisheries) as well as protected species potentially impacted by the site should be described.

5-8. Pathway Analysis

The Pathway Analysis for an integrated site will allow the team to identify all source–receptor interactions for both the OE and the HTRW components of the project. Analyzing exposure pathways for OE or HTRW projects requires linking a source to a receptor, although the interactions differ. All complete exposure pathways will be illustrated in the integrated CSM. Figure 5-2 presents an example integrated CSM for an OB/open detonation (OD) area (the generation of this integrated CSM is explained in Appendix D).

a. Source. All sources can be identified by analysis of the Facility, Physical, and Release Profiles. The team needs to be aware that many types of OE use areas can provide a source of HTRW, and ensure that the integrated CSM evaluates these sources. Common sources must be dealt with in an integrated way, and will become part of an integrated CSM.

b. Interaction. Information from all profiles will assist in identifying source–receptor interactions. Analysis of the interactions for an integrated CSM consists of separate evaluations for the OE and the HTRW component. For either component, the interaction has elements that must be present for the pathway to be complete. Those interactions forming complete pathways will be shown in the integrated CSM.

c. Receptors. Receptors are identified from the Land Use and Exposure Profile, as well as the Ecological Profile. The evaluation of receptors must take into account current and future land use. Site restrictions for OE may also limit or alter the receptors evaluated for the HTRW component. The team needs to consider all receptors with the potential for exposure to sources at the site.

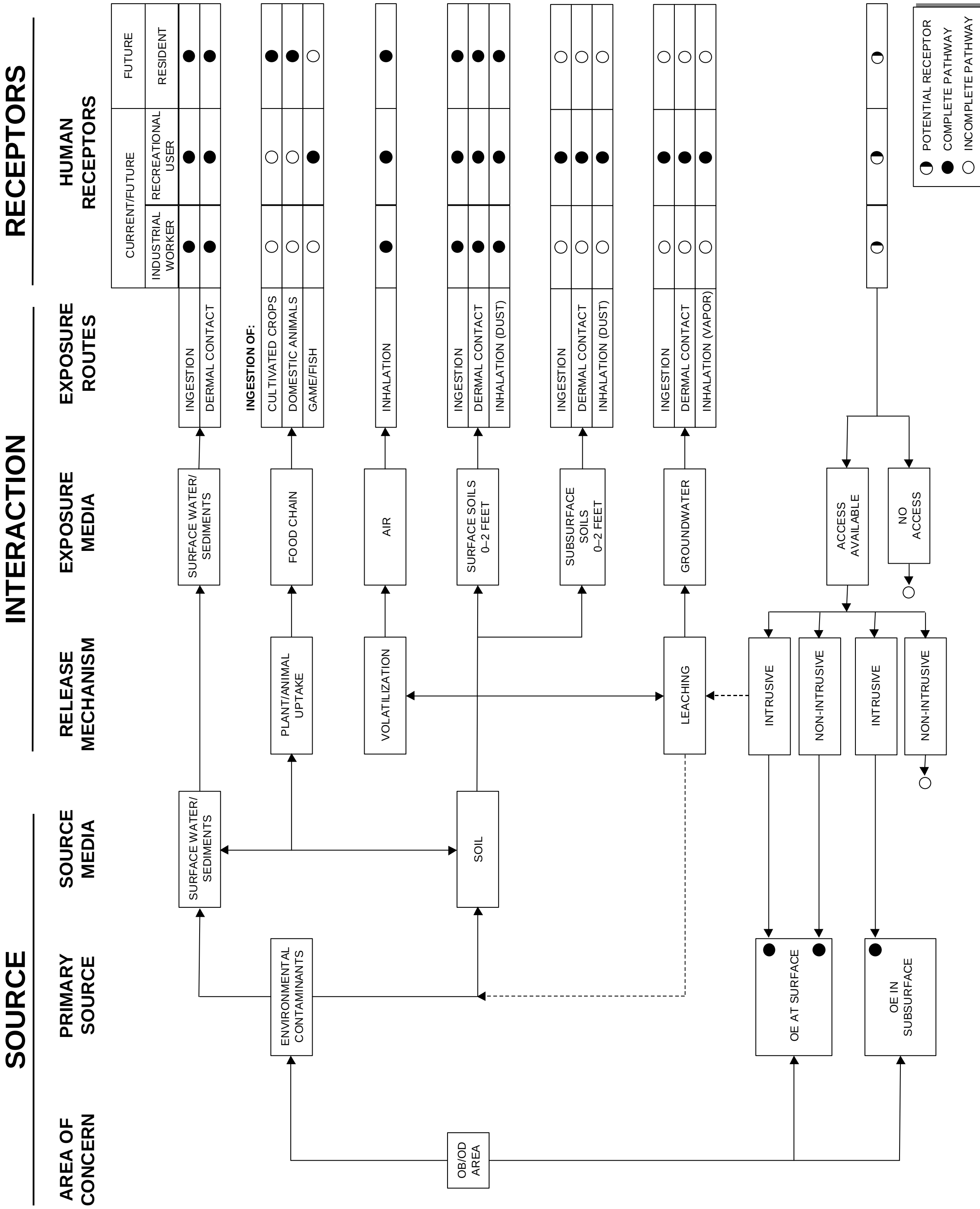

Figure 5-2. Example Integrated CSM for an OB/OD Area

Appendix A
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Appendix B
Acronyms And Definitions

ASR	Archives Search Report
ASTM	American Society for Testing and Materials
CSM	Conceptual Site Model.
CWM	Chemical Warfare Material
DoD	U.S. Department of Defense
DQO	Data Quality Objective
EM	Engineering Manual
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
ER	Engineer Regulation
GIS	Geographical Information Systems
HTRW	Hazardous, Toxic, and Radioactive Waste
IDA	Industrial Development Authority
OB	Open Burn
OD	Open Detonation
OE	Ordnance and Explosives
PDT	Project Delivery Team
PM	Project Manager
TPP	Technical Project Planning
USACE	U.S. Army Corps of Engineers
UXO	Unexploded Ordnance

Access
The ability of a receptor to enter a source area.

Activity
Any action by a receptor that may result in direct contact with individual OE items in the source area.

Archives Search Report (ASR)
An ASR is an evaluation of past OE activities at an installation. The purpose of an ASR is to assemble historical records and available data and assess potential ordnance presence.

Conceptual Site Model (CSM)
The CSM is a description of a site and its environment that is based on existing knowledge. It describes sources of OE or HTRW at a site; actual, potentially complete, or incomplete exposure pathways; current or reasonably anticipated future land use; and potential receptors. The source–receptor interaction 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 team.

Data Implementor

Technical personnel (e.g., chemists, engineers, geologists, scientists) who contribute to the data implementor perspective are responsible for identifying sampling and analysis methods suitable for satisfying the data users' data needs. Data implementors are generally referred to as either a sampling or analysis type of data implementor. Data implementor is a classification used in EM 200-1-2, *Technical Project Planning (TPP) Process*.

Data Quality Objective (DQO)

DQOs are qualitative and quantitative statements that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions. They are project-specific statements that describe the intended data use(s), the data need requirements, and the means to achieve them (sampling and analysis) for each data point. DQOs become the formal documentation of the data quality requirements.

Data User

Data users are technical and other personnel responsible for engineering, scientific, and legal evaluations that are the basis for site decisions. Progress to site closeout typically requires the collaborative involvement of many technical disciplines to represent data user perspectives of risk, compliance, remedy, and responsibility. Data users are responsible for determining data needs required to satisfy the project objectives. Data user is a classification used in EM 200-1-2, *Technical Project Planning (TPP) Process.*

Decision-Maker

Decision-makers (i.e., customer, project manager, regulators, and stakeholders) each have specific interests in the outcome of site-related activities. The most important responsibility of each decision-maker is to participate in the team's efforts to identify and document project objectives during early phases of the planning process. Decision-Maker is a classification used in EM 200-1-2, *Technical Project Planning (TPP) Process.*

Exposure

Contact of an organism with a chemical or physical agent. Exposure is quantified as the amount of the agent available at the exchange boundaries of the organism (e.g., skin, lungs, organs) and available for absorption. (EPA/540/1-89/002)

Exposure Pathway

The course a chemical or physical agent takes from a source to an exposed organism. An exposure pathway describes a unique mechanism by which an individual or population is exposed to chemical or physical agents at or originating from a site. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route. If the exposure point differs from the source, a transport/exposure medium (e.g., air), or media, also is included. (EPA/540/1-89/002)

Exposure Point
A location of potential contact between an organism and a chemical or physical agent. (EPA/540/1-89/002)

Exposure Route
The way a chemical or physical agent comes into contact with an organism (e.g., ingestion, inhalation, dermal contact). (EPA/540/1-89/002)

Interaction
Ways that receptors come into contact with a source.

Media
Air, surface water, sediment, soil, and ground water are the most common types of environmental media at a site. Media can be any naturally occurring environmental material that can be affected by contamination at a site.

Ordnance and Explosives (OE)
Ordnance and explosives consists of either (1) ammunition, ammunition components, chemical or biological warfare material or explosives that have been abandoned, expelled from demolition pits or burning pads, lost, discarded, buried, or fired (i.e., UXO) and that are no longer under accountable record control of any DoD 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. (EP 1110-1-18)

Project Delivery Team (PDT, Team)
The PDT is responsible and accountable for ensuring that effective, coordinated actions combine to deliver the completed project according to the Project Management Plan. The PDT shall consist of everyone necessary for successful development and execution of all phases of the project. PDT members will include the customer, the PM, representatives from various technical disciplines within USACE, stakeholders, representatives from other federal or state agencies, vertical members from division and headquarters, and others necessary to effectively develop and deliver a successful project. The team composition can vary greatly, depending on the specific goals and expectations of the customer. The USACE team members may come from any functional area or geographic location, and are selected solely on their ability to successfully plan and execute their portion of the project. They may be on the team full time or only on a temporary basis.

Project Objectives
Project objectives are the short- and long-term site issues to be addressed and resolved at a site. Satisfying or resolving the project objectives, based on the underlying regulations or site decisions, is the purpose of all site activities. Most project objectives are a consequence of the governing statutes and applicable regulations.

Receptor
A receptor is an organism (human or ecological) that contacts a chemical or physical agent.

Source
Sources are those areas where OE or HTRW has entered (or may enter) the physical system.

Stakeholders
Individuals and organizations that are involved in or may be affected by the project.

Technical Project Planning (TPP) Process
The process for designing data collection programs at HTRW sites. The TPP process helps ensure that the requisite type, quality, and quantity of data are obtained to satisfy project objectives that lead to informed decisions and site closeout. The four phase TPP process is a comprehensive and systematic planning process that will accelerate progress to site closeout within all project constraints. The TPP process can be used from investigation through closeout at small, simple sites, as well as large, complex sites. The TPP process is a critical component of the USACE quality management system that meets the American National Standard Institute for planning collection and evaluation of environmental data. The TPP process is documented in EM 200-1-2, *Technical Project Planning (TPP) Process*.

Unexploded Ordnance (UXO)
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. (EP 1110-1-18)

Appendix C
Range Operations Overview

C-1. General

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.

C-2. Storage Areas

These 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 are 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.

C-3. Firing Points

These 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 them to their 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.

C-4. Targets

These 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 safety 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 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. As indicated by the example in Figure C-1, determination of the OE hazards in an impact area can be quite complex. Numerous weapons systems firing a different types 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. UXO (armed or fuzed) and residual OE compounds are likely to be present.

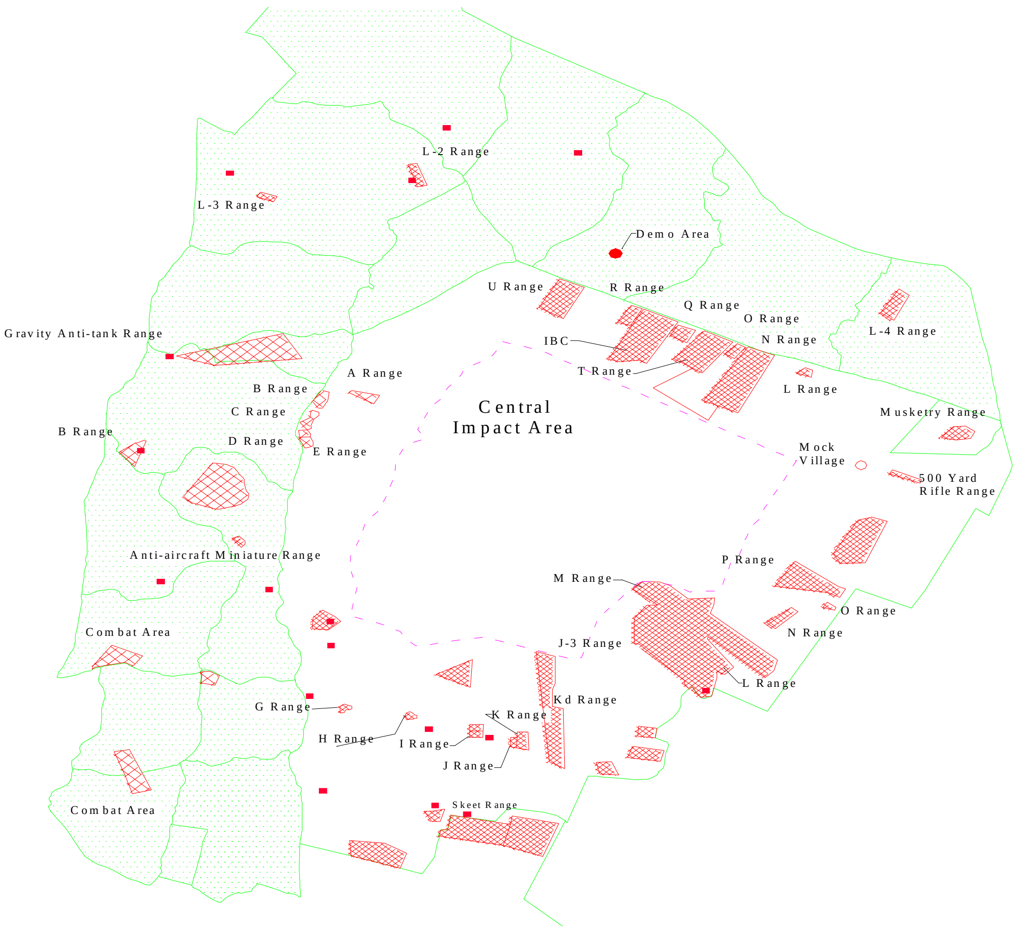

Figure C-1. Typical Range Complex Impact Area

C-5. OB/OD Areas

These 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 moveable, and those that are determined unsafe to move. Those that are unsafe to move are destroyed where they are found by detonating in place. 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
Development of an Integrated CSM

D-1. Introduction

The following is a hypothetical example for demonstration only. It is intended to illustrate how a team might begin the process of developing an integrated CSM. The reader is cautioned that CSM development should be based on site-specific parameters and information.

D-2. Background

a. Former Camp Swampy was a World War II facility for training of U.S. Army troops. The facility was declared excess in 1956, and in 1957 the property transferred to the local township Industrial Development Authority (IDA). The IDA transferred a small parcel in the southeast corner to a private landowner 2 years later. The remaining property has been subsequently leased to several commercial enterprises for various uses. An ASR conducted in 1993 identified a mortar range and OB/OD area at the former camp. Surface clearance had been conducted prior to transfer, and no OE items were known to remain at the site. In 2001, several explosions were heard during a prescribed burn in a forested area of the former installation. The detonations were suspected to be from mortar rounds on the property. Presented with this information, the IDA contacted the local district of the USACE for assistance. Since no extensive sampling investigation had been conducted prior to the transfer, the District initiated an integrated OE/HTRW investigation.

b. A PM from the geographic District was assigned overall management of the former Camp Swampy investigation. The OE project will precede the HTRW investigation. To initiate the project, the PM assembled a PDT (team) consisting of OE specialists, HTRW specialists, state and federal regulators, and representatives from the IDA, business owners, and local landowners at the site. The team's first order of business was to establish goals and objectives of the investigation to follow. One of the objectives was to develop a CSM to capture the source–receptor interactions to guide future data collection efforts. The team gathered all historical information available for the site, including aerial photographs from the operating period of the facility. The team then organized the available information into the following profiles.

D-3. Facility Profile

a. The team was able to determine current use and ownership of former Camp Swampy from existing information and a site visit. The majority of the 18,000-acre facility is leased from the IDA by a timber products company and used to grow pine trees. The timber products company also sub-leases this land to a local hunting club, which has a cabin on the northern boundary of the property. The acreage is not fenced, but there are locked gates across access roads through the property. The industrial area (the former cantonment area) still has several buildings that are in use at the site, also leased through the IDA. A metal fabrication shop occupies one building, and a grocery storage company uses two warehouses and an office building. A 6-foot tall security fence surrounds the industrial area.

b. An existing map from 1943 for former Camp Swampy revealed the location of both the mortar firing line and the OB/OD area. The actual mortar range dimensions, however, were not documented. The map was updated with information the team had uncovered and is shown as Figure D-1. Because the detonations occurred during a controlled burn at the tree farm, the team hypothesized that cultivation and harvesting of the trees over the years resulted in relocation of OE items through disturbance of the soil. This activity, and the presence of the planted pines, had obliterated any ground scars that may have once existed at the site.

c. The team obtained a standard range layout for mortar ranges for the 1943–1945 period to establish approximate dimensions for this OE use area (Figure D-2). The team also noted that the standard layout was typically modified to meet site conditions. A typical mortar range has three areas of concern, the firing point (firing line), the impact area, and the danger area. The firing line is assumed to be 75 feet (25 yards) wide and the impact area (target area) is assumed to begin a minimum of 1800 feet (600 yards) from the firing point, continuing downrange the maximum distance of the mortars fired. These dimensions were estimated using an 81-mm HE, M43 mortar as worst case, which has a maximum range of 11,700 feet (3,300 yards). Regulations require that an additional 1800-foot (600-yard) danger area be applied to each side and to the downrange distance. The area of the explosions appeared to be consistent with the range impact area identified by the standard layout.

d. The OB/OD area was defined by operating manuals as a 400-foot diameter circle at the crest of a small hill. During the site visit, the team noted an area of bare, disturbed soil and stressed vegetation in this area. Five distinct mounds were visible that indicated debris burial from the OB/OD operation. The team hypothesized that the potential OE items included mortars, small arms, smokes, flares, and simulators as both broken and unfunctioned rounds. OE scrap was noted across the entire area. An accelerant, either gasoline or diesel fuel, was assumed to have been used to initiate the burns.

D-4. Physical Profile

a. The facility is located in an area of gently rolling hills, with topographic relief of not more that 50 feet. Coastal plain sediments dominate this area, with well-sorted sand being the dominant strata and major component of the soil. The rapid drainage characteristics of this soil make it an excellent medium for growing pine trees, a major industry of the area. In addition to the dense rows of pine trees, most of the acreage also supports thick underbrush that is periodically burned to allow better access to the trees.

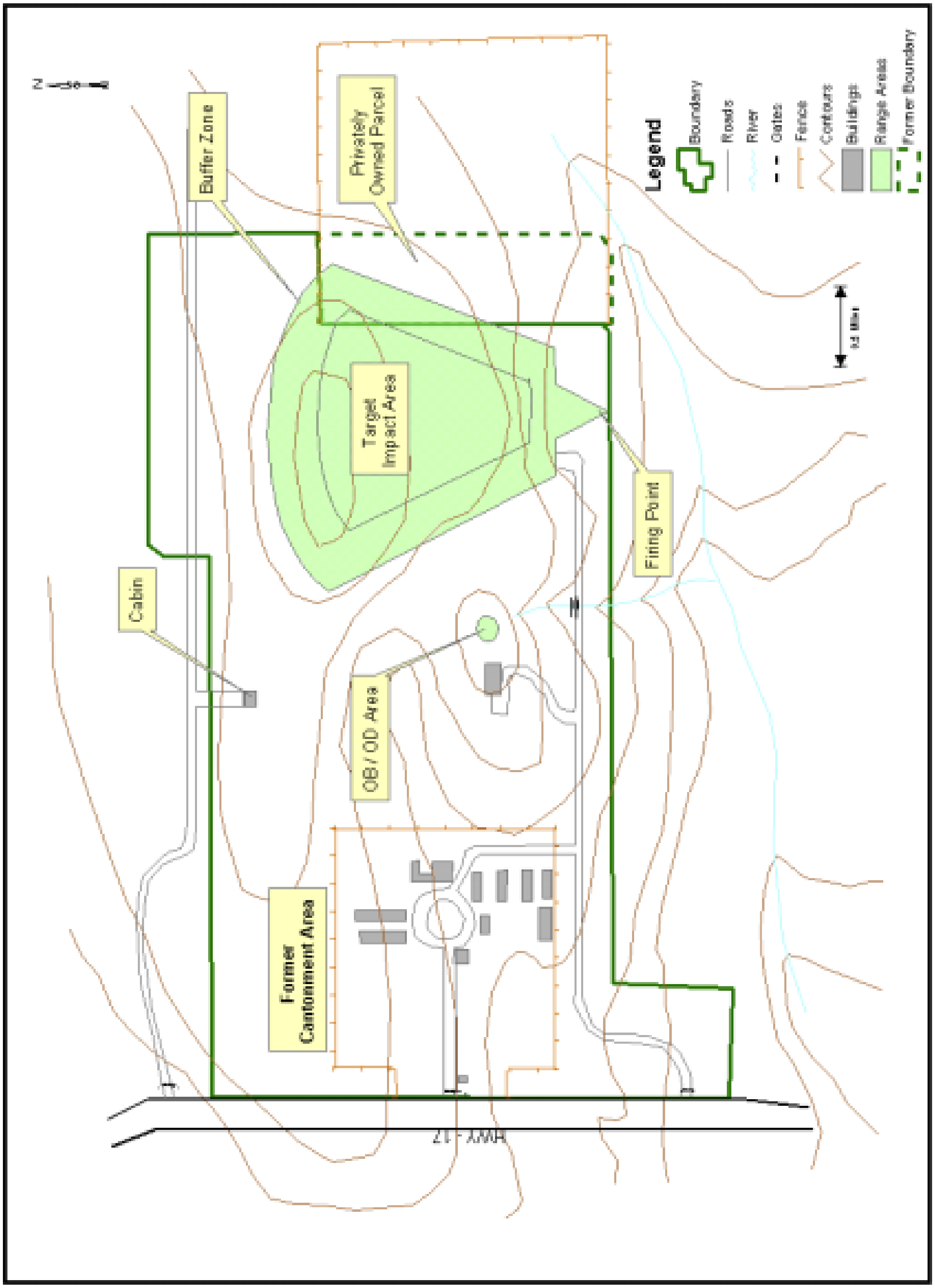

Figure D-1. Preliminary Site Map

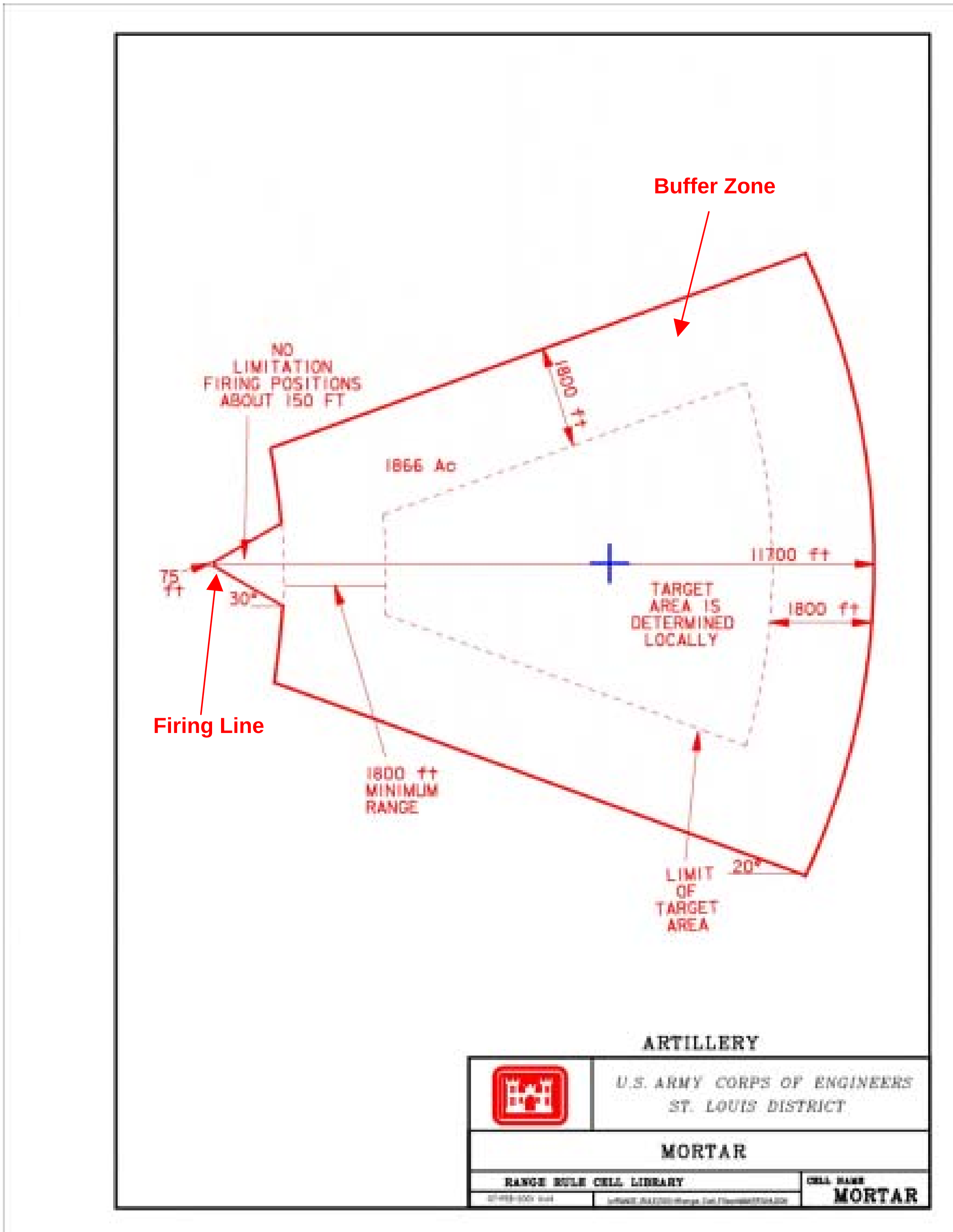

Figure D-2. Mortar Range

b. The team reviewed available state records of residential drinking water wells in the surrounding area and determined that ground water averaged 20–25 feet below ground surface. There are no wells in the former cantonment area, but it was discovered that a shallow water well exists at the cabin, presumably used during the hunting season.

c. A small creek originates about 150 feet southeast of the OB/OD area. Some red staining, thought to be iron oxide, was noted seeping from the creek bank downhill of the OB/OD area. The creek joins a river about 1.5 miles west of the facility. Despite the former camp's name, there are no wetland areas located at the property.

D-5. Release Profile

Using the Facility Profile information, the team identified the OE areas of concern as the former mortar range and the OB/OD area. The mortar range was further divided into two areas based on typical use, the hazards associated with that use, and potential source materials. These two areas are the firing line and the impact/target area. The probable locations of all source areas were placed on the site map for later confirmation.

D-6. Land Use and Exposure Profile

a. The team documented use of the former mortar range as managed forest lands, and the former OB/OD area as currently unused. The on-site population includes workers at the industrial area, but interviews with these personnel indicated that they do not utilize either area during work hours. Timber company workers occupy the areas of concern on those occasions when planting, harvesting, or the controlled burns occur. Recreational use (hunting and hiking) was also noted, although the team has not yet identified the extent of this site use.

b. The surrounding land use is agricultural, with 12 single-family homes located within a 3-mile radius of the property. These residents rely on private wells for their drinking water. The industrial area, however, is serviced by the municipal water supply system. The small creek traversing the site discharges to a river that is used extensively for recreation (boating, swimming, and fishing).

D-7. Ecological Profile

The Ecological Profile for former Camp Swampy includes a description of the managed pine forest habitat that occupies most of the acreage. Ecological receptors include game animals (e.g., deer, turkeys) and other terrestrial animals. Fish and other aquatic organisms inhabit the downstream river, which serves as a popular recreation area. No threatened or endangered species are known to utilize the area.

D-8. Pathway Analysis

Analysis of the profile information should allow the team to identify all source–receptor interactions (exposure pathways) for the site. An exposure pathway is the course a physical or chemical agent takes to contact a receptor. For OE, an exposure pathway must include a source, access, activity, and a receptor. Each pathway for HTRW must include a source, an exposure medium, an exposure route, and a receptor. The pathway may also include a release mechanism (e.g., volatilization) and a transport medium (e.g., air), if the point of exposure is not at the same location as the source. In preparation for the CSM, the team compiled the following.

D-9. OE Sources

Three source areas were identified. They are the firing line at the mortar range, the mortar impact area, and the OB/OD area. OE is expected in subsurface soils at the firing line, and both surface and subsurface soils at the impact area and OB/OD area. The exposure media for the mortar range areas are expected to include surface and subsurface soils, as well as ground water from leaching of the OE constituents and accelerants. The same exposure media are expected for the OB/OD area. Additionally, the bare soils at this area make releases to air a potential, as well as releases to surface water and sediments in the nearby creek.

- The firing line was hypothesized to potentially contain a burn area and burial pits. A burn area was common during training to dispose of excess propellant charges from the mortars. Disposal pits were another concern to the team. An uncommon but potential practice was to bury unused munitions near the firing point, rather than return these to the Ammunition Supply Point. This type of unsanctioned burial usually would occur near the firing point. The potential contaminants at the firing line area are explosive and propellant compounds, including trinitrotoluene, nitrocellulose, nitroglycerin, dinitrotoluene, as well as fuels and metals. The potential for OE items buried at the firing line to function is low because the expected items are probably unfuzed, and if fuzed, would not have been subjected to the forces required to arm the fuzes.

- The expected contaminants at the impact area include TNT and its breakdown products, and this area is also suspected of having a serious explosive safety hazard from UXO resulting from dud-fired rounds or incomplete detonation. The team will evaluate site conditions to determine the expected depth of penetration of OE at the impact area.

- The OB/OD area is identified as a third source area at the site. Probable source materials at this area include all types of munitions used at the installation (e.g., mortars, small arms rounds, smokes, flares), due to kick-outs during operations. The potential for OE items functioning was also noted as low because the expected items are probably unfuzed, and if fuzed, would not have been subjected to the forces required to arm the fuzes.

a. Interaction. The source–receptor interactions for an OE site require access and activity.

(1) *Access*. Currently, access to the source areas is unlimited. Future access restrictions are unlikely as well, as the reasonable future site use is expected to remain the same.

(2) *Activity*. Current and future activities that can bring receptors into contact with OE are tree farm activities (cultivation/planting of trees, harvesting of the trees, and conduct of the occasional controlled burns), as well as recreational site use, whereby hunters can contact OE items at the ground surface.

b. Receptors. On-site tree farm workers have the greatest exposure potential since their jobs entail intrusive work. On-site recreational users and off-site residents have the potential for exposure; however, their on-site activities would make it less likely for direct contact with OE.

D-10. HTRW Sources

HTRW source areas are the same as those for OE. The firing line at the mortar range has the potential for release of HTRW into the surface and subsurface soils. Contaminants at this area are expected to be explosives and propellants and their breakdown products. This area is also suspected of containing an accelerant, probably diesel fuel, to facilitate burns. At the mortar impact area, the team expects TNT and its breakdown products to be found in surface and subsurface soils. The third source area is the OB/OD area. Both surface and subsurface soil are expected to contain explosives, their breakdown products, and metals. Fuel contamination from an acceller-ant is also likely at this location. The team also documented the red staining at the creek so that future site investigations can verify its composition.

a. Interaction. The source–receptor interactions at an HTRW site require an exposure medium (or media) and an exposure route.

(1) *Exposure Media*. Exposure media are those that contain the source, or those media that become contaminated through migration of the contaminant from the source area. The team identified the exposure media to be:

- Surface and subsurface soils at all three source areas.
- Surface water and sediments at the creek (via overland flow of contamination in surface soils, and the red staining at the bank).
- Air (via volatilization and particulate resuspension from surface soils).
- Ground water (via leaching from surface and subsurface soils).
- Food chain (via plant uptake from soils, contaminated fish and wildlife consumption, and contaminated domestic animal consumption).

(2) *Exposure Routes*. Exposure routes are those processes by which a contaminant or physical agent comes in contact with a receptor. For most environmental contaminants, these processes include ingestion, inhalation, and dermal contact. Ingestion is applicable to all expo-

sure media except air. Dermal contact is applicable to all exposure media except air and food chain. Inhalation is applicable to air, soils, and ground water.

b. Receptors. Current receptors to HTRW contamination are tree farm workers and recreational users (hunters at the cabin). Although site use is expected to remain commercial/industrial, the HTRW investigation will look at potential residential use, to possibly eliminate the need for deed restrictions and 5-year reviews.

D-11. Integrated Conceptual Site Model

Once the pathway analysis was completed, the team developed a graphic CSM component that integrated the profiles to illustrate all source-receptor interactions at the site. Figure D-3 provides a graphic representation of these interactions for the OB/OD unit, one of the three source areas. This graphic, along with the accompanying profile narrative and maps, form the CSM for this source area.

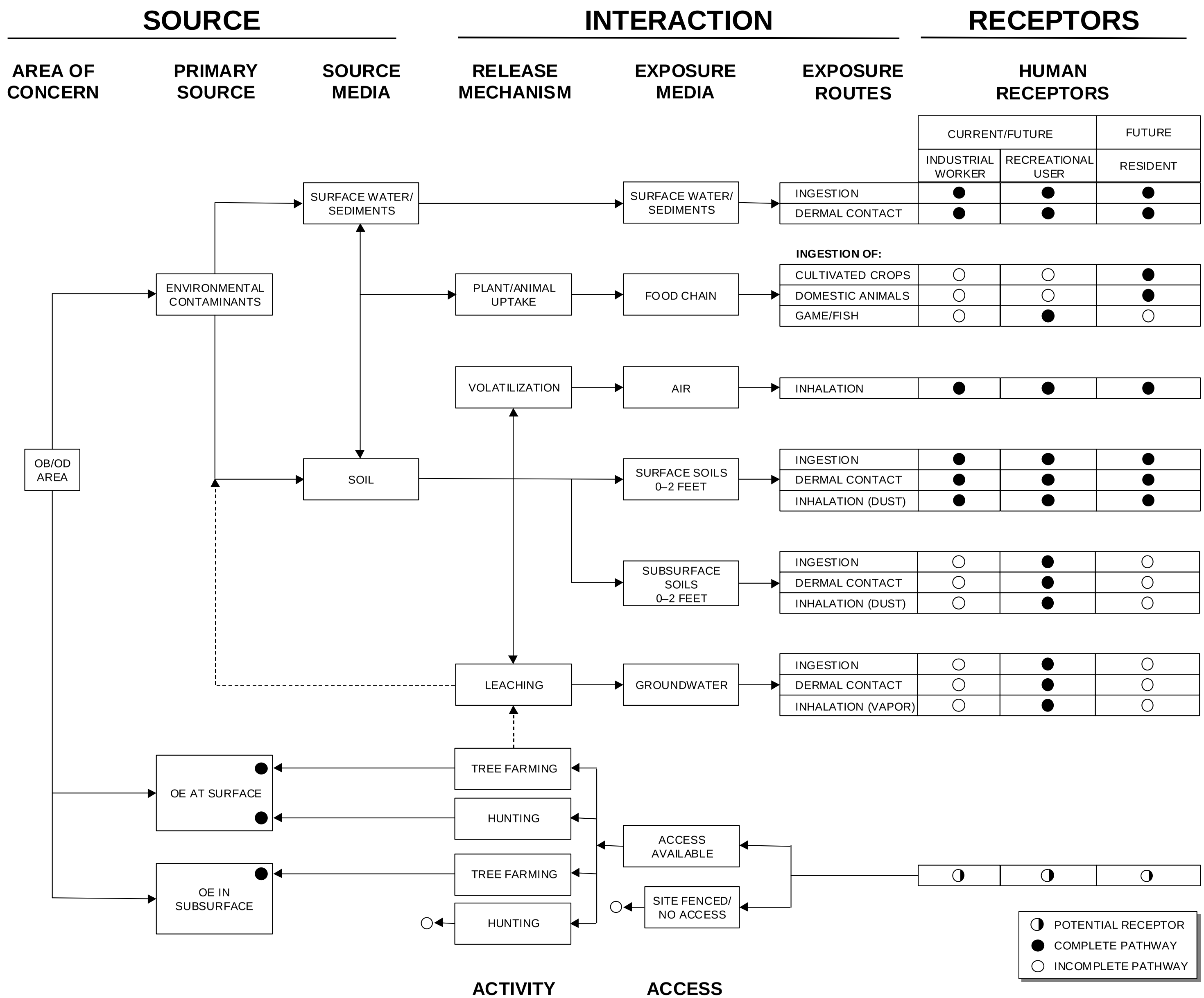

Figure D-3. Source-Receptor Relationships for OE and HTRW Sites