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**CEMP-CE**

# Environmental Quality
# Conceptual Site Models

FOR THE COMMANDER:

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**Purpose**. This Engineer Manual provides procedural guidance to develop Conceptual Site Models for sites where munitions and explosives of concern, chemical warfare materiel, munitions constituents, and/or hazardous, toxic, and radioactive waste are known or suspected to be present. This guidance should be used together with other Department of Defense and relevant guidance for execution, including the systematic planning process, as described in the Uniform Federal Policy for Quality Assurance Project Plans Manual and Munitions Response Quality Assurance Project Plan Toolkit Module 1. The target audience for this document is the Project Delivery Team.

**Applicability**. This manual applies to all Headquarters U.S. Army Corps of Engineers elements and all Divisions, Districts, and field operating activities having responsibilities for Military Programs and/or Civil Works facilities where munitions and explosives of concern, chemical warfare materiel, and/or hazardous, toxic, and radioactive waste/munitions constituents are known or suspected to be present. This guidance is provided to assist any organization or project delivery team involved in evaluation and decision-making for environmental response actions.

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

**Proponent and Exception Authority**. The proponent of this regulation is the CEMP-EC. The proponent has the authority to approve exceptions or waivers to this regulation that are consistent with controlling law and regulations. Only the proponent of a publication or form may modify it by officially revising or rescinding it.

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*This regulation supersedes EM 200–1–12, dated 28 December 2012.

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**Glossary of Terms**

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## Chapter 1
## Introduction

### 1–1. Purpose

This Engineer Manual provides procedural guidance to develop Conceptual Site Models (CSMs) for sites where munitions and explosives of concern (MEC), chemical warfare materiel (CWM), munitions constituents (MC), and/or hazardous, toxic, and radioactive waste (HTRW) are known or suspected to be present. This guidance should be used together with other Department of Defense (DoD) and relevant guidance for execution, including the systematic planning process (SPP), as described in the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) Manual (USEPA, 2005) and Munitions Response Quality Assurance Project Plan (MR-QAPP) Toolkit Module 1 (Intergovernmental Data Quality Task Force [IDQTF], 2020). The target audience for this document is the Project Delivery Team (PDT).

### 1–2. Distribution statement

Approved for public release, distribution is unlimited.

### 1–3. References

See Appendix A.

### 1–4. Records management (recordkeeping) requirements

The records management requirement for all record numbers, associated forms, and reports required by this regulation are addressed in the Army Records Retention Schedule-Army (RRS-A). Detailed information for all related record numbers is located in ARIMS/RRS-A at https://www.arims.army.mil. If any record numbers, forms, and reports are not current, addressed, and/or published correctly in ARIMS/RRS-A, see Department of the Army (DA) Pamphlet 25-403, Guide to Recordkeeping in the Army.

### 1–5. Associated publications

This section contains no entries.

### 1–6. Scope

The CSM development process outlined in this manual may be applied to any phase or activity (for example, investigation, removal, design, operation/maintenance, Five-Year Reviews) of a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) environmental response. The CSM is typically prepared as a component of existing documents such as work plans, quality assurance project plans (QAPPs), site characterization reports, final removal/remedial action reports, or similar documents as determined by the PDT. It may also be prepared or refined as a standalone document that supports pre-scoping SPP or public interaction. Although this CSM development process is presented in relation to CERCLA response actions, it may be applied as appropriate with other regulatory frameworks.

## Chapter 2
## Description of a Conceptual Site Model

### 2–1. Introduction
This chapter presents an overview of the CSM, describing the ways it can be depicted and how it should be used. It also describes when the CSM should be developed and updated, the processes to be used, and the PDT members who should be involved with these processes.

### 2–2. Conceptual site model overview
*a.* A CSM defines the most current description of a site and its environment, including both natural and man-made features. The CSM describes sources of contamination known or suspected to be present at a site (MEC, CWM, MC, and/or HTRW). It also describes current and reasonably anticipated future land uses and related receptors, as well as the potential interactions between the receptors and contamination sources (exposure pathways). The CSM is a critical part of a project that supports planning, modeling and data interpretation, communication between members of the PDT and with the public, and decision-making. These decisions can range from sampling strategies to cleanup actions. A CSM provides a structure or framework to summarize and display information about a site and identify additional information needed to develop technically sound decisions.

*b.* A CSM is a dynamic, not static, site model. CSM development is an iterative process that reflects the progress of activities at a site from initial assessment through site close-out. The PDT should start CSM development as soon as work is initiated on a project (for example, for Formerly Used Defense Sites (FUDS), after the Inventory Project Report (INPR) is approved). Initially, the CSM will be almost entirely conceptual but will be refined as data are acquired throughout each phase (see Section 2-10 for CERCLA phases and their relationship to CSM development). Potential source areas, receptors, and media of concern should be documented in the initial CSM. Later versions of the CSM may be used to evaluate the effectiveness of sampling, help focus design efforts, record results of response actions and implement long-term management actions. The CSM can help translate general regulatory objectives into more site-specific project objectives, such as data quality objectives (DQOs) and data needs. The CSM also supports planning for data collection, which should be focused on complete or potentially complete exposure pathways that are based on current or reasonably anticipated future land use. To this end, describing the CSM is a critical part of developing the UFP-QAPP or MR-QAPP for a project – Worksheet #10 of the UFP-QAPP and MR-QAPP contain the CSM information.

*c.* The CSM is developed through analysis of site-specific information that the PDT collects and integrates to illustrate the interaction between the receptors that may be affected and the potential contamination source areas. Through this illustration, the PDT conducts an exposure pathway analysis to show how site conditions function as a system. As more data are generated, the understanding of this system becomes more refined allowing greater focus for subsequent project phases. Upon update at the end of a phase, it reflects the current understanding of a site and conditions that indicate or could lead to unacceptable threat to human or ecological receptors. A well-developed

CSM incorporates information to develop remedial action objectives (RAOs) and ensure that response actions are protective of human health and the environment. Additionally, when combined with adaptive site management strategies, the CSM can help the PDT to develop response action designs that ultimately lead to faster site closeout. This general process is the same for both MEC, CWM, and HTRW/MC contamination.

*d.* Data quality must be evaluated and considered 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 for another use. The decision to use the data should be based on its applicability to the project's objectives. All data sources should be described, copied, and archived for future reference.

## 2–3. Conceptual site models for munitions and explosives of concern versus chemical contaminants

The risks presented by MEC and HTRW/MC are different. MEC presents a risk of injury resulting from the unintentional detonation of a munition or munition component, presenting an acute hazard in which injury or death only occurs if a receptor interacts with a MEC item. The risk of this happening is a combination of the likelihood of an encounter, the likelihood of an interaction following a given encounter, based on land use activities, and the likelihood of a detonation based on the nature of the land use activities as well as the properties of the munition (for example, sensitivity). HTRW and MC are chemical contaminants that most often present a risk to human health and the environment through acute or chronic exposures. The degree of risk posed by HTRW/MC is usually proportional to the toxicity of the contaminants and their quantity or concentration, as well as the extent and duration of exposure. A single site may have risks resulting from both MEC and HTRW/MC. The risks presented by CWM may be comparable to either MEC or HTRW/MC, depending on the CWM involved and the nature of the release. For purposes of developing CSMs for CWM, the PDT should address the CSM elements described in this document for MEC and/or HTRW/MC, as appropriate.

## 2–4. Project delivery team composition

PDT composition will vary with the complexity of the site and the nature of the hazards or risks present. The Project Manager (PM) leads a PDT that includes technical experts, regulatory personnel, and other stakeholders who provide various planning perspectives. An effort should be made early in the process to identify special challenges or interests that require input from specific disciplines or groups. These disciplines can include, but are not limited to, biologists, chemists, cultural resource specialists, engineers, environmental scientists, explosives safety specialists, geochemists, geologists, geophysicists, hydrogeologists, risk assessors, toxicologists, and Office of Counsel representatives. Each group will have knowledge, opinions, and data needs that may differ and/or overlap.

## 2–5. Conceptual site model profiles

*a.* An effective CSM presents known or suspected conditions regarding contaminants and receptors, and the potential interactions between them. The PDT must be able to recognize the type of information relevant to the development of a CSM.

In most cases, the needed information can be categorized into five “profiles” that address site-specific information. These include:

(1) Facility Profile: describes site history, site boundaries, man-made features, and potential contaminant sources at or near the site.

(2) Physical Profile: describes natural factors at the site that may affect contaminant release, fate and transport, or accessibility.

(3) Release Profile: describes the movement and extent of contaminants in the environment; bounds the locations where MEC, MC, and HTRW may be present.

(4) Land Use and Exposure Profile: describes land uses and activities as well as applicable exposure scenarios, receptors, and receptor locations, and pathways.

(5) Ecological and Cultural Resources Profile: describes the natural habitats and associated ecological receptors, as well as the cultural resources, present on and around the site.

*b.* The PDT can collect profile information from a variety of sources. The PDT should review all relevant historical and current documentation, conduct interviews, query regulatory and other agencies, and perform site visits, if needed, to gather profile information. Information from similar sites may also be useful. Information from historical documentation should be verified to minimize replication of incorrect or out-of-date information. Electronic data resources and/or repositories that are supported and maintained by government agencies or institutions should be identified and used to gather readily available, current, and relevant information (for example, well inventories, aquifer mapping, etc.). This is addressed further in Section 2-9.

*c.* Examples of the types of information typically associated with each profile type are presented in Table 2-1. Because site specific conditions vary, a PDT may determine that different or additional information is needed for any given site.

*d.* The vertical profile (sometimes referred to as the “vertical CSM”) is a CSM element that combines elements from several of the CSM profiles listed in Table 2-1. The vertical profile describes a variety of depth-related data related to site contamination, receptors, and exposure routes, such as details concerning lithology, bedrock, groundwater, land use activities, receptor populations, investigation methods and results, contamination locations and concentrations, and exposure pathways. The vertical profiles for MEC and HTRW/MC are addressed in more detail in Chapters 3 and 4, respectively.

**Table 2–1**
**Profile Types and Information Needs**

| Profile Type | Typical Information Needs |
|---|---|
| Facility Profile | • Location and boundary of FUDS property, Munitions Response Area (MRA) and Munitions Response Site (MRS).<br>• Physical boundaries (past and current), fencing, administrative controls, rights-of-entry (ROE), etc.<br>• Ownership history and past operations, including activities, and types and number of personnel.<br>• Details on man-made structures, including buildings, sewer systems, process lines, underground utilities.<br>• Current and historical features that indicate the potential presence of HTRW including process, manufacturing, storage, and waste disposal areas.<br>• Current and historical features that indicate the potential presence of MEC or MC, including impact areas, range areas, storage areas, munitions manufacturing, disposal areas, firing points, and target locations.<br>• Other historical features that might indicate potential source areas (for example, landfills or lagoons, ground scars, impact craters, stained soil, or stressed vegetation)<br>• Concise summary of relevant findings from previous investigations/actions/events. |
| Physical Profile | • Topographic and vegetative features and other natural barriers.<br>• Surface water features and drainage pathways.<br>• Surface and subsurface geology, including soil type and properties.<br>• Hydrogeological data for depth to groundwater and aquifer. characteristics (for example, hydraulic gradient/flow direction, hydraulic conductivity, porosity, seepage velocity), including aquifer yield if available.<br>• Meteorological data.<br>• Soil boring or monitoring well logs and locations.<br>• Natural processes that may cause contamination to move or be uncovered (for example, erosion).<br>• Development, construction (for example, grading) that may have occurred after transfer from DoD.<br>• Other physical site factors or constraints that might affect site activities.<br>• Geophysical data related to detection and classification depths (predicted and actual, based on site-specific noise). |
| Release Profile | • Known or suspected contaminants of potential concern, including MEC and HTRW/MC, and their associated environmental media and release mechanism(s).<br>– For MEC, a description of fillers, fuzing, and status (unexploded ordnance (UXO) or discarded military munitions (DMM)).<br>– For HTRW/MC, a description of chemical properties (for example, solubility, volatility, adsorption coefficient, tendency to bioconcentrate).<br>• Sampling locations and investigation/analytical results.<br>• Suspected and confirmed locations of contaminant releases, including lateral and vertical extents, and estimated quantities and/or concentrations. |

| Profile Type | Typical Information Needs |
|---|---|
| Release Profile, continued | • Determination of contaminant movement from source areas.<br>• Distribution of contaminants in different phases and media (for example, DNAPL/LNAPL, adsorbed on vadose zone soils or aquifer materials, dissolved phase, soil vapor).<br>• Natural attenuation processes (for example, aerobic, anaerobic, and abiotic degradation of chlorinated solvents or redox/pH-mediated dissolution or precipitation of metals).<br>• Mass flux between media (for example, mass discharge from an aquifer into surface water, back diffusion from fine-grain geologic units).<br>• Geochemistry (for example, redox conditions, pH, alkalinity, reactive minerals).<br>• Impact of chemical mixtures and co-located waste on transport mechanisms.<br>• Migration routes and mechanisms (HTRW and MC).<br>• Modeling results. |
| Land Use and Exposure Profile | • Types of current or reasonably anticipated future land uses at or near the site.<br>• Receptors associated with current or reasonably anticipated future land use (for example, residential, recreational, commercial, agricultural, industrial, public forest, conservation area) at or near the site.<br>• Receptor activities (intrusive and non-intrusive), including frequency, depth, and nature of activities.<br>• Complete or potentially complete exposure pathways for known or suspected site contaminants.<br>• Demographics, including subpopulation types and locations (for example, schools, hospitals, day care centers, site workers).<br>• Zoning, master planning, community interests, and any government restrictions such as safety fly zones or noise zone near airports.<br>• Locations of site resources (for example, water supply wells, recreational areas (hiking, swimming, boating, fishing, etc.), grazing lands, burial grounds). |
| Ecological and Cultural Resources Profile | • Primary use(s) of the area(s) and degree of disturbance, if any.<br>• Identification of ecological receptors in relation to habitat type (endangered or threatened species, migratory animals, fish, etc.).<br>• Relationship of any releases to potential habitat areas (locations, contaminants or hazards of concern, sampling data, migration pathways, etc.).<br>• Description of sensitive environments at the site, including habitat type (wetland, forest, desert, pond, etc.), size, and quality.<br>• Description of historic buildings or structures; prehistoric sites; historic or prehistoric objects or collection; rock inscriptions; culturally significant earthworks, canals, or landscapes. |

## 2–6. Exposure pathway analysis

*a.* The PDT uses this information to identify the exposure pathways at the site. Exposure pathways describe the routes via which receptors can be exposed to a hazard or hazardous substance. The CSM summarizes which receptor exposure pathways for MEC and HTRW/MC are (or may be) complete and which are (and are likely to remain) incomplete. Exposure pathways (sources, receptors, and the interactions between them), must be evaluated for both current and reasonably anticipated future land uses at a site. Pathway analysis will guide data collection activities and can be used to inform stakeholders of site conditions.

*b.* An exposure pathway is considered incomplete unless all four of the following elements are (or may be) present (USEPA, 1989):

(1) A source or release of contamination.

(2) An environmental transport mechanism and/or exposure medium.

(3) An exposure point at which the receptor can come into contact with the contamination.

(4) A receptor and a likely route of exposure at the exposure point.

*c.* If any of these elements is not currently present or is not reasonably anticipated to be present in the future, then the pathway is incomplete. An incomplete exposure pathway indicates there are no current or future means by which a receptor (human or ecological) can be exposed to either MEC or HTRW/MC and, therefore, no hazards or risks from exposure to MEC or HTRW/MC would be expected. This information can be used to focus the investigation of the site by suggesting which complete or potentially complete exposure pathways need to be evaluated.

*d.* The elements of the exposure pathway are described further below:

(1) Source or Release of Contamination. Sources/releases are those areas where MEC or HTRW/MC have entered (or may enter) the physical system. The PDT collects information about sources and source areas when it generates the facility, physical, and release profiles. Even though a source (for example, impact area or landfill) may be easily labeled, it is extremely important that the entire PDT understand as much about the source as possible, including known or suspected munitions or HTRW/MC contaminants. Although many details about the source may not be known, the PDT needs to determine what is known and what is assumed about the source early in the project. It is also important to understand the fate and transport characteristics of the release so that appropriate remedial technologies can be applied. Sufficient understanding of the affected media, including hydrogeology, geochemistry, and potential for natural attenuation, is key to developing a good CSM.

(2) Exposure Medium (and/or Environmental Transport Mechanism): These are the environmental media (for example, soil, sediment, surface water, groundwater, air) in which the source of contamination exists. While movement of MEC is generally not significant and MEC sources typically remain in the medium to which they are released, HTRW/MC often undergo various processes (for example, volatilization, migration) such that media other than the source area can become contaminated. For example, contamination in soil can migrate into groundwater or can volatilize into the air. The PDT must take this into account and consider all potential exposure media and environmental transport methods for contaminants at a site.

(3) Exposure Point. Exposure may occur when receptors come into contact with contaminated media. A point of exposure is the location in the environment where a receptor can be exposed. As discussed for exposure media above, HTRW/MC often undergo various processes (for example, volatilization, migration) such that media other than the source area can become contaminated. Consequently, the exposure point may be located away from the location of the original release. For example, if contamination in soil migrates into groundwater, which then is pumped from the ground and used as

drinking water, the point of exposure could be the faucet(s) from which that water was consumed.

(4) Receptors and Exposure Routes. A receptor is an organism (human or ecological) that is or can be exposed to a chemical or physical agent, or contaminant, via an exposure route. Human and ecological receptors are identified in the land use and exposure profile, and the ecological profile. The pathway evaluation must consider receptors related to both current and reasonably anticipated future land use. Human receptor subcategories can include residents, site workers, construction workers, recreational users, site visitors, and trespassers. Ecological receptor subcategories are based on the potentially affected species. Exposure routes describe the ways in which receptors can come into contact with a source of contamination within an exposure medium, such as intentional or incidental direct contact, intentional or incidental ingestion, inhalation, exposure via the food chain, etc. In evaluating exposure routes, it is essential to understand the types of actions and activities undertaken by the receptors. Information from all CSM profiles will assist in identifying source-receptor exposure routes. Routes of exposure differ slightly for MEC and HTRW/MC (see Chapters 3 and 4, respectively).

*e.* Examples of exposure pathway elements for MEC and HTRW/MC are presented in Table 2-2, while an example exposure pathway schematic is presented in Figure 2-1.

**Table 2–2**
**Examples of Exposure Pathway Elements for MEC and HTRW/MC**

| Exposure Pathway Element | Example for MEC | Example for HTRW |
|---|---|---|
| Source or release of contamination | WWII range training resulted in MEC being present at a former target area | HTRW leaks from drums at a disposal pit at a former military camp |
| Environmental transport mechanism and/or exposure medium | The MEC are present in the soil at the former target area | The HTRW first leaks into soil, then migrates to groundwater |
| Exposure point at which the receptor can come into contact with the contamination | A recreational hiking trail passes through the former target area | The contaminated groundwater is used as drinking water by a local subdivision |
| Receptor and a likely route of exposure at the exposure point | A hiker encounters and then picks up a surface MEC item | A resident in the subdivision drinks the water |

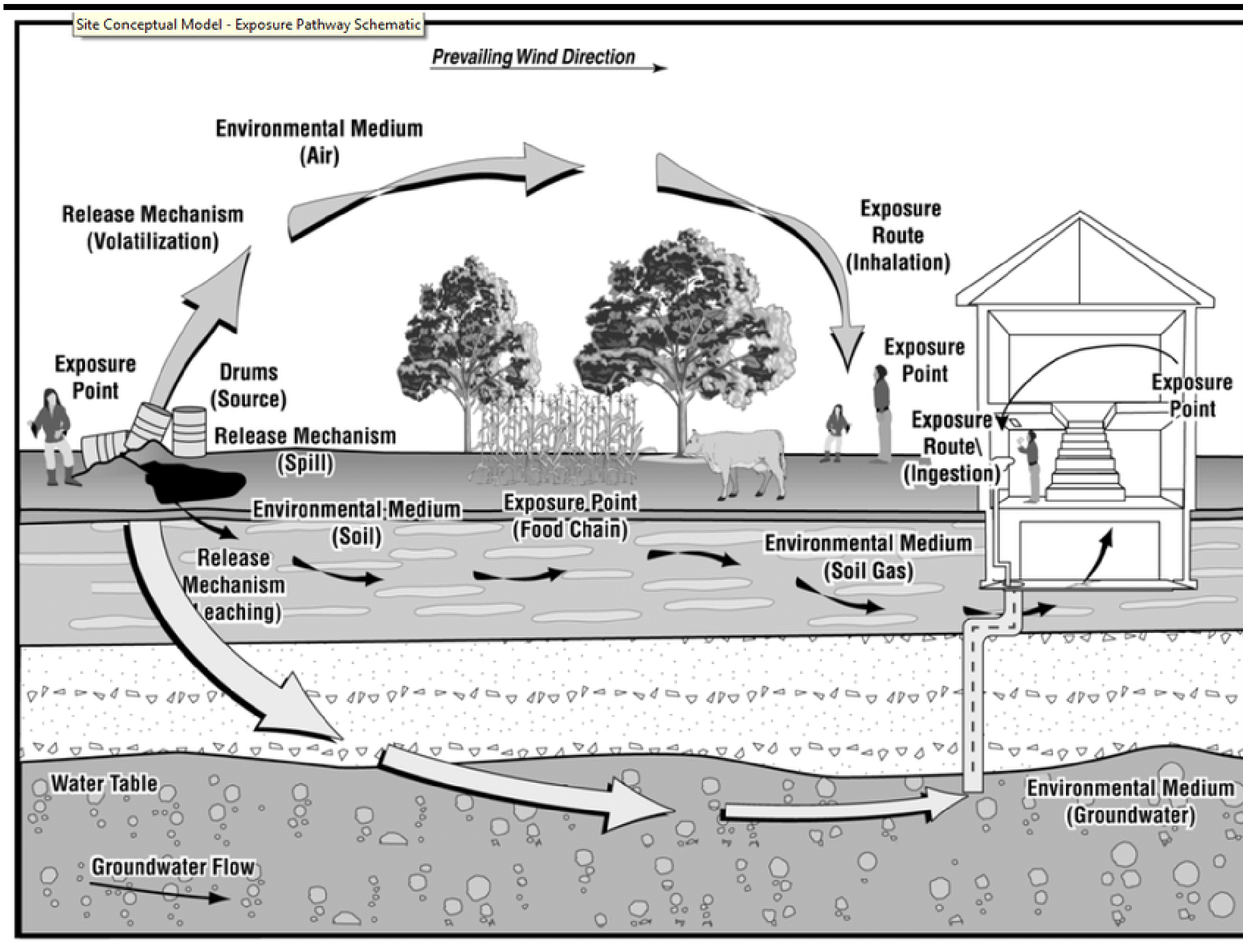



**Figure 2–1. Exposure pathway schematic**
**(Source: Agency for Toxic Substances and Disease Registry, 2005)**

## 2–7. Representation of the conceptual site model

A CSM illustrates the sources and receptors present at a site, and the processes that may result in exposure. The CSM can vary in content and level of detail, depending on complexity of the site as well as available or required information. A simple figure or narrative may depict a CSM for a simple site. However, for most sites, the CSM is far more complex and typically should be documented using a written narrative supported by tables, maps, cross-sections, diagrams, or other graphics to describe the entire model. For MEC, the CSM depicts the confirmed or suspected source of munitions, based on the munitions-related activities that occurred on the site. The CSM also describes how receptors may come into contact and interact with MEC based on land use activities. For MC and HTRW, the CSM focuses on the source, exposure routes through environmental media, and exposure of receptors. Regardless of what formats are chosen to illustrate the model, all CSMs should provide an accurate representation of the source–receptor interactions present at the site. See Appendix D for examples of various CSM representations.

*a.* Narrative Description.

(1) A narrative is a written description of site conditions, based on profile information. The level of detail will vary based on the complexity of the site and the

information available. Narrative descriptions should include a summary of information on sources, receptors and activities that may lead to interactions with or exposure to contaminants. In some cases, a narrative may be all that is needed to document site conditions for a CSM.

(2) Written descriptions of CSMs can also be presented in tabular form. In these tables, the columns can contain the various CSM elements, such as contaminants, receptors, and interactions, while each row can describe those elements for different MRSs and exposure media. Figure 2-2 provides an example of a tabular CSM.

| SITE DETAILS | Known or Suspected Contamination Source(s) | Potential/Suspected Location and Distribution | Source or Exposure Medium | Current and Future Receptors | Potentially Complete Exposure Pathway |
|---|---|---|---|---|---|
| NAME: Rocket and Rifle Grenade Range<br>Acreage: 125 total. Only obtained ROE for 69 acres<br>Suspected Past United States DoD Activities (*release mechanisms*): Unexploded ordnance (UXO) from rocket and rifle grenade firing range training<br>Current and Future Land Use: Cultivated cropland and wooded areas | MEC:<br>• Rocket, 2.36-inch, practice<br>• Rifle grenade<br>• Hand grenade | MEC:<br>Potentially present throughout MRS, with greater potential quantities at HUAs | Surface and subsurface soil | Construction workers, site workers (agricultural), recreational users (hunters), and site visitors | Intentional/unintentional interaction with MEC in surface and/or subsurface soil |
| | MC:<br>• MC metals: copper, lead, and zinc<br>• Explosives | MC:<br>Not confirmed, but potentially present within HUAs | Surface and subsurface soil | Construction workers, site workers (agricultural), recreational users (hunters), site visitors, and ecological receptors | Dermal contact with surface and/or subsurface soil containing MC |
| | | MC:<br>Not confirmed, but potentially present at HUAs | Groundwater | Residents, construction workers, and site workers (agricultural) | Ingestion as drinking water or dermal contact with GW containing MC |
| NAME: Mine Training Area<br>Acreage: 109 acres<br>Suspected Past United States DoD Activities (*release mechanisms*): UXO/discarded military munitions (DMM) from engineer mine training<br>Current and Future Land Use: Cultivated cropland and wooded areas | MEC:<br>• Mine, Practice, M1<br>• Mine, Practice, M4<br>• Mine, Fuze, M1 | MEC:<br>Potentially present throughout MRS, with greater potential quantities at HUAs | Surface and subsurface soil (most likely subsurface) | Construction workers, site workers (agricultural), recreational users (hunters), and site visitors | Intentional/unintentional interaction with MEC in surface and/or subsurface soil |
| | MC:<br>• MC metals: copper, lead, and zinc<br>• Explosives | MC:<br>Not confirmed, but potentially present within HUAs | Surface and subsurface soil | Construction workers, site workers (agricultural), recreational users (hunters), site visitors, and ecological receptors | Dermal contact with surface and/or subsurface soil containing MC |
| | | MC:<br>Not confirmed, but potentially present at HUAs | Groundwater | Potential future residents, construction workers, and site workers (agricultural) | Ingestion as drinking water or dermal contact with GW containing MC |

**Figure 2–2. CSM table for an MRS (example)**

*b.* Pictorial Presentation. A pictorial presentation includes the necessary elements of a CSM, including the sources, receptors, and land use activities that may lead to interactions and/or exposure. This format is useful for presenting the CSM to a range of stakeholders. Figure 2-3 provides an example of a pictorial CSM for an MRS, while Figure 2-4 provides a similar example for HTRW/MC contamination.

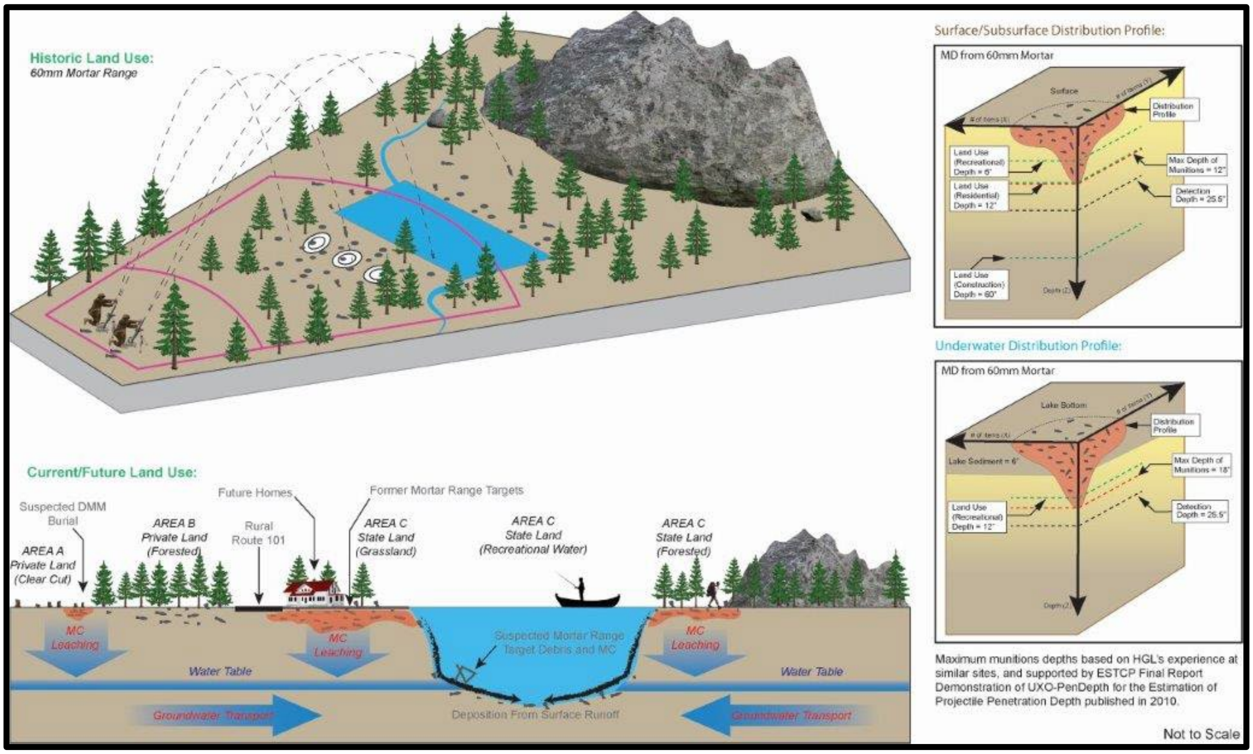



**Figure 2–3. Pictorial CSM for an MRS (example)**

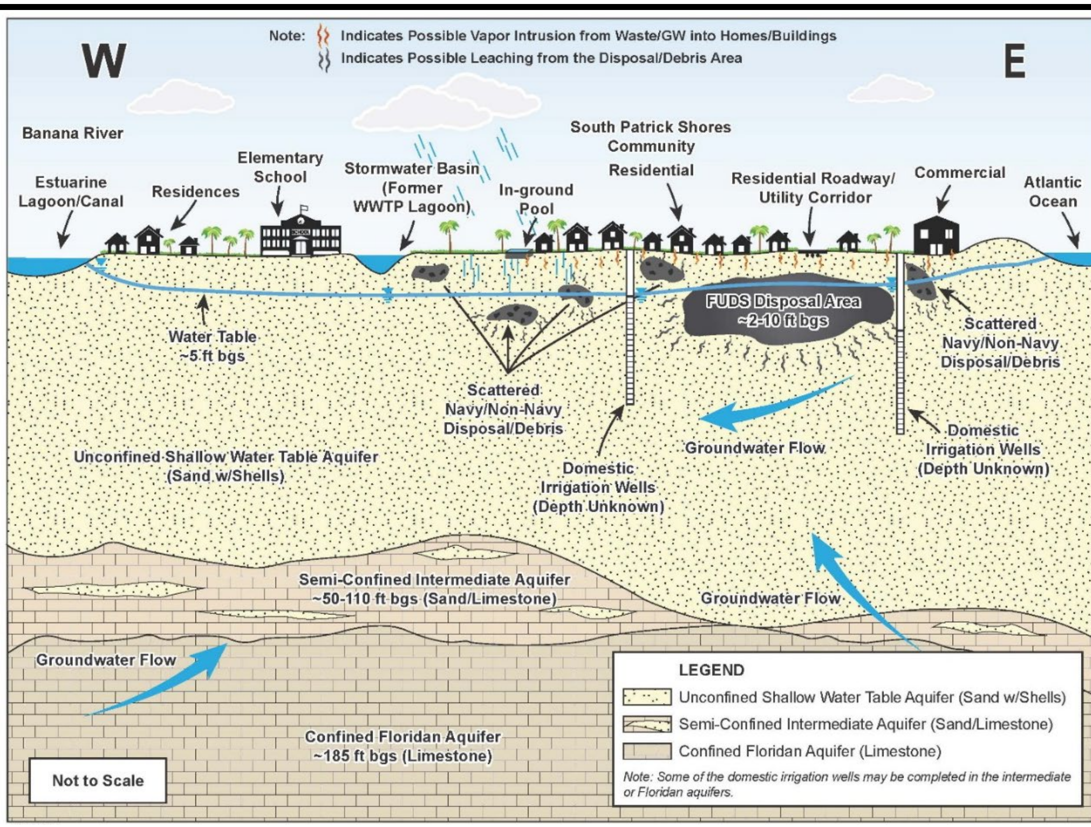



**Figure 2–4. Pictorial CSM for environmental contamination (MC, HTRW) (example)**

*c.* Graphical Representation. The graphical representation can provide an effective summary of complete or incomplete exposure pathways. It is commonly used for MEC and HTRW/MC. An example graphical representation of a CSM for an HTRW project or munitions response to MC is shown in Figure 2-5. 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 sources and receptors involves a contaminant release mechanism, 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 air pathway.

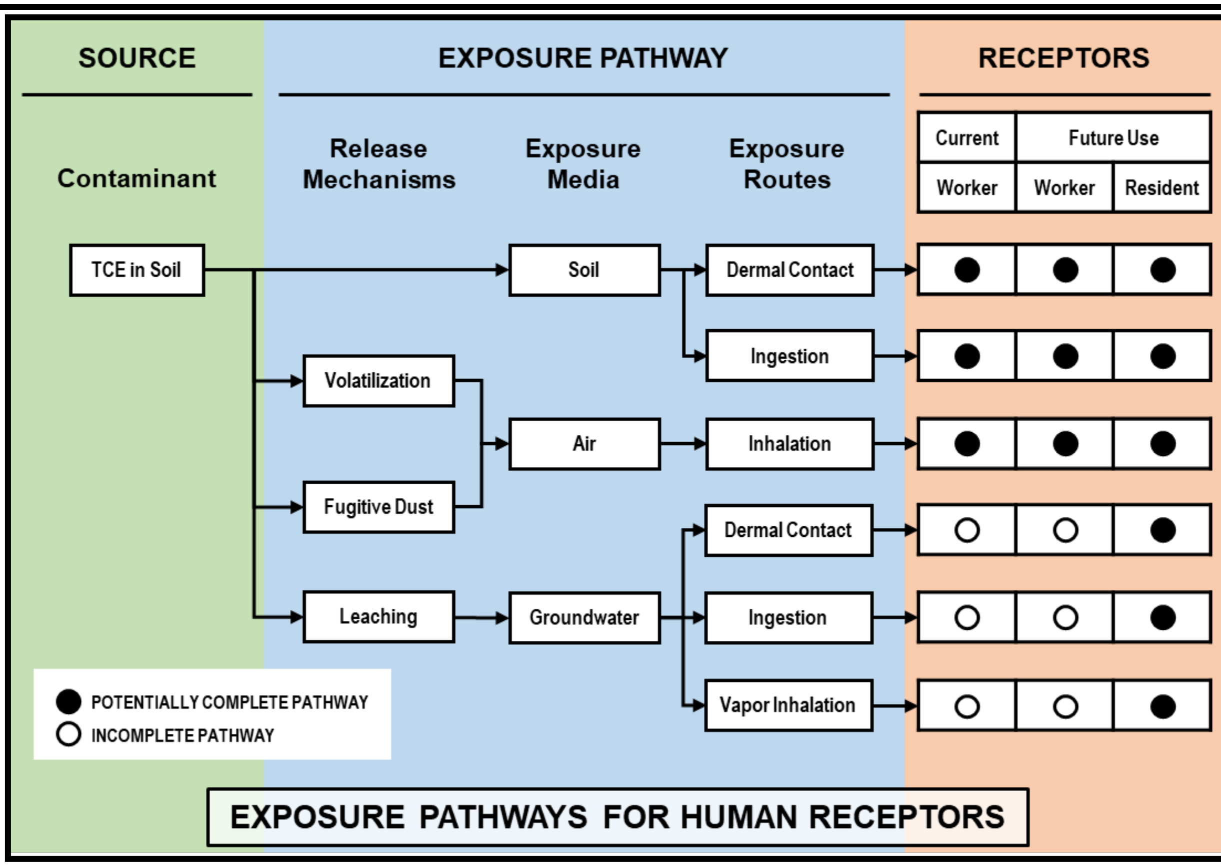



**Figure 2–5. Graphical presentation of HTRW/MC CSM exposure pathways (example)**

*d.* Other Representations. A CSM is a summary of the existing body of knowledge for a project that may be 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 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 MEC-related issues might opt for a range map depicting firing points and impact areas and the potential for human interaction with these. Site data can also be presented using light detection and ranging (LiDAR), or other remote sensing imagery and digital elevation models.

*e.* Geographic Information Systems (GIS). The data collected and stored for a project may be complex and immense. The PDT is strongly encouraged to use GIS as a tool to store, manipulate, and present these data in a CSM. In addition to data storage and presentation, major CSM components (sources, exposure routes/media, and receptors) can be presented in a GIS as separate data layers, each having their own spatial components. These layers can relate directly to elements of the CSM diagram, such as the exposure pathway diagram shown in Figure 2-5. The intersections of the data layers can indicate where there are potentially complete exposure pathways, while the outputs can be used to describe the site and focus the investigation (Figure 2-6).

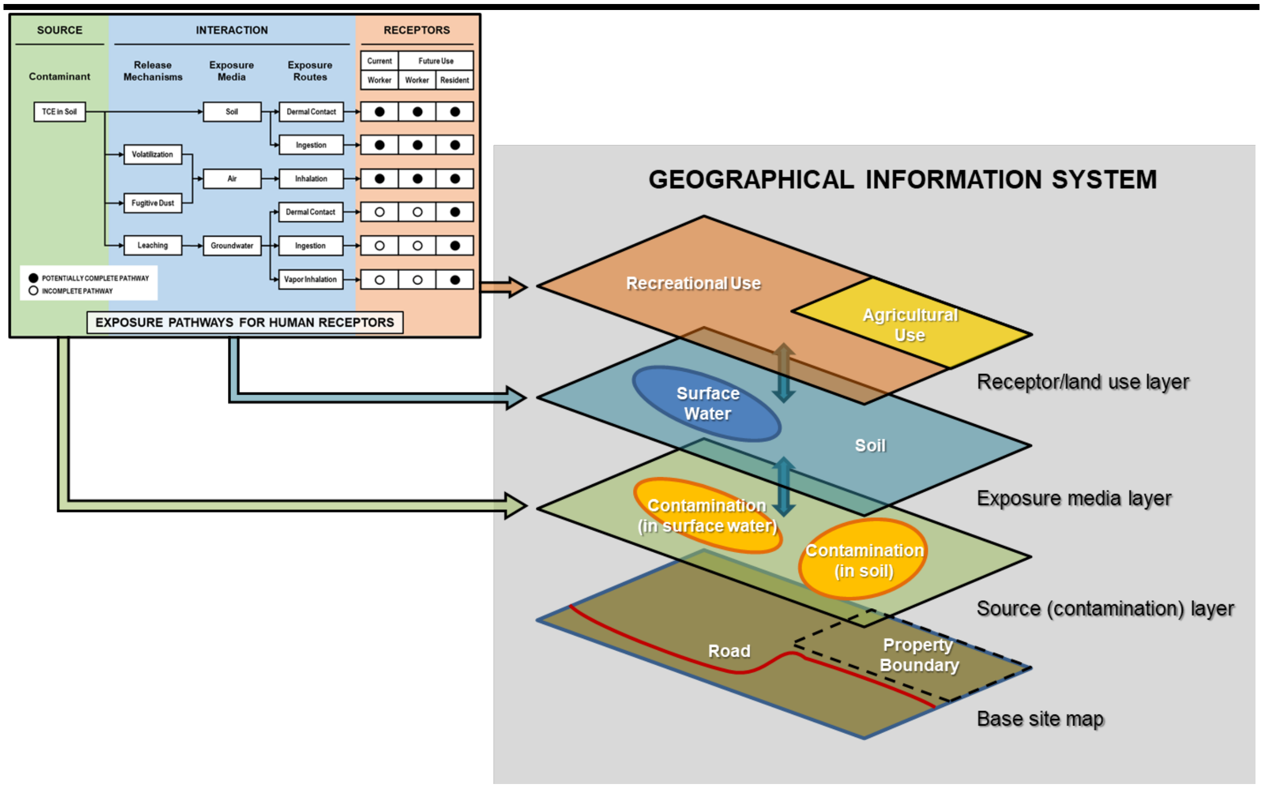



**Figure 2–6. How GIS data layers can relate to CSM exposure pathways**

## 2–8. Development and refinement of a conceptual site model

*a.* As knowledge and understanding of a site increase with additional data, the model used to represent that information should also grow. A CSM requires continual refinement during the CERCLA process (see Section 2-10). A CSM can help a PDT to identify data gaps and data needs for each phase of the project and can be integral to identifying key trigger points needed for adaptive site management strategies (ITRC [Interstate Technology & Regulatory Council], 2017). Generally, using the SPP, the PDT should develop project goals and identify the data needs to address those goals. Comparing those data needs with the information in the most current CSM will then reveal the difference between what is known and what is unknown (that is data gaps). The CSM should be updated after completion of each project phase.

*b.* The development and refinement processes are summarized in Figure 2-7. Site profiles are developed from the existing data to document an initial CSM. The PDT must then create reasonable hypotheses regarding potential for exposure. For example, analysis of the groundwater pathway will usually entail some hypotheses about groundwater 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 judgment. 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.

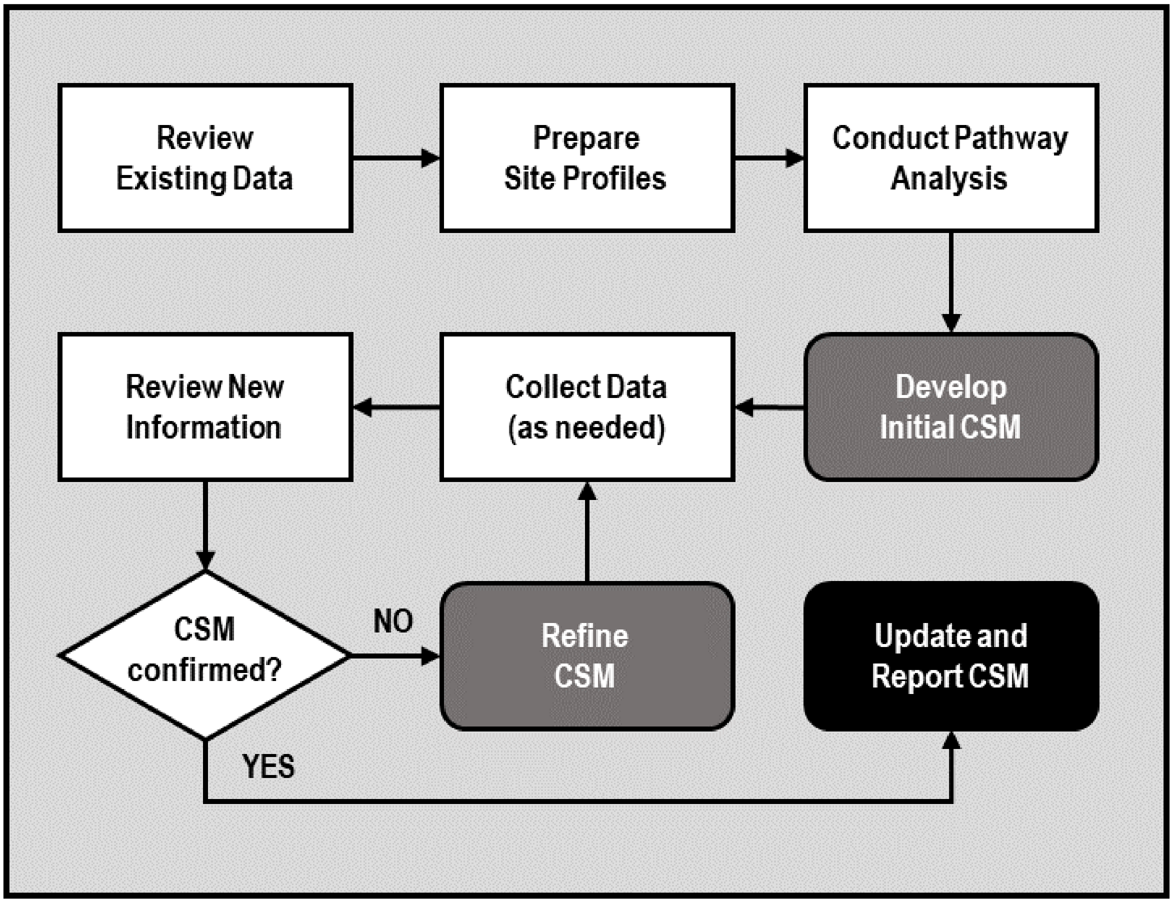



**Figure 2–7. CSM development/refinement process**

*c.* A CSM can be developed during any phase of a project. In addition, site characterization or other response actions may reveal unanticipated contamination, the presence of unexpected munitions, or other sources. As an example, UXO, DMM, or MC might be discovered during investigation of an HTRW site. Although not expected during the initial phase of the investigation, the CSM should now be refined to address such a discovery. Additionally, the project's objectives should be reviewed and revised as needed. An example of preliminary CSM development for a site with both Military Munitions Response Program (MMRP) and HTRW/MC concerns in presented in Appendix C.

## 2–9. Information resources for preliminary CSM development

*a.* One of the most critical steps in developing the initial CSM is identifying and retrieving information for the various CSM profiles (facility, physical, release, land use and exposure, ecological and cultural resources; see Section 2-5). For most sites, a Preliminary Assessment (PA) report including a historical records search provides useful preliminary profile information. (A historical records search is an evaluation of past military activities at an installation. Its purpose is to assemble historical records and other available data about site activities to assess whether MEC or HTRW/MC may be present.) Additional historical and current site information may be obtained from maps, aerial photographs, existing reports, cross sections, land surveys, LiDAR imagery, environmental studies, or laboratory analytical data. (Also see the Guidelines for Munitions Response Historical Records Review (ITRC, 2003).)

*b.* However, while these prior documents may include a wealth of information, it is essential that PDTs verify information from existing or historical documents to minimize replication of incorrect or outdated information through “cut-and-paste” practices. Electronic data resources and/or repositories that are supported and maintained by various government agencies or institutions should be identified and used to gather readily available, relevant, and up-to-date information (for example, well inventories, aquifer mapping, etc.). Large quantities of data are now maintained online, and the accuracy and validity of these data are typically far more reliable than that copied from a 20-year-old report. Table 2-3 provides multiple examples of these online information resources. This list is not exhaustive but provides a possible starting point for online data searches.

*c.* Procurement contracts or inventory records also provide information about items or materials purchased and used by various departments. Operational manuals or procedures are also essential resources for information relating to how activities were performed in the past. Landfill or burial pit disposal records, when available, offer valuable data on what wastes may be present. For FUDS properties, the PDT should also consult the Common Operations, Range Operations, and Installation Reports compiled by the U.S. Army Corps of Engineers (USACE) Environmental and Munitions Center of Expertise (EM CX). These reports provide a historically documented discussion of how the military conducted operations such as vehicle maintenance, aircraft maintenance, training ranges, and other operations of interest with potential for releases to the environment. (Most of the Common Operations Reports for FUDS properties are available on the non-project section of FUDS Docs. Contact the EM CX for available reference documents.) While they are not a substitute for documentation of actual operations at a site, they provide insight on what to look for and what might be expected on a FUDS property. Note that implementation at individual sites may vary from the standard operating procedures. Installation Reports were also developed for installation types, such as ground forces training installations, army airfields, Atlas missile sites and other installations that were numerous or had specific narrow missions.

*d.* Interviews with current or former site personnel may provide anecdotal information or process knowledge about the site or specific activity, though the PDT must evaluate and consider reliability of otherwise unsubstantiated anecdotal information before making project decisions based on this data alone. For military installations, the base historian, real property manager, and range managers should be contacted. Local fire or law enforcement offices may have information if there have been responses to MEC discoveries, chemical spills, or other incidents.

*e.* Federal, local, and state agencies, and Native American tribes, should be contacted to ascertain information regarding potential presence of resources including but not limited to threatened or endangered species, cultural resources, wetlands, or conservation areas. For historically agricultural land, there are increasing occurrences of landowners removing land from agricultural production and enrolling in conservation programs administered by the United States Department of Agriculture and local Farm Service Bureaus or other agencies. For land so enrolled, it is important to obtain from the landowner any land use restrictions or land management practices that are imposed by the respective program agency.

*f.* Current landowners should be contacted and interviewed to identify if they have any plans to change land use(s) and/or any special requirements for conduct of work on their property, and whether they have additional information about the property that may be of use. To the extent practicable, former landowners should also be contacted to glean additional information about the site. Land use plans should be documented in an appropriate project document to support basis for reasonably anticipated land use assumptions. The PDT must evaluate and consider reliability of this information before using it for project decisions.

**Table 2–3**
**Online Information Resources for Preliminary CSM Development**

| CSM Data Element | Examples of Online Information Resources |
|---|---|
| Site Location | FUDSMIS GIS: http://maps.crrel.usace.army.mil:7778/apex/fuds.fudscm2.map (CAC required) |
| Site Ownership | Conduct internet search for "County + State + Tax Parcels"<br>Examples: County of Hawaii, HI, Real Property Tax Office, Cooke County, Texas, and County of Maui, HI. |
| Historical Military Use | FUDSMIS: https://fudsmis.usace.army.mil/#Fudsmis/Home (CAC required)<br>Use INPRs, Preliminary Assessments (PAs), Historical Photograph Analyses, maps, etc. |
| Physical Profile | USGS GIS: https://apps.nationalmap.gov/downloader/#/<br>Data Basin (based on available datasets): https://databasin.org/maps/new/# |
| Facility Profile | Army Geospatial Center: www.agc.army.mil and www.agc.army.mil/Maps/<br>Use aerial imagery for periods before, during, and after DoD jurisdiction. (Obtain "leaf-free" or "leaf-off" imagery where possible.) |
| Soils (inc. Bedrock Depths) | USDA Web Soil Survey: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm |
| Geological Setting | USGS: https://mrdata.usgs.gov/geology/state/ |
| Hydrogeologic Setting | Conduct internet search for "County + State + Aquifers" – availability varies by state<br>Example: https://www.twdb.texas.gov/groundwater/data/gwdbrpt.asp |

| CSM Data Element | Examples of Online Information Resources |
|---|---|
| Endangered Species, Sensitive Habitats | USFWS Information for Planning and Consultation: https://ipac.ecosphere.fws.gov/ |
| Cultural Resources | NPS: https://www.nps.gov/subjects/nationalregister/index.htm<br>For cemeteries: https://www.findagrave.com/<br>Can also conduct internet searches of county and state registers. |
| Meteorological Data | NOAA: https://www.weather.gov/ (enter location by zip code, choose “Local Forecast Office,” and then “Climate and Past Weather” to get to the NOWData service).<br>Example: https://www.weather.gov/wrh/Climate?wfo=fwd |
| Site Accessibility | Google Maps: https://www.google.com/maps/ - use “Street View”<br>AllTrails: https://www.alltrails.com/ |

*g.* Site visits are highly recommended to identify significant features of 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, as well as interview people associated with the site. Visual evidence, such as munitions debris, waste containers, impact craters, berms, target stands, targets, firing trenches, risers/vents indicative of former septic tanks or underground fuel storage tanks, ground scars, soil staining, or stressed vegetation can directly indicate that MEC or HTRW/MC contaminants may be present.

## 2–10. Work phases and conceptual site model development

The following sections address development of a CSM and its uses in the CERCLA phases. CSM development for a project begins when work is initiated on a project (for example, after the INPR is approved) and the CSM continues to be refined throughout the response process as new information becomes available (see Figure 2-8).

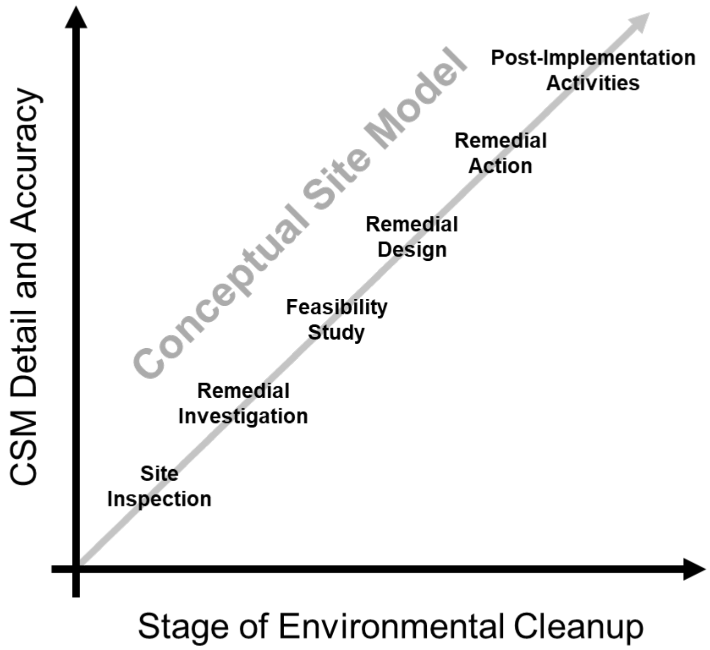



**Figure 2–8. The CSM becomes more detailed as the project progresses**

*a.* Site Inspection (SI).

(1) A CSM for a project is typically initiated at the SI phase using information from the PA report. Typical information sources include the Archive Search Report or Historical Records Review, aerial photography, site usage history, and interviews. The CSM is used to identify data gaps and data needs to support the SI objectives to:

*(a)* Eliminate from further consideration those releases that pose no significant threat to public health or the environment.

*(b)* Determine the potential need for removal action (time critical or non-time critical).

*(c)* Collect or develop data to support Hazard Ranking System (HRS) scoring by USEPA.

*(d)* Characterize the release for effective and rapid initiation of the remedial investigation (RI).

*(e)* Collect data to apply the DoD Relative Risk Site Evaluation (RRSE) and/or Munitions Response Site Prioritization Protocol (MRSPP).

(2) A CSM contains the most current information available to describe potential source areas, receptors and the interactions between the two. Identified complete or potentially complete exposure pathways that may pose unacceptable risks to human health or the environment may require an RI or imminent threats may necessitate a removal action.

*b.* Engineering Evaluation/Cost Analysis (EE/CA). For the EE/CA, development of the CSM facilitates the representation of contaminant source(s) and exposure pathways that require a removal response to mitigate imminent threat posed to human or ecological receptors.

*c.* Remedial Investigation/Feasibility Study (RI/FS).

(1) A CSM is used to identify data gaps and data needs that support the RI objectives to:

*(a)* Determine nature and extent of contamination.

*(b)* Collect information to bound an MRS.

*(c)* Determine if there are unacceptable risks or hazards associated with site-related contamination or the presence of MEC or HTRW/MC contamination.

*(d)* Collect sufficient information to allow development and evaluation of remedial alternatives.

(2) Initially, in the RI, the potential sources, interactions and receptors are evaluated against existing data for the site to identify data gaps and then, based on project goals, determine the resulting data needs (note that not all data gaps at an MRS are necessarily data needs for a project). Addressing these data needs forms the basis for the RI field effort. DQOs are developed to address the data needs. New data on sources, interactions and receptors are compared to the current CSM, with the CSM refined as necessary. This in turn may result in new or revised data gaps and data needs that may impact DQOs and the design of site characterization. The CSM may also be used to identify modeling that may be required to determine potential exposure points, exposure point concentrations and whether there is an unacceptable risk to receptors.

(3) At the FS phase, the CSM is used to assist designers in identifying source areas, any media, pathways, or exposure routes that must be addressed by the remediation, and site conditions that may affect implementation of various remedial alternatives under consideration. RAOs are developed to address the sources, media, and/or pathways identified as posing a risk or hazard. Proposed remedies are compared to the RAOs and the CSM to determine their relative effectiveness at addressing known or suspected contamination to be present, eliminating or controlling it in a given medium, and determining their effectiveness at breaking an exposure pathway.

*d.* Remedial Design/Remedial Action (RD/RA). Following updates to reflect RI/FS and risk assessment findings, the CSM is critical in facilitating the development of the RD to implement the selected remedy documented in the Record of Decision. The CSM describes sources, contaminated media, or exposure pathways that require remedial action to eliminate risks, as well as identifying features of the site that might affect the remedial response (for example, terrain, access conditions, etc.). Multiple media may need to be addressed, or multiple institutional controls may need to be placed on a site to address accessibility or exposure scenarios described in the CSM. Design features are compared to the CSM to determine their ability to eliminate unacceptable risk.

*e.* Operations and Maintenance (O&M) and Long-Term Management (LTM). Pathways and receptors may change during the conduct of a response, or contaminant concentrations may change, requiring related changes in LTM goals and programs. During the O&M phase of a project, the CSM may be used to identify or adjust any Long-Term Management that may be required. As source areas and media are remediated, features of a remediation system are adjusted or shut off based on exposures and pathways described in the CSM. The CSM is refined to reflect any changes in exposure pathways or routes and contaminated media.

*f.* Five-Year Reviews. During a Five-Year Review, RAOs documented at the time of remedy selection are compared against the current CSM to determine if they are still valid. Remedial measures are compared against the CSM to determine if the measures remain protective of human health and the environment. Current pathways and media contamination are evaluated to determine if remedial measures are controlling or eliminating a pathway or to see if remedial measures continue to be effective in controlling or preventing contaminant migration. The CSM is refined to reflect any changes in exposure pathways, exposure routes and/or contaminated media. Emerging contaminants should also be considered, as appropriate.

*g.* Expected Profile Information at Each CERCLA Phase. Table 2-4 provides a general overview of the different CSM profile information expected at the end of each project phase. This table can be used as a guide to check whether a CSM has the necessary information before proceeding with the project. It can also be used to support data gap analysis to evaluate the additional information that needs to be gathered before moving from one phase to another.

**Table 2–4**
**Expected Profile Information at Each CERCLA Phase**

| CSM PROFILE | SI | RI/FS | RD/RA |
|---|---|---|---|
| FACILITY PROFILE | | | |
| Location, boundary(ies), and size(s) of MRA and MRS | YES | YES | YES |
| Physical boundaries (past and current), fencing, administrative controls, ROE, etc. | YES | YES | YES |
| Ownership history and past operations, including activities, and types and number of personnel | YES | YES | YES |
| Details on man-made structures, including buildings, sewer systems, underground utilities | YES | YES | YES |
| Current and historical features indicating potential presence of HTRW, MEC, or MC | YES | YES | YES |
| Other historical features that might indicate potential contaminants source areas | YES | YES | YES |
| Concise summary of relevant findings from previous investigations/actions/events | YES | YES | YES |
| PHYSICAL PROFILE | | | |
| Topography and vegetation features, and other natural barriers | YES | YES | YES |
| Surface water features and drainage pathways | YES | YES | YES |
| Surface and subsurface geology, including soil type and properties | YES | YES | YES |
| Hydrogeological data for depth to groundwater and aquifer characteristics | YES | YES | YES |
| Soil boring or monitoring well logs and locations | YES | YES | YES |
| Meteorological data | YES | YES | YES |
| Natural processes that may cause contamination to move or be uncovered (for example, erosion) | YES | YES | YES |
| Development/construction (for example, grading) that may have occurred after transfer from DoD | ? | YES | YES |
| Other physical site factors or constraints that might affect site activities | ? | ? | YES |
| Geophysical data related to detection and classification depths (predicted and actual) | -- | YES | YES |

| CSM PROFILE | SI | RI/FS | RD/RA |
|---|---|---|---|
| RELEASE PROFILE | | | |
| Known or suspected contaminants, assoc. media, and release mechanisms | YES | YES | YES |
| Sampling locations and investigation/analytical results | YES | YES | YES |
| Suspected locations of contaminant releases | ? | YES | YES |
| Fate & transport mechanisms of releases (mass flux, geochemistry, hydrogeology) | - | YES | YES |
| Confirmed locations and estimated extent of contaminant releases (horizontal/vertical) | -- | YES | YES |
| Confirmed extent of contaminant releases (horizontal/vertical) for remedial response | -- | ? | YES |
| Determination of contaminant movement from source areas | -- | YES | YES |
| Impact of chemical mixtures and co-located waste on transport mechanisms | ? | YES | YES |
| Migration routes and mechanisms (HTRW/MC) | ? | YES | YES |
| Modeling results | ? | ? | YES |
| LAND USE AND EXPOSURE PROFILE | | | |
| Types of current or reasonably anticipated future land uses at or near the site | YES | YES | YES |
| Receptors associated with current or reasonably anticipated future land uses at or near the site | YES | YES | YES |
| Receptor activities (intrusive and non-intrusive), inc. frequency, depth, and nature | ? | YES | YES |
| Complete or potentially complete exposure pathways for known or suspected site contaminants | YES | YES | YES |
| Demographics, including subpopulation types and locations | YES | YES | YES |
| Resource use locations (for example, water supply, recreational areas, grazing lands, burial grounds) | YES | YES | YES |
| Zoning, master planning, community interests, and government restrictions at the site | ? | YES | YES |
| ECOLOGICAL AND CULTURAL RESOURCES PROFILE | | | |
| Primary use(s) of the area(s) and degree of disturbance, if any | ? | YES | YES |
| Identification of ecological receptors in relation to habitat type (inc. endangered species) | ? | YES | YES |
| Relationship of releases to potential habitat areas | ? | YES | YES |
| Description of sensitive environments at the site, including habitat type, size, and quality | ? | YES | YES |
| Description of cultural resources, including historic buildings, prehistoric sites, etc. | ? | YES | YES |

YES Required to be addressed/included in CSM by completion of this phase.
? Not required, but CSM could include if appropriate.
-- Not required (sufficient information unlikely to be available at this phase).

# Chapter 3
# Development of a Conceptual Site Model for a Munitions Response Site

## 3–1. Introduction

*a.* This chapter describes the CSM development process for an MRS, defines key terms, and provides examples for each step of the development process. The primary focus of a CSM for an MRS is to illustrate where MEC is most likely to be encountered and how receptors may be affected by the presence of MEC. For a receptor to be potentially affected by MEC on an MRS, the receptor must have access to the MRS and the receptor must conduct an activity that would result in direct physical contact and interaction with MEC. A CSM is developed through collection of the profile information (see Section 2-5) and subsequent pathway analysis.

*b.* Information from the CSM will ultimately be used for two primary functions. The first is to determine if there are areas of unacceptable risk on the MRS. The PDT should ensure that the CSM is developed and described in terms that are consistent with the risk assessment methodology to be used. The second primary function of the CSM is to assist in the development and evaluation of remedial alternatives in the FS. The PDT should ensure that all relevant data are captured and the appropriate inputs to the cost model are available (for example, extent of contamination, anomaly densities, depth profiles, terrain features, etc.).

*c.* When executing an MMRP project the planning documents will follow the UFP-QAPP format. The CSM is presented in Worksheet #10. For munitions response remedial investigations, the IDQTF developed the MR-QAPP Toolkit, Module 1: RI/FS.

**3–2. Facility profile**

*a.* In addition to general site information, the facility profile provides the initial basis for the specific type of MEC that may be present and the most likely locations of MEC based on munitions-related activities (for example, production, live-fire training and testing, disposal operations). The facility profile should, at a minimum, include:

(1) Site location, size, and ownership history.

(2) Concise history of the use, storage and disposal of munitions and other hazardous substances at the site.

(3) Identification of munitions and other hazardous substances known or suspected to be present.

(4) Concise summary of relevant findings from previous investigations (if applicable).

*b.* Note that small arms ammunition (see definitions), which are not considered to pose a unique explosive hazard, and DMM may be found anywhere on an installation; however, they will most likely be found where munitions-related activities occurred. Table 3-1 lists types of source areas, the possible activities that may have occurred, and the potential MEC for each area. See Appendix B, Range Operations Overview, for a discussion of design, operation and maintenance of training ranges. More comprehensive information can be found in the Common Operations Reports for FUDS properties, which are available on the non-project section of FUDS Docs (see Section 2-9).

**Table 3–1**
**Common Range Types, Possible Activities, and Potential MEC**

| Types of Source Areas | Possible Munitions-Related Activities | Expected MEC Status and Types |
|---|---|---|
| Grenade Court/Range | Hand grenade training/testing Rifle grenade training/testing | UXO (hand or rifle grenades) |
| Small Arms Range | Pistol, rifle, machine gun and skeet firing ranges | Not Applicable; small arms ammunition is not considered MEC |
| Artillery Range | Anti-aircraft, tank, recoilless rifle ranges | UXO (projectiles, submunitions) |
| Bombing Target | Aircraft bombing | UXO (bombs and submunitions) |
| Air-to-Air Gunnery Range | Air-to-air firing | UXO (projectiles, rockets, guided missiles) |
| Air-to-Ground Gunnery Range | Strafing and other air to ground firing | UXO (projectiles, rockets, guided missiles) |
| Ground-to-Air Gunnery Range | Anti-aircraft firing | UXO (projectiles, rockets, guided missiles) |
| Ground-to-Ground Range (Rocket Range) | Rocket and missile firing | UXO (rockets, guided missiles) |
| Multiple/Combined Use training area | Multiple training activities | UXO (projectiles, grenades, rockets, bombs) |
| Training/Maneuver Areas | Tactical training | DMM and some UXO (simulators, signals, pyrotechnics, and other training devices) |
| OB/OD Areas | Disposal of munitions | DMM, MC (for example, TNT, RDX) present in high enough concentration to pose an explosive hazard |
| Ammunition Plants (for example, building voids, piping, settling ponds, soil) | Production of explosives and munitions | MC (for example, TNT, RDX) present in high enough concentration to pose an explosive hazard |
| Storage Areas/Transfer Points | Storage and handling of munitions | Possibly DMM (various) |
| Firing Points | Preparation and firing of authorized weapons systems | Possibly DMM (various) |
| Impact Area | Multiple training activities | UXO (projectiles, grenades, rockets, bombs) |
| Burial Pits | Mass burial of large quantities of DMM | DMM (various) |
| Bivouac Areas | Troop encampments | Possibly DMM (various) |

*c.* When developing the CSM, features indicating known or suspected source areas should be identified. Source areas may be assumed based on common indicators including, but are not limited to:

(1) Known or suspected target or impact areas.

(2) Historical records of munitions use.

(3) Historical presence of MEC, munitions debris, or range-related debris.

(4) Scarring:

*(a)* Land scarring (for example, depressions, craters).

*(b)* Rock scarring resulting in fresh rock face, and rubble.

*(c)* Tree scarring or lack of or an unusual abundance of vegetation.

(5) Manmade or land features indicating munitions related activities (for example, concrete pads, berms, mounds).

(6) Incident reports of explosives or munitions emergencies (for example, Explosive Ordnance Disposal [EOD], local bomb squad).

(7) Eyewitness accounts of munitions use.

*d.* Such indicators can help the PDT focus on areas where MEC is most likely to be encountered. Figures 3-1 through 3-4 are examples of some indicators of source areas.

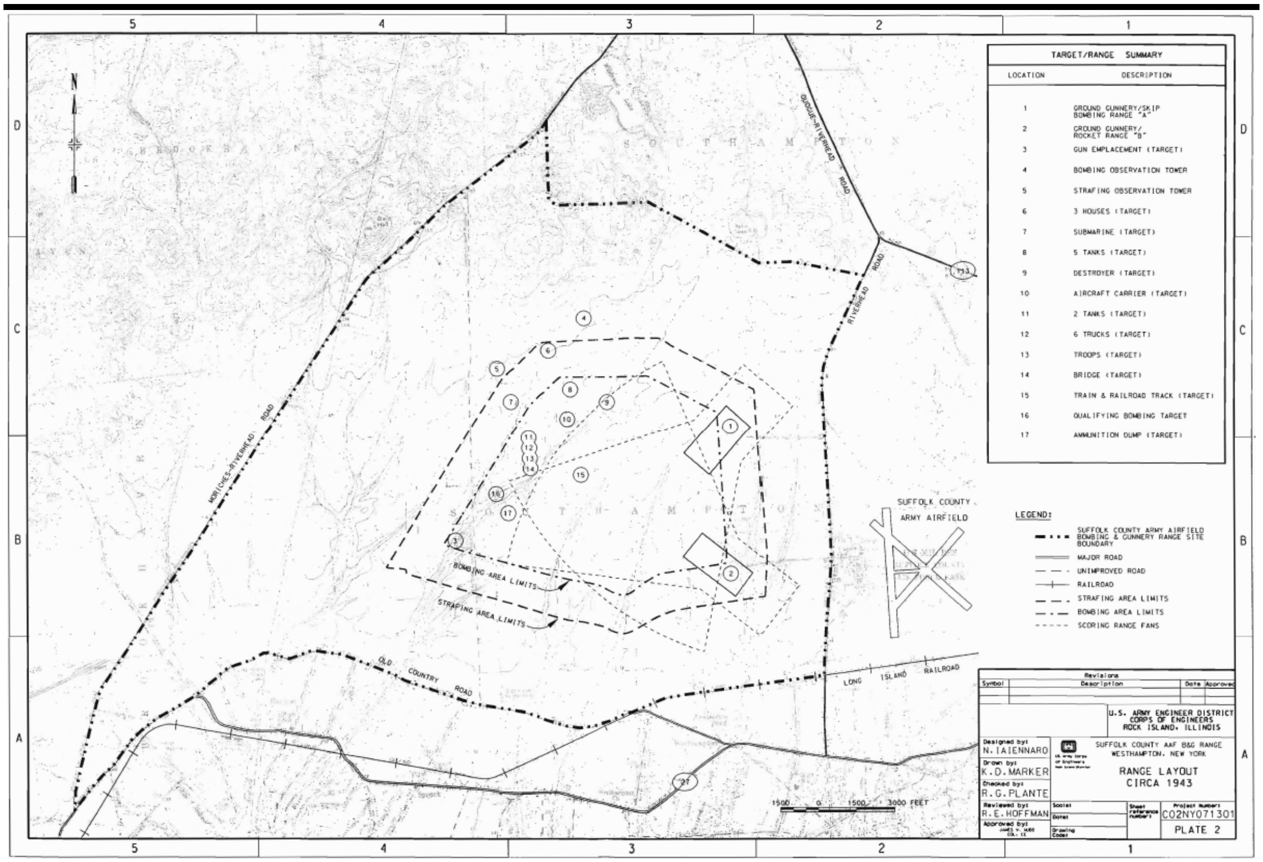



**Figure 3–1. Historical range map**

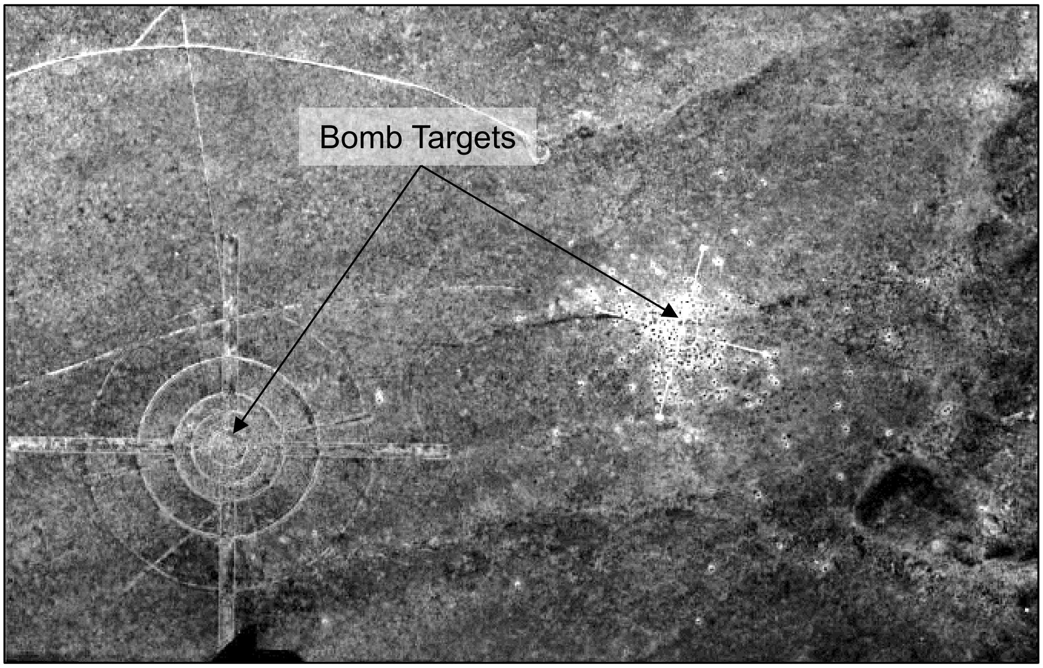



**Figure 3–2. Historical aerial photograph showing bomb target and ground scarring**

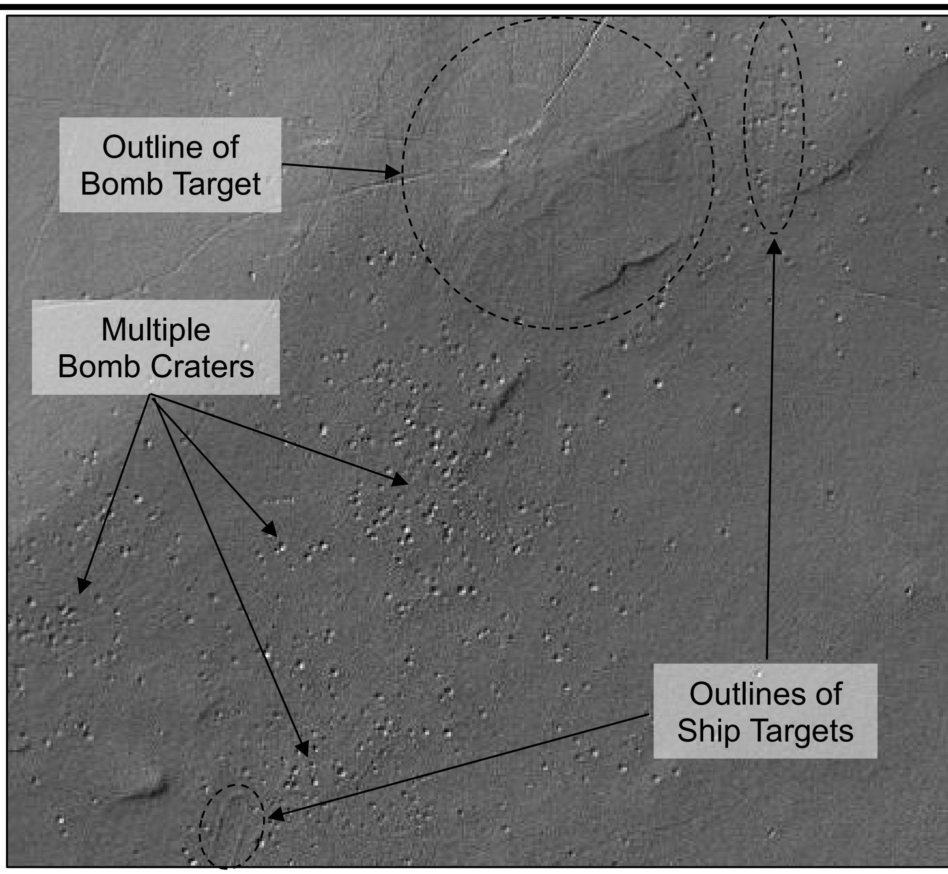



**Figure 3–3. LiDAR imagery showing bomb targets and ground scarring**

*e.* Natural terrain and man-made features are important considerations when assessing past range activities. Certain terrain features can limit the use of portions of a range, potentially impacting the areal extent of MEC. In Figure 3-4, the standard layout for a range is shown in both design and as-built drawings. A comparison of the two shows the total area of the range is reduced by the terrain feature. This effect is more applicable to direct fire (for example, bazooka) than indirect fire (for example, mortar, artillery) weapons.

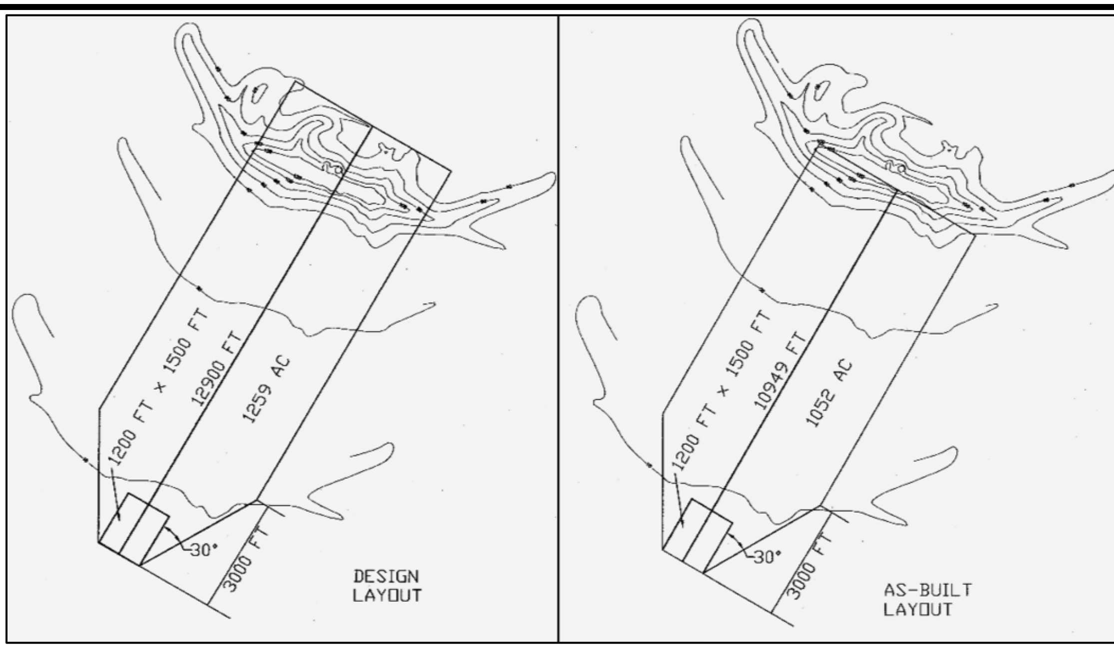



**Figure 3–4. Effect of natural terrain on range layout**

## 3–3. Physical profile

*a.* The physical profile for an MRS will provide a description of an MRS's physical properties. Physical properties effect the engineering aspects of detection and removal of MEC. Physical properties may impact the location and movement of MEC, as well as accessibility to the site. The physical profile should include:

(1) Topography and vegetation.
(2) Geologic and hydrogeologic setting.
(3) Hydrology, including mean high/low water line, if appropriate.
(4) Climate.
(5) Sensitive habitats.
(6) Areas that are inaccessible to investigation.

*b.* Certain terrain features (for example, impassable or rough terrain, such as steep cliffs; fast moving water; wetlands; tidal plains; water depth) and locations (for example, wilderness areas, distance from shore) limit a receptor's access to an MRS, which can reduce the likelihood of encountering MEC. Such terrain features may also limit potential response actions. This information should be collected and included in the CSM.

*c.* Naturally occurring conditions can affect the detection of subsurface anomalies when using geophysical instruments and methods. These conditions and the physical characteristics of the munitions may affect the various types of detection instruments in different ways. Terrain and geology features may introduce electronic noise, making detection difficult. Dense vegetation may affect the ability to get an instrument's sensor close enough to the surface, thereby limiting its effectiveness. Such vegetation may also limit choices for positioning technologies. Soil composition and moisture content are key elements to consider. These same instruments can also be used underwater to detect anomalies. However, the underwater environment presents a whole new set of challenges such as crab pots, outboard motorboat engines, large coral deposits, large rocks, etc. The PDT must evaluate these potential problems when planning their mapping strategy.

*d.* The physical profile is also important for identifying constraints on field activities and evaluating potential response actions.

**3–4. Release profile**

*a.* The release profile is developed to describe MEC hazards as they are known or suspected to be present in the environment. The release profile will, at a minimum, include:

(1) Description and locations of any known or suspected areas where munitions were handled, used, stored, or disposed (for example, targets, safety buffer zones, maneuver areas, storage facilities or open burning /open detonation (OB/OD) areas).

(2) Current understanding of the location and distribution (horizontal and vertical) of munitions and hazardous substances.

(3) Evaluation of prior land-disturbing activities that may have had the potential to redistribute MEC.

*b.* The release profile will contain critical information for the MEC risk assessment. It allows the PDT to visualize how MEC is present in the environment and the hazards it presents. When combined with information from the land use and exposure profile, the PDT gains an understanding of how potential interactions with MEC may occur.

*c.* Source Areas for MEC are described by categorizing MEC-contaminated areas as either "high use areas (HUA)" or "low use areas (LUA)." These terms are described in the MR-QAPP toolkit as follows:

(1) HUA: High anomaly density area (as determined by a geophysical investigation) where munitions use has been confirmed. Unexploded ordnance (UXO) and/or discarded military munitions (DMM) are anticipated to be present in HUAs.

(2) LUA: Low anomaly density area (as determined by a geophysical investigation) where the potential presence of munitions cannot be ruled out. Examples of LUA include buffer zones and maneuver areas.

*d.* Both HUAs and LUAs are potential source areas; however, HUAs are considered to have a much greater likelihood of containing MEC simply because more munitions use occurred there. HUAs are typically associated with target/impact areas or demilitarization sites (for example, open burning/open detonation). LUAs are typically associated with range safety buffer zones and maneuver areas.

*e.* An RI for MEC should be designed to locate and distinguish the HUAs and LUAs. MEC items are typically found in discrete locations and removed or destroyed in accordance with DoD explosives safety standards when they are discovered. Therefore, the determination of residual MEC presence is often inferred based on previous discoveries or the presence of munitions debris and/or range-related debris. If the investigation reveals that munitions were not used on a portion of an MRS, that portion may be categorized as a “no evidence of use (NEU) area.” The types of weapons systems and munitions used, and their respective range limits will usually provide a basis for estimating the spatial distribution of MEC within an impact area and its associated buffer zones. Standard layouts for range boundaries may also be used to help determine the anticipated locations where MEC are most likely to be present. The PDT should also consider how prior MEC clearance activities, such as interim surface and subsurface removal actions or partial range clearances, might affect the characteristics of MEC contamination, including HUAs. Such activities can alter the CSM and might make residual contamination more challenging to detect during investigations.

*f.* The PDT also needs to evaluate any naturally occurring processes (for example, erosion, flooding, frost heave, tidal action, etc.) or physical activities (for example, farming, construction, earth movement during range use or reconfiguration, dredging of sediment, etc.) that may have caused, or could cause, MEC to be relocated or become exposed over time. Data related to the geology, geomorphology, and hydrology of a site, as well as activities that have occurred at the site should be collected to assess this potential. For example, subsurface MEC can rise to the surface through frost heave if certain site conditions exist. These conditions are more prevalent in the northeast portion of the country. In the west, wind erosion is a more common occurrence that can cause MEC to become exposed to the surface. The most common cause of MEC to be moved, however, is for people to pick it up and move it from one location to another. This is especially true where old munitions sites are being cleared for agriculture or development. There are many reports of farmers uncovering old munitions and munitions debris when plowing, moving it off to the side and reporting it to authorities.

*g.* Special consideration must be given for underwater MEC. The DoD’s Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP) have funded numerous research projects to help understand the movement and migration of underwater munitions. At present, research has shown that the density of the specific munitions item controls whether it will be mobile in the wave zone. Most munitions are too dense to be transported, and instead will tend to scour in place or roll downslope. Munitions found on the beach after a storm most likely eroded out of sand. When developing a CSM with an underwater component, the latest scientific research on the subject should be reviewed (for example, https://www.serdp-estcp.org/Program-Areas/Munitions-Response).

## 3–5. Land use and exposure profile

*a.* The land use and exposure profile is used to identify current and reasonably anticipated future on-site and surrounding off-site land uses and associated receptors. It is also used to describe the current and reasonably anticipated future frequency of use, access, and activities that could result in receptor exposure to MEC. The land use and exposure profile should include:

(1) Current and reasonably anticipated future land use.

(2) Neighboring land uses.

(3) Current and reasonably anticipated future receptors and exposure pathways.

(4) Access conditions and frequency of use.

*b.* The land use and exposure profile identifies the human activities on the MRS (for example, hiking, hunting, farming, construction) that may result in a potential contact with MEC. The potential for contact must also consider the location of MEC (identified in the facility and release profiles) and the intrusiveness, intensity and frequency of those activities at the MRS. Population densities and demographic information, which can normally be based on the most recent census, should also be included.

*c.* A land use and exposure profile should also be developed for any known or reasonably anticipated future land use. Zoning, master planning, and community interest are important as the PDT agree upon an MRS's reasonably anticipated land use. These profiles will assist in determination of the appropriate receptors to be evaluated in the pathway analysis.

## 3–6. Ecological and cultural resources profile

The presence of ecological or cultural resources on an MRS should be considered in development of the CSM. Humans are typically considered as the primary and often the only receptor to MEC because animals tend to not interact with MEC in ways that impart sufficient energy to result in an explosive incident. However, the presence of ecological or cultural resources on an MRS should be known to avoid or mitigate response actions (for example, vegetation removal) that could adversely impact such resources. Ecological resources 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. Special use areas (for example, fisheries) potentially impacted by the site should also be described. Note that the ecological risk assessment required by CERCLA evaluates a broad range of ecological receptors not limited to those listed under the Endangered Species Act. Therefore, the CSM should describe the general site ecosystem in addition to any species of special concern. Cultural resources may include historic buildings or structures; prehistoric sites; historic or prehistoric objects or collections; rock inscriptions; earthworks, canals, or landscapes.

## 3–7. Vertical profile

*a.* The vertical profile (sometimes referred to as the "vertical CSM") is a CSM element that combines elements from several of the CSM profiles listed in Table 2 1. The vertical profile describes a variety of depth-related data related to site contamination, receptors, and exposure routes. For munitions response CSMs, this information includes, but is not limited to:

(1) The anticipated depth distribution for each type of MEC known or suspected to be present at the MRS.

(2) For each type of seed item used (if seeds were used), the depth interval over which those seeds were emplaced.

(3) The reliable and maximum detection depths (that is for least favorable and most favorable orientations, respectively) for each type of MEC known or suspected to be present and for each type of seed item used.

(4) A reporting of the vertical distribution of all detected and all recovered pieces of metal, preferably using histograms with five- or ten-centimeter bin intervals. If different groups of sources are known, such as MEC items, munitions debris, range-related debris, and non-munitions related items, each group should be reported individually.

(5) Maximum and/or common interaction zone depths for each type of land use activity. If the maximum depth varies for all the activities that can occur for that land use, then the maximum depth for each must be shown (for example, recreational use can have very frequent surface-only activities [hiking] and seldom have subsurface ground disturbances to one foot (digging latrines or fire pits, emplacing tent stakes, etc.)).

(6) For each type of MEC, the estimated maximum depth it could exist within the land use interval. RI characterization results may confirm the MEC can exist throughout the land use interval (for example, MEC was recovered at the maximum land use depth). If the RI findings do not prove MEC exists throughout the land use interval (for example, MEC was not recovered to the maximum land use depth) then the PDT, supported by appropriate subject matter experts, must estimate the potential depth distribution for each type of MEC known or suspected to be present within each identified land use interval. The rationales for these estimates should be explained in the CSM. (NOTE: while vertical distribution of detected and recovered pieces of metal, including munitions debris, can be used to support these estimates, munitions debris depth alone is NOT a reliable predictor of MEC depth – it is possible to use parametric data based on remedial action data for similar sites, munitions penetration data from SERDP/ESTCP, and PDT estimates made using professional judgement and experience.)

(7) The bedrock depth, if known, for sites where bedrock might limit MEC depth and/or intrusive activities (initial information on regional bedrock depth can be found at the USDA Web Soil Survey: https://websoilsurvey.sc.egov.usda.gov/).

(8) For remedial or removal actions, the removal depth described in the relevant Record of Decision.

*b.* The vertical profile will aid in the development of the RAO and the development and evaluation of remedial alternatives. Figure 3-5 is an example of a vertical profile illustration for an RI, while Figure 3-6 shows an example vertical profile for a remedial action.

**3–8. Exposure pathway analysis**

Careful analysis of the profile information should allow the PDT to identify potential source receptor interactions with MEC. The CSM will illustrate all potential pathways (see Section 2-7 for various CSM representations). For MEC, a complete pathway must include the presence of MEC (a source), a receptor, access to an MRS, and an activity that provides for a potential interaction (for example, touching, disturbing, moving) with MEC.

*a.* Sources. Source areas are identified during generation of the facility, physical, and release profiles from archival research or direct evidence compiled during a site visit. A source area is described by the following components: the type of area (HUA, LUA, or NEU), the location and dimensions of the area, and the density and distribution (including estimated or confirmed depth) of MEC within the area. If the location or distribution of MEC has changed over time because of physical process or human activity, this movement can increase the potential for human exposure.

*b.* Exposure Media. Exposure media for MEC are typically soil or sediment containing MEC that have become contaminated following a release.

(1) Soil (surface and subsurface) is the most common exposure medium for MEC. The PDT must determine the depth of contamination, the potential for human contact with the contamination while conducting intrusive or non-intrusive activities. While uncommon for MEC, it is also important to evaluate whether natural processes or human actions might result in MEC items being moved or exposed.

(2) Sediment is a less common exposure medium for MEC. However, human receptors can be exposed under certain conditions, such as through wading or swimming.

*c.* Exposure Point. As discussed in Chapter 2, because movement of MEC is generally not significant, MEC sources typically remain in the medium to which they are released. For this reason, the exposure points for MEC are most often at their source location unless they have been relocated via natural processes or human actions.

*d.* Receptors and Exposure Routes.

(1) Receptors. Receptors for MEC are identified in the Land Use and Exposure Profile. Typically, the PDT only considers human receptors regarding potential MEC exposures because animals tend to not interact with MEC in ways that impart sufficient energy to result in an explosive incident. Evaluation of actual and potential receptors must consider both current and reasonably anticipated future land use. Human receptors are typically divided 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.

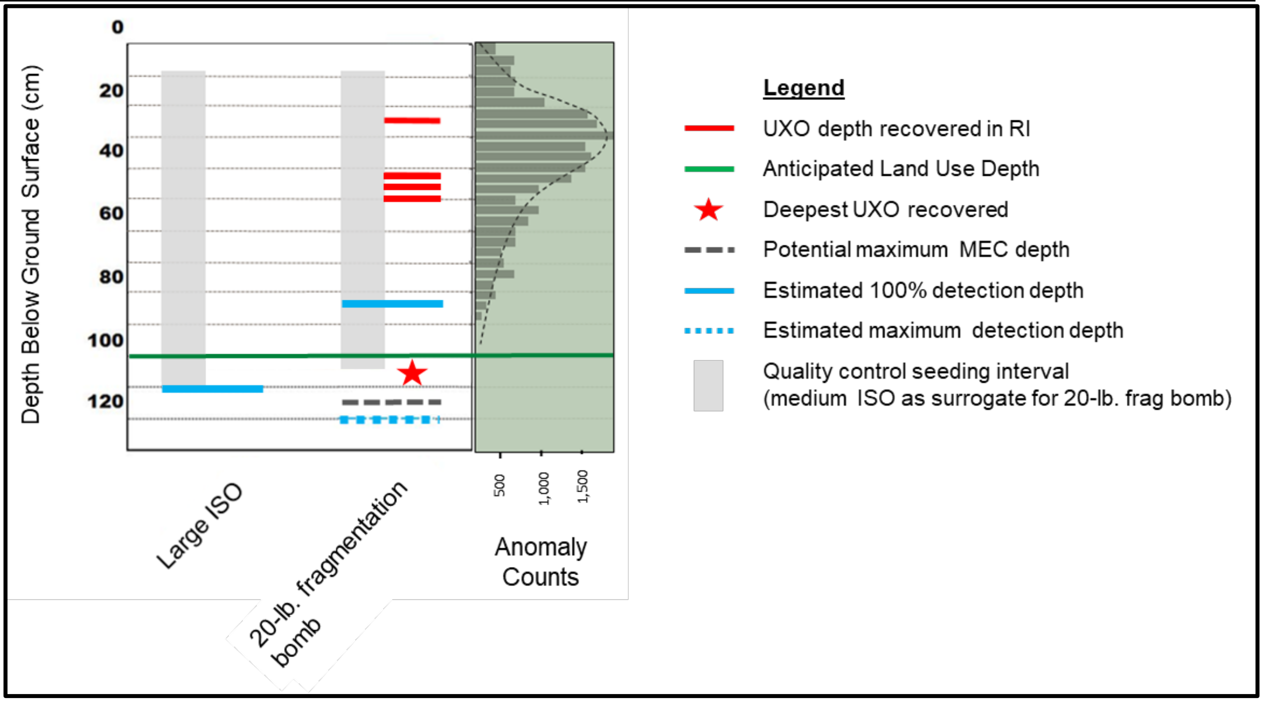



**Figure 3–5. Remedial investigation vertical profile (example)**

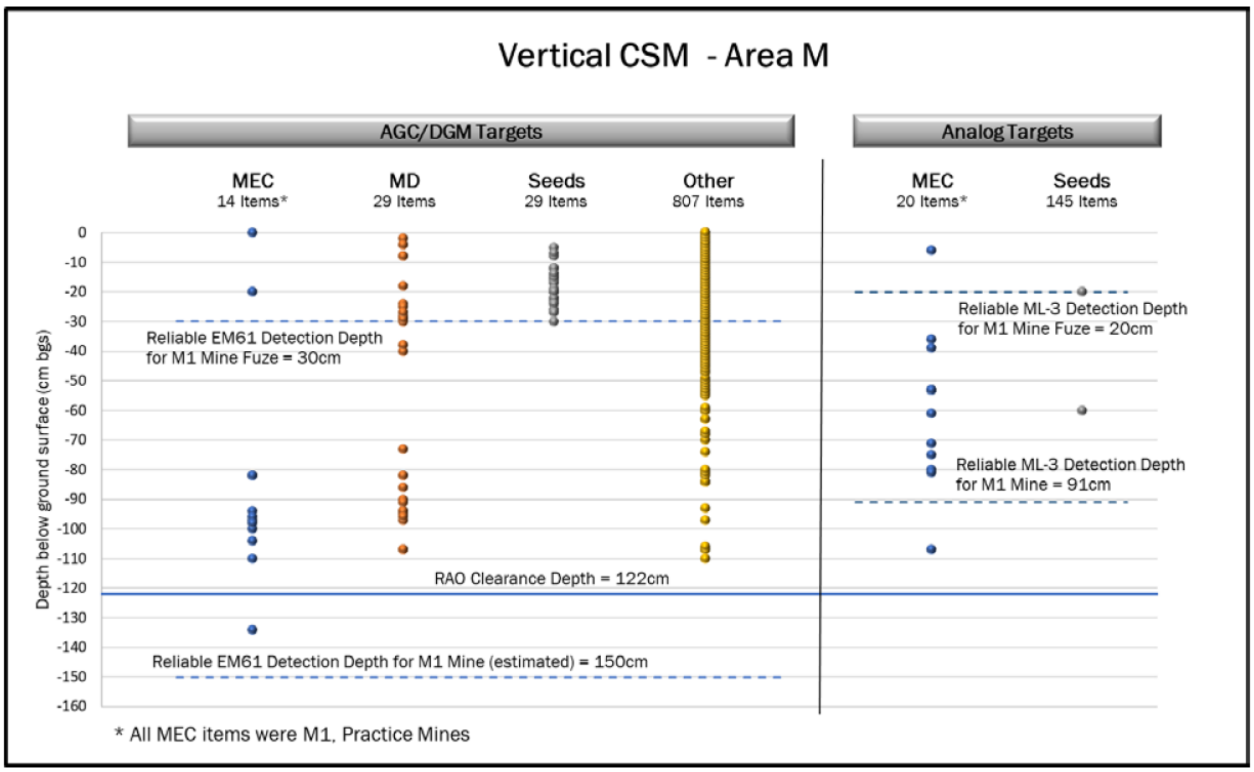



**Figure 3–6. Remedial action vertical profile (example)**

(2) Exposure Routes. An exposure route for MEC involves a receptor's encounter with a MEC item, followed by, or concurrent with, an interaction that imparts energy to the item resulting in a harmful explosive incident. An "encounter" is defined as a chance event during which a receptor gets sufficiently close to a MEC item that they might interact with it (note that this does not require the individual to interact with the MEC item). An "interaction" is defined as when, upon encounter, a receptor imparts energy to the MEC item, either intentionally or unintentionally, such that it might function (note that this does not require the receptor to physically come into direct contact with the MEC item). These concepts are addressed in additional detail in EM 200-1-15. The conditions affecting exposure routes for MEC include munitions distribution and types and their potential to cause harm, as well as access to the source and the activities being conducted:

*(a)* Access Conditions. The ability of a receptor to enter an MRS can be affected by both natural and man-made features. These features must be analyzed to determine if the access component of a pathway is complete or could become complete with the reasonably anticipated future land use for the MRS. Terrain, vegetation and other natural features (for example, sheer cliffs, crevices, fast running or deep water) in the physical profile for an MRS may provide natural barriers that limit access to, or movement within, an MRS. Additionally, man-made features (for example, fences, buildings, concrete pads) identified in the facility profile can also limit access to the MEC source or exposure media. Although access is generally defined in terms of access to an MRS, the location of MEC may also limit access (for example, while MEC on the surface is typically always accessible, MEC in the subsurface is inaccessible to all non-intrusive activities). The frequency of access must also be considered. An MRS may have completely open access but have very few visitors. The population and population density near an MRS and potential for transient populations (for example, hikers, boaters) to visit an MRS during specific periods of time should also be evaluated.

*(b)* Nature of Activity. Activity considers intrusiveness, intensity and frequency of the actions that result in an exposure to MEC. Identification of MEC pathways should focus on current or future activities that bring humans into contact with the MEC, based on current or reasonably anticipated future land uses. For example, construction could lead to an exposure to MEC in the subsurface. Information from all profiles will be used in establishing the activities of the receptors. Different activities may be associated with each receptor type and it is critical to understand and clearly describe the actions that may result in direct contact with individual MEC items in the source area. It is also important to evaluate the depth of intrusive activity against the estimated depths of MEC. Contact with MEC cannot occur where the depth of intrusive activity does not reach the depth of the MEC, and the pathway would not be complete. Future use of property containing MEC may result in intrusive activities (for example, construction or agriculture) that increase the potential for contact. The intensity and frequency of activities should also be evaluated.

# Chapter 4
# Development of a Conceptual Site Model for Hazardous, Toxic, and Radioactive Waste and Munitions Constituents Responses

## 4–1. Introduction

This chapter describes the steps in developing the HTRW/MC portions of the CSM. As with MEC, the primary focus of the CSM is to illustrate the interaction between contaminant sources and receptors. This is accomplished through development of profile information (see Section 2-5) and subsequent pathway analysis. The Defense Environmental Restoration Program (DERP) addresses all CERCLA hazardous substances, pollutants, and contaminants which includes MC but does not include petroleum. However, petroleum may possibly be addressed under DERP to correct environmental damage that creates an imminent and substantial endangerment to public health or welfare or the environment.

## 4–2. Facility profile

*a.* Facility profiles are used to determine potential source areas at a site. Source areas should be identified based on the presence or suspected presence of a contaminant. Sources of contaminants are described in terms of chemical composition, their known or suspected location, and concentration or amount. The PDT should be familiar with the historical operations at a site to recognize potential unauthorized disposal sites or areas with likelihood for incidental spills or releases. Potential HTRW source areas typically include landfills, surface impoundments, scrap yards, fire training areas, process buildings, and underground storage tanks. Potential MC source areas are often the same as MEC source areas (see Table 3-1). All suspected source areas should be marked clearly on a site map, including the relationship to property boundaries.

*b.* Historical site operations (for example, maintenance facility, paint shop, fire training area) and site physical characteristics (for example, berms, depressions, soil staining or stressed vegetation) provide initial clues to the location of potential source areas. Sampling data, if available, are typically the most reliable indicator of HTRW source areas. In the absence of adequate sampling data, other methods may be used to develop reasonable hypotheses regarding potential HTRW source areas. In general, biased sampling data provide information on the presence or absence of significant contamination at potential source areas, while results from statistical sampling designs provide information on the extent of contamination and risk. Additionally, review of historical aerial photography over time is good practice to determine if there are signs of potential source areas and should be included in the profile information (Figure 4-1). Also included should be information indicating whether there have been any subsequent uses of the property if the facility is no longer active (as is the case for FUDS).

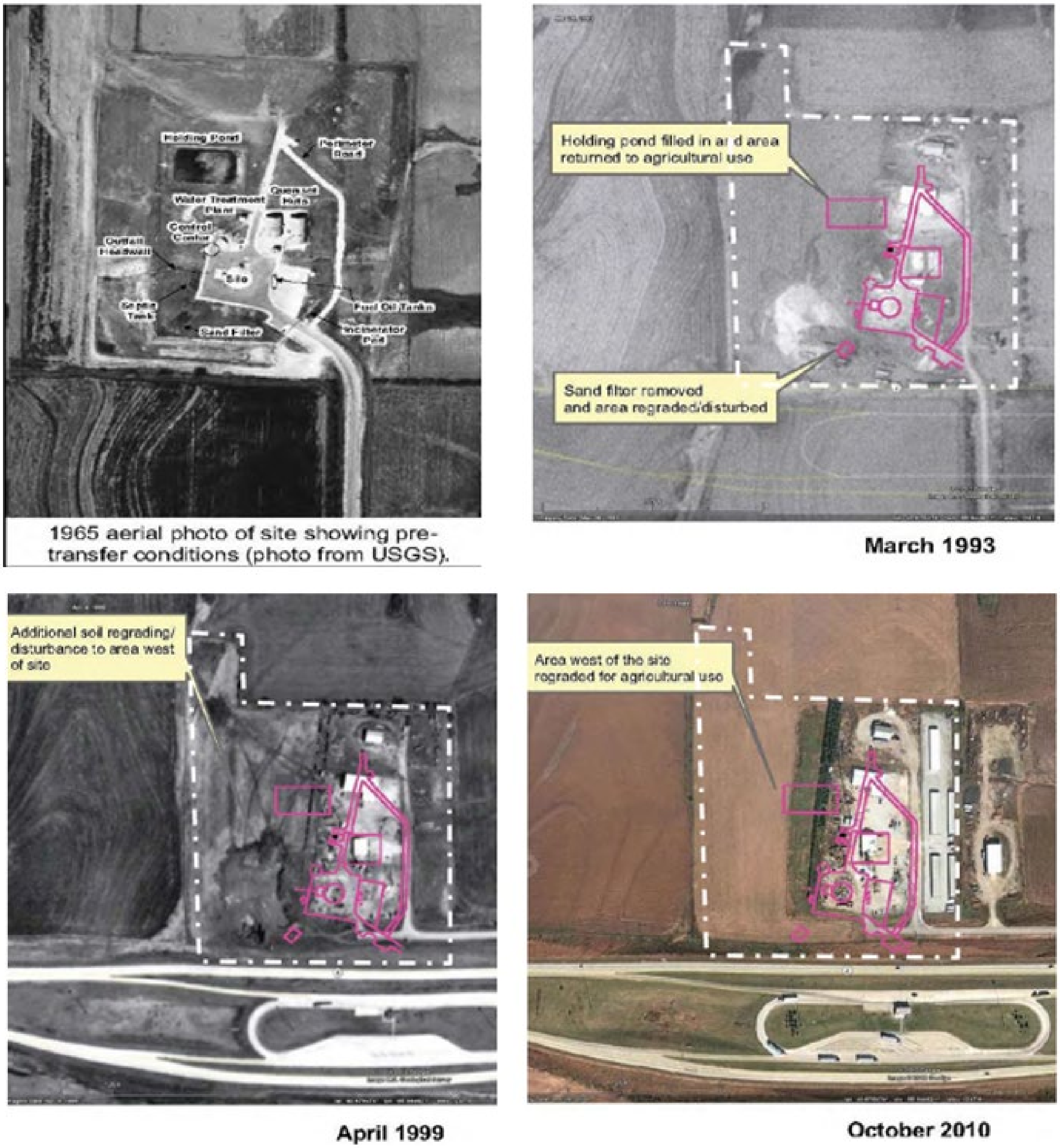



**Figure 4–1. Aerial imagery of a Lincoln Atlas "F" missile site from 1965 to 2010**

*c.* Former range operations can also indicate where potential MC source areas might be found. The PDT defines the range boundaries to focus their investigation and typically base the MC sampling on geophysical investigation results. For example, the geophysical investigation should result in a map showing the density of subsurface anomalies (Figure 4-2), which can indicate where MC are most likely to be found.

Although this information would be reflected in the MEC portion of the CSM, this information would be critical to the MC portion of the CSM as well because it shows those areas most likely to be a source of environmental/chemical contamination from MC (Figure 4-3).

*d.* Some locations with MEC may also have other environmental/chemical contamination. For example, fuels were often used at OB/OD areas as accelerants when excess munitions were destroyed. Similarly, the manufacture of explosives at ammunition plants generated large quantities of waste rinse water that was retained in impoundments and often released contaminants to other media.

*e.* Changes in the chemical composition of HTRW/MC may occur over time and from exposure to the environment and should be considered when determining the appropriate sampling and analytical methods. 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.

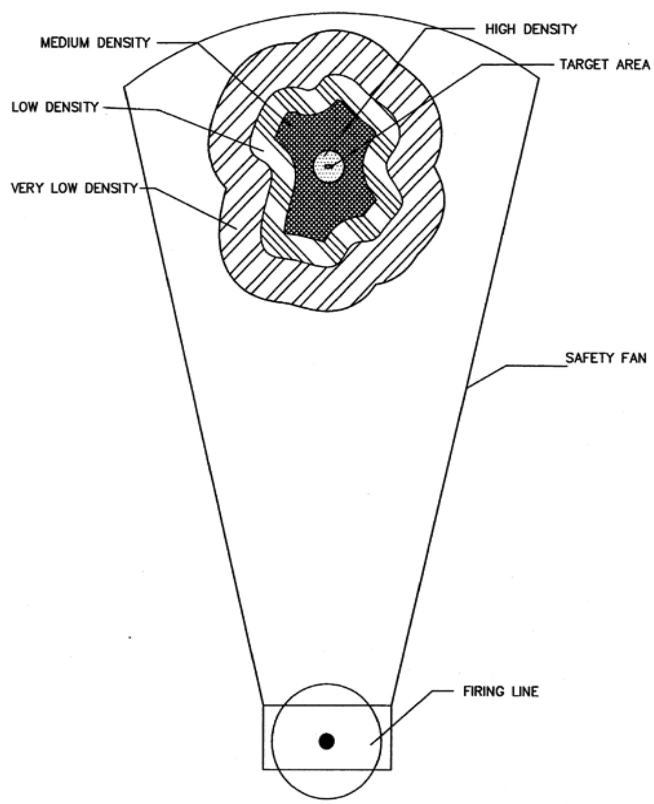



**Figure 4–2. Anomaly density indicating a former target area**

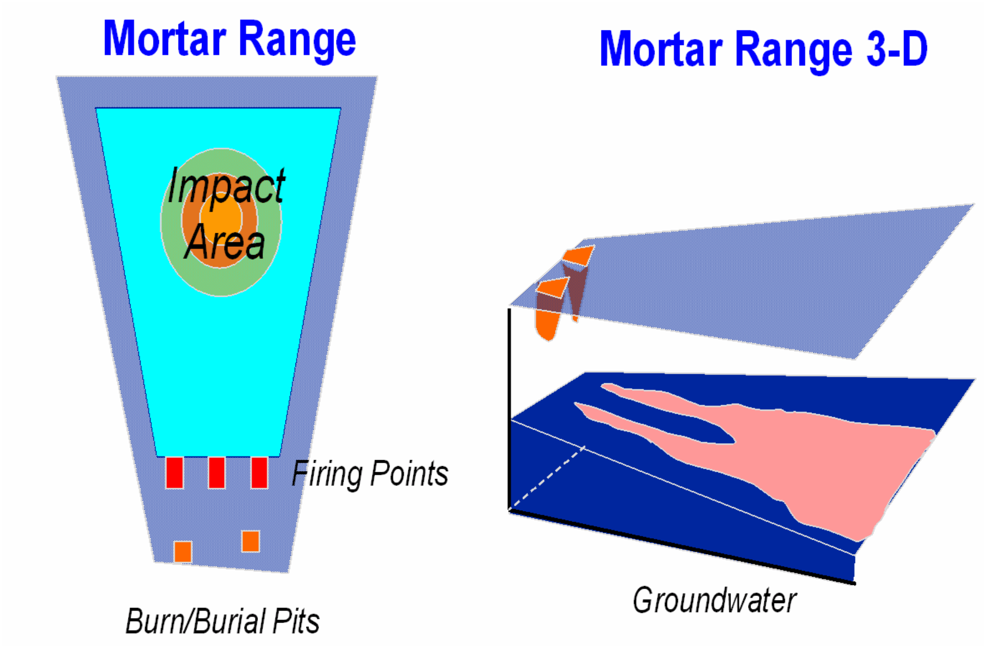



**Figure 4–3. Areas of potential MC distribution at a mortar range**

## 4–3. Physical profile

*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 groundwater characteristics, hydrogeology, and topography. Soil type and soil properties (moisture content, corrosivity, pH, etc.) can affect the fate and transport of HTRW/MC contamination.

*b.* Physical profiles also describe site conditions important in determining exposure potential. Excessive topographic relief, dense vegetation, water bodies, or other physical characteristics may be extremely important for transport pathway considerations. Subsurface conditions, geology, hydrology and aquifer characteristics are also extremely import to characterize as many HTRW/MC remedial alternatives rely on a clear understanding and presentation to ensure selection of an appropriate remedial alternative and ultimately remedial success.

*c.* The physical profiles is also important for identifying constraints on field activities and evaluating potential response actions.

## 4–4. Release profile

*a.* An HTRW or MC contaminant is rarely completely immobile after it is released into the environment. Therefore, pathway analysis for 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.

*b.* Release mechanisms should be identified for each source present at the site and multiple release mechanisms may exist for the same source. A drum of liquid contaminant may leak into soil as a primary release mechanism, then create a secondary release mechanism through dissolution in groundwater. Volatilization 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. Additionally, the CSM needs to present the media to which the release occurred and should include a description on the phase of contamination present, the hydrogeology/geology of the areas impacted and the geochemistry of not only the impacted media but also of areas not impacted (such as an aerobic vs anaerobic aquifer). Fate and transport mechanisms such as mass flux, permeability and transmissivity are key parameters that should be included in the CSM. For HTRW sites, specifically with petroleum or chlorinated solvent contamination, the most complete CSMs describe the aquifer matrix heterogeneity using high resolution characterization technologies.

*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, groundwater, sediments, surface water, air, and biota. The biotic medium can exist through uptake, accumulation, or concentration of contaminants by organisms and subsequent transport of that contaminant through the food chain.

### 4–5. Land use and exposure profile

*a.* The land use and exposure profile is used to identify current and reasonably anticipated future on-site and surrounding off-site land uses and associated receptors. It is also used to describe the current and reasonably anticipated future frequency of use, access, and activities that could result in receptor exposure to MC/HTRW. The land use and exposure profile should include:

(1) Current and reasonably anticipated future land use.

(2) Neighboring land uses.

(3) Current and reasonably anticipated future receptors and exposure pathways.

(4) Access conditions and frequency of use.

*b.* Demographic as well as sensitive subpopulation information is included in this profile. This will aid in determining the appropriate receptors to be evaluated in the pathway analysis. Although the source–receptor interactions may differ, understanding receptor populations and their activities is necessary for either MEC or MC/HTRW investigations and remedial actions.

*c.* The exposure profile identifies the available human 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 human receptors must be identified in this profile (ecological receptors are identified in the Ecological and Cultural Resources Profile – see below). Zoning, master planning, and community interest are critical to determining and defending determined or reasonably anticipated future land use.

### 4–6. Ecological and cultural resources profile

This profile includes a description and use of the natural habitats and culturally significant resources 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. Special use areas (for example, fisheries) potentially impacted by the site should also be described. Note that the ecological risk assessment required by CERCLA evaluates a broad range of ecological receptors not limited to those listed under the Endangered Species Act. Therefore, the CSM should describe the general site ecosystem in addition to any species of special concern. Cultural resources may include historic buildings or structures; prehistoric sites; historic or prehistoric objects or collections; rock inscriptions; earthworks, canals, or landscapes.

## 4–7. Vertical profile

*a.* The vertical profile (sometimes referred to as the “vertical CSM”) describes a variety of depth-related data associated with site contamination, receptors, and exposure routes. For HTRW/MC CSMs, this information includes, but is not limited to:

(1) Contaminant concentrations – to include depth distribution, spatial patterns and concentration isocontours.

(2) Geologic information – soil types, geologic heterogeneity, geologic formations.

(3) Constructed and natural features.

(4) Hydrogeology and aquifer conditions (confined, unconfined, perched, vertical hydraulic gradient, high versus low permeable zones, transmissivity, etc.) and depth to water table.

*b.* The vertical profile will aid in the development of the RAO and the development and evaluation of remedial alternatives. Figure 4-4 shows an example of a vertical profile for groundwater at an HTRW site, while Figure 4-5 shows both a plan view and a profile view of a groundwater plume at an HTRW site.

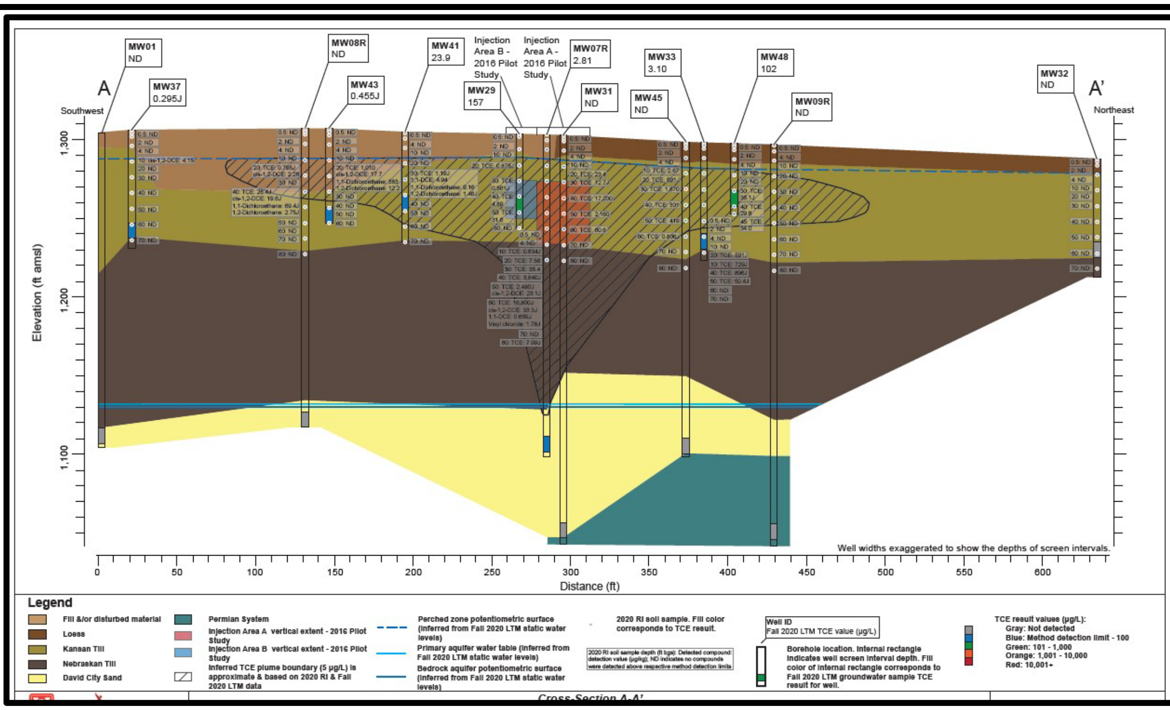



**Figure 4–4. Vertical profile for groundwater at an HTRW site (example)**

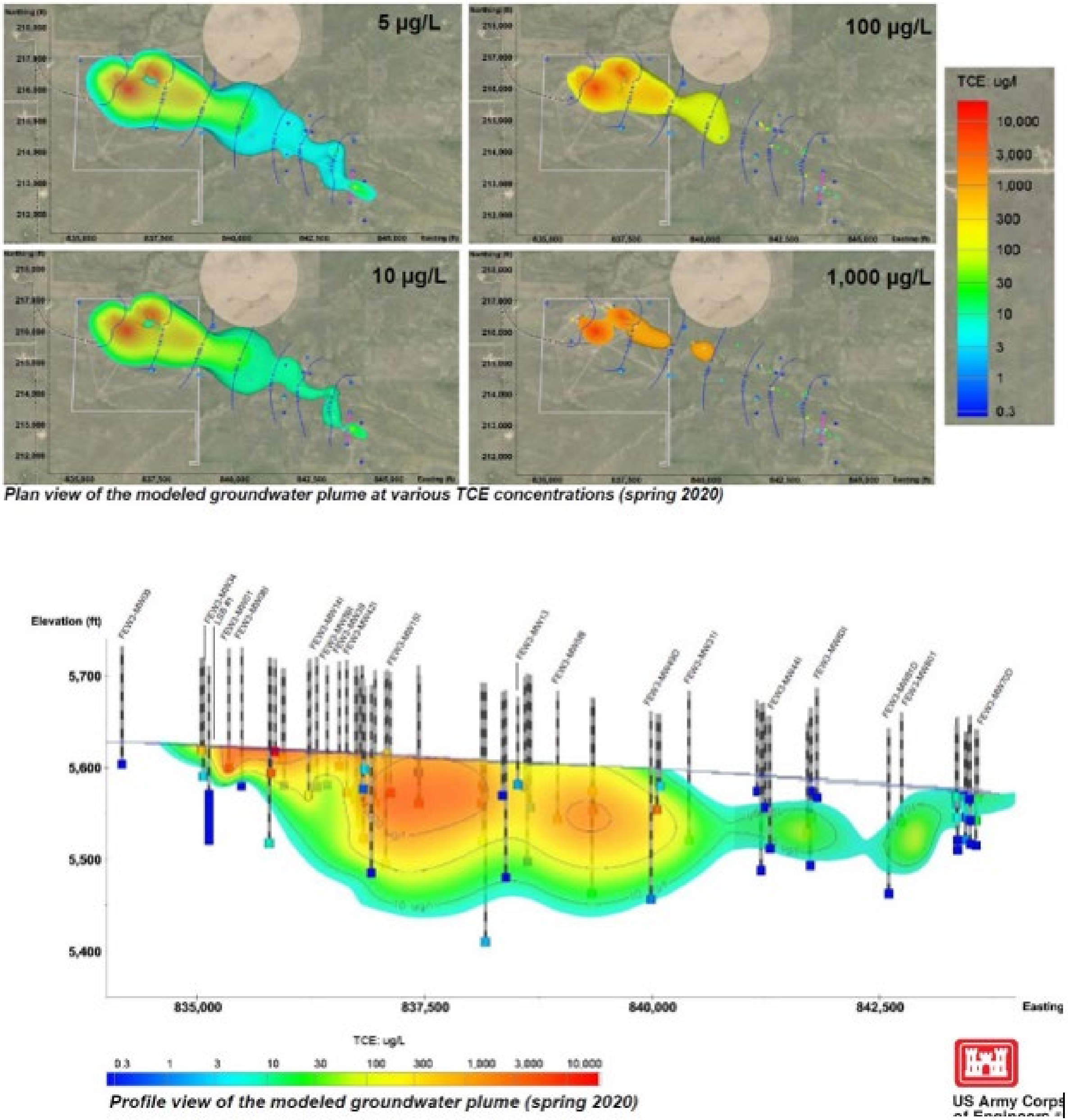



**Figure 4–5. Plan view (top) and profile view (bottom) of a groundwater plume at an HTRW site**

## 4–8. Exposure pathway analysis

Careful analysis of the profile information should allow the PDT to identify all source–receptor interactions, for both current, determined, or reasonably anticipated future land use. The CSM will illustrate all potential pathways (see Section 2-7 for various CSM representations). Each pathway must include a source, an exposure medium, an exposure route, and a receptor. The pathway may also include a release mechanism (for example, volatilization) and a transport medium (for example, 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. For MC, potential source areas are the same as those identified for MEC in Chapter 3. Source areas are described by the following components: area use, type and concentrations of contaminants, and lateral and vertical extent within media.

*b.* Exposure Media. Exposure media for HTRW/MC typically are soil, sediment, water, or air containing the source and those media that become contaminated through migration of the contaminant from the source area.

(1) Soil (surface and subsurface) is important as an exposure medium where there is potential for receptor contact with contamination or for contaminant migration into another medium. The PDT must determine the depth of contamination, the potential for human or biotic contact with the contamination, and the migration potential of the contaminant.

(2) Groundwater is important as an exposure medium when contaminated groundwater is used, or may be used, for domestic purposes. Contaminants are rarely released directly into groundwater. Groundwater is usually contaminated by migration from soil. The PDT must consider factors that affect the likelihood of a contaminant reaching groundwater, such as density and solubility of the contaminant, depth to the aquifer, and permeability of the overlying strata. Contaminant migration within the aquifer must consider transmissivity of the water-bearing unit, presence and continuity of confining layers, as well as fate and transport properties of the contaminant.

(3) Sediments are most important as exposure media for ecological receptors, as sediment-dwelling organisms typically serve as a food source for organisms higher on the food chain. Human receptors can be exposed under certain conditions, such as through wading or swimming.

(4) Surface water is important as an exposure medium when contamination is released directly to the surface water body, or through contaminant migration from another medium (for example, surface soil or groundwater). Human receptors can be exposed through recreational activities (for example, swimming, wading, or fishing) or domestic uses of the surface water.

(5) Air is important as an exposure medium 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. Vapor phase VOCs from groundwater and soils is an important consideration when evaluating risk owing to vapor intrusion for workspaces and residential dwellings.

(6) The biotic exposure medium (plant or animal tissue) is important when considering the potential for transfer of contaminants through the food chain. Bioaccumulation and bioconcentration of some contaminants in plants or animals can result in exposure of other receptors to harmful contaminant concentrations.

*c.* Exposure Point. As discussed in Chapter 2, HTRW/MC often undergo various processes (for example, volatilization, migration) that results in media other than the source area becoming contaminated. For this reason, the exposure point may be located away from the location of the original release. For example, if contamination in soil migrates into groundwater, which then is pumped from the ground and used as drinking water, the point of exposure could be the faucet(s) from which that water was consumed.

*d.* Receptors and Exposure Routes.

(1) Receptors. Receptors for HTRW/MC are identified in the Land Use, Exposure Profile, and the Ecological and Cultural Resources Profile. The PDT must consider both human and ecological receptors. Evaluation of actual and potential receptors will consider both current and reasonably anticipated future land use. Human receptors are typically divided into several categories to represent varying degrees of potential exposure. These may include residents, site workers, construction workers, recreational users, and trespassers. Similarly, ecological receptors are typically divided by species, trophic groups, and/or taxonomic class (for example, birds, mammals, etc.). The probability, frequency, and duration of each receptor's exposure to the contaminant are assessed.

(2) Exposure Routes. Exposure routes are those processes or actions by which a contaminant contacts a receptor. For most HTRW/MC contaminants, these include ingestion, inhalation, and dermal contact. Ingestion can be both incidental (for example, getting contaminated soil or water on a receptor's skin, which then gets transferred to their mouth) and intentional (for example, consuming contaminated water, plants, or livestock). Inhalation can be an exposure route for volatile contaminants and suspended particles of dust from a contaminated source. 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, or a receptor may inhale volatile compounds from groundwater used as a domestic water supply or via vapor intrusion. Multiple receptors may be, and typically are, exposed through a single exposure route. Ingestion of contaminated soil or surface water is as much a concern for terrestrial or aquatic wildlife as for humans.

**Appendix A**
**References**

**Section I**

**Required Publications**
Unless otherwise indicated, all U.S. Army Corps of Engineers publications are available on the USACE website at https://www.publications.usace.army.mil/. Army publications are available on the Army Publishing Directorate website at https://armypubs.army.mil. DoD Publications are available on the ESD website at https://www.esd.whs.mil.

**AR 385–63**
Department of the Army, U.S. Marine Corps, Range Safety.

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

**ER 200–1–5**
Policy for Implementation and Integrated Application of the U.S. Army Corps of Engineers Environmental Operating Principles and Doctrine.

**ER 200–1–7**
Chemical Data Quality Management for Environmental Restoration Activities.

**ER 200–3–1**
Environmental Quality – Formerly Used Defense Sites (FUDS) Program Policy.

**ER 1110–1–8157**
Geotechnical Data Quality Management for Hazardous Waste Remedial Activities.

**EM 200–1–15**
Technical Guidance for Military Munitions Response Actions.

**EM 200–1–4**
Risk Assessment Handbook: Volume I - Human Health Evaluation.
Risk Assessment Handbook: Volume II - Environmental Evaluation.

**10 USC 2710**
Environmental Restoration: Inventory of unexploded ordnance, discarded military munitions, and munitions constituents at defense sites (other than operational ranges) (Available at https://uscode.house.gov/)

**42 USC 2011**
Development and Control of Atomic Energy: Atomic Energy (Available at https://uscode.house.gov/)

**42 USC 9601**
Comprehensive Environmental Response, Compensation, and Liability: Definitions (Available at https://uscode.house.gov/)

**32 CFR 179**
Office of the Secretary of Defense: Munitions Response Site Prioritization Protocol (MRSPP) (Available at www.govinfo.gov)

**40 CFR 266**
Environmental Protection Agency: Military Munitions (Available at www.govinfo.gov)

**40 CFR 300**
Environmental Protection Agency: National Oil and Hazardous Substances Pollution Contingency Plan; Involuntary Acquisition of Property by the Government (Available at www.govinfo.gov)

**Agency for Toxic Substances and Disease Registry**
https://www.atsdr.cdc.gov/

**ASTME 1689–20**
Standard Guide for Developing Conceptual Site Models for Contaminated Sites (Available at www.astm.org)

**EPA/240/B-06/001**
Guidance on Systematic Planning Using the Data Quality Objectives Process (Available at www.epa.gov)

**EPA/240/B-06/004**
Systematic Planning: A Case Study for Hazardous Waste Site Investigations (Available at www.epa.gov)

**EPA-505-B-04-900A**
Uniform Federal Policy for Quality Assurance Project Plans (Available at www.epa.gov)

**EPA/540/1-89/002**
Risk Assessment Guidance for Superfund, Human Health Evaluation Manual (Available at www.epa.gov)

**FUDSMIS (Formerly Used Defense Sites Management Information System)**
https://fudsmis.usace.army.mil/#Fudsmis/Home (CAC required)

**FUDSMIS Geographic Information System**
http://maps.crrel.usace.army.mil:7778/apex/fuds.fudscm2.map (CAC required)

**IDQTF MR-QAPP Module 1: RI/FS**
Uniform Federal Policy for Quality Assurance Project Plans, Munitions Response QAPP Toolkit Module 1: Remedial Investigation (RI)/Feasibility Study (FS) (Available at www.epa.gov)

**IDQTF MR-QAPP Module 2: RA**
Uniform Federal Policy for Quality Assurance Project Plans, Munitions Response QAPP Toolkit Module 2: Remedial Action (Available at www.epa.gov)

**Munitions Response Historical Record Review**
Interstate Technology & Regulatory Council, Unexploded Ordnance Team. 2003. (Available at www.itrcweb.org/guidance)

**National Park Service National Register of Historic Places**
https://www.nps.gov/subjects/nationalregister/index.htm

**NOAA National Weather Service**
https://www.weather.gov/

**OSD Memorandum 18 Dec 2003**
Definitions Related to Munitions Response Actions (Available at https://www.epa.gov/sites/default/files/documents/mrp_definitions_12-18-03.pdf)

**Remediation Management of Complex Sites**
Interstate Technology & Regulatory Council, Remediation Management of Complex Sites Team. 2017. (Available at www.itrcweb.org/guidance)

**USDA Web Soil Survey**
https://websoilsurvey.sc.egov.usda.gov/

**USFWS Information for Planning and Consultation**
https://ipac.ecosphere.fws.gov/

**USGS Geographic Information System (National Map Download Application)**
https://apps.nationalmap.gov/downloader/#/

**USGS Geologic maps of US states**
https://mrdata.usgs.gov/geology/state/

## Section II

### Prescribed Forms

This section contains no entries.

## Appendix B
## Range Operations Overview

### B–1. General

When developing a CSM for a former military site, it is critical for the PDT to understand the basics of design, operation, and maintenance of training ranges. Different range locations were used for different operations, each of which may have had distinctly different associated hazards. This appendix presents an overview of the most important range elements. More comprehensive information can be found in the Common Operations Reports for FUDS properties, which are available on the non-project section of FUDS Docs.

### B–2. Targets

These are locations within a larger impact area at which munitions are intended to be fired, launched, or dropped. 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 present no residual safety hazards. However, a significant percentage – typically from 1 to 20% – did not function as intended. Either the munitions did not function at all, or they functioned incompletely such that only part of the filler was consumed. When munitions were fired, launched, or dropped, but inadvertently do 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 are regarded as extremely hazardous sites. A group of ranges in the same location may be grouped into a range complex. At many larger range complexes, several ranges may share a common impact area. As indicated by the example in Figure B-1, determination of the MEC hazards in an impact area can be challenging. Numerous weapons systems firing different types of ammunition over a time may result in an impact area that is difficult to characterize. Both MEC hazards and environmental contaminants must be evaluated. UXO (armed or fuzed) and residual MC are likely to be present.

### B–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 and were only combined and configured for use at a firing point. In many cases, there were excess components, especially propellant, resulting at firing points from the use of munitions. 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.

### B–4. 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.

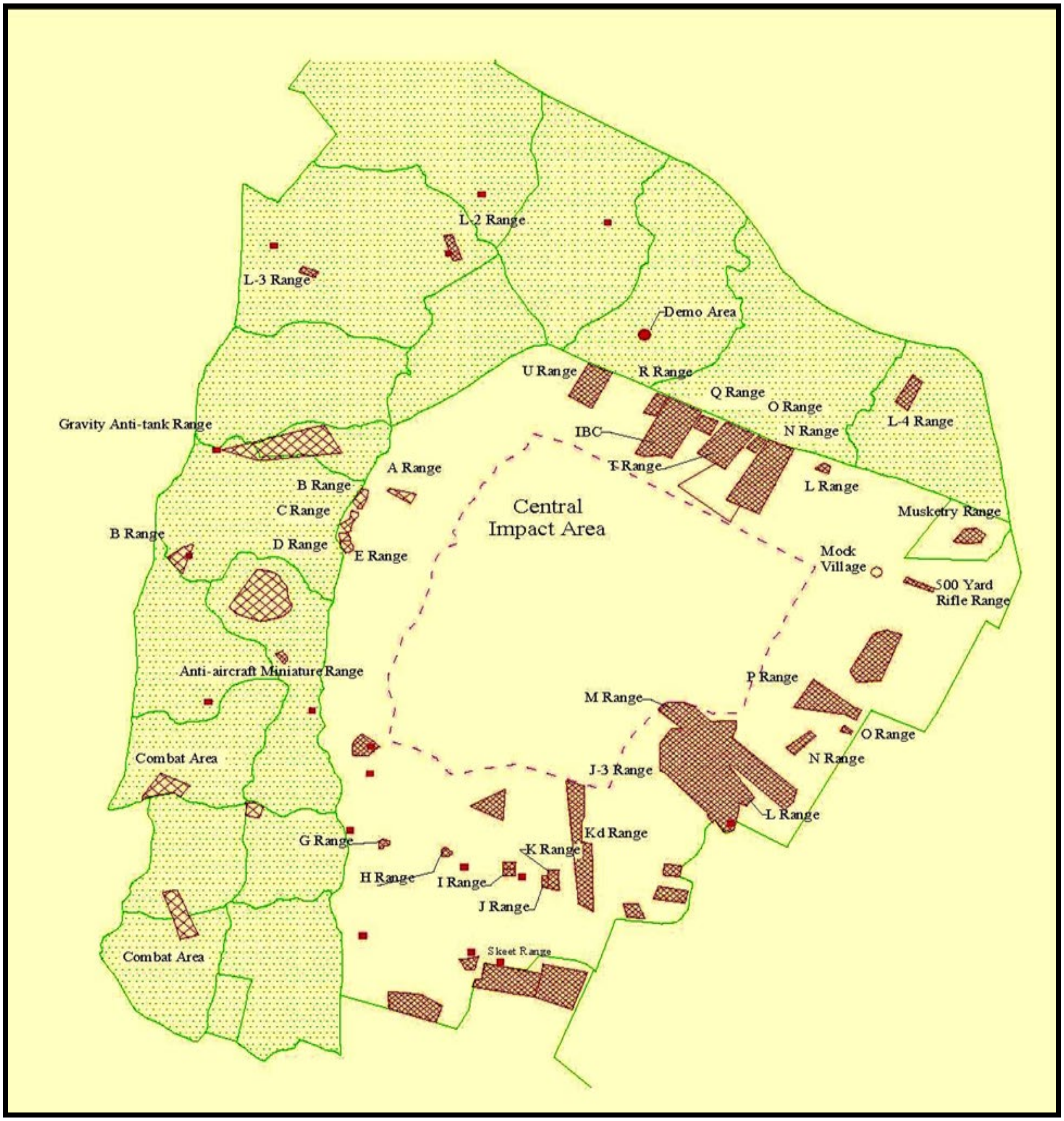



**Figure B–1. Typical range complex impact area**

## B–5. Open burn/open detonation areas

These are locations where munitions are destroyed by burning or detonation. Typically, excess military munitions were destroyed at OB/OD areas; however, UXO from target and impact areas are sometimes transferred to OB/OD areas for destruction as well. Regarding potential transfer, UXO are divided into those items that trained personnel determine are “acceptable to move” and those that are “unacceptable to move” for explosives safety reasons. Those that are unacceptable to move are destroyed where they are found by detonation in place. UXO and other munitions that are determined to be acceptable to move can either be detonated in place or transferred to another location, such as an OB/OD area, for destruction. For reasons of safety, UXO are never disassembled and their components recovered whether or not they are acceptable to move. Demolition operations are not always effective and entire munitions, as well as dangerous components, can remain after a disposal operation if adequate precautions are not taken. Like target areas, demolition areas should be regarded as extremely hazardous sites.

## B–6. Maneuver areas

Maneuver areas are used to train personnel and units to operate in a field environment. Maneuvers involve movement of personnel, units, equipment, and supplies. Units of varying sizes (for example, brigade, regiment, battalion, company, or platoon level) can conduct maneuvers within the defined boundaries of the maneuver area. Use of live firing weapons is prohibited or restricted in maneuver areas. Simulators and blank ammunition are used during maneuvers to train troops.

## Appendix C
## Developing a Preliminary Conceptual Site Model for an MRS or HTRW Site (Example)

### C–1. Introduction

The following is a hypothetical example for demonstration only. It is intended to illustrate how a PDT might develop a preliminary CSM for a site with both MMRP and HTRW concerns at the beginning of a project. The reader is cautioned that CSM development should be based on site-specific parameters and information. For purposes of this appendix, assume all other FUDS policies and procedures have been followed, there are no concerns regarding releases by other parties, and the following discussion only concerns the development of a preliminary CSM. All examples should be assumed to follow all applicable laws, regulations, and DoD, DA, and USACE policies and guidance. Any errors or deviations are unintentional.

### C–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. A Preliminary Assessment (PA) conducted in 1993 identified a mortar range and OB/OD area at the former camp (see Figure C-1). Surface clearance had been conducted prior to transfer, and no MEC 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.

*b.* A PM from the geographic USACE district was assigned overall management of the former Camp Swampy investigation. The MMRP project will precede the HTRW investigation. To initiate the project, the PM assembled a PDT consisting of munitions response specialists, HTRW specialists, state and federal regulators, and representatives from the IDA, business owners, and local landowners at the site. The PDT’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 PDT gathered all historical information available for the site, including aerial photographs from the operating period of the facility. The PDT then organized the available information into the following profiles.

## C–3. Facility profile

*a.* The PDT 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 PDT had uncovered and is shown as Figure C-1. Because the detonations occurred during a controlled burn at the tree farm, the PDT hypothesized that cultivation and harvesting of the trees over the years resulted in relocation of MEC 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 PDT obtained a standard range layout for mortar ranges for the 1943–1945 period to establish approximate dimensions for this potential source area (Figure C-2). The PDT 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 1,800 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 1,800-foot (600-yard) wide 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 PDT noted an area of bare, disturbed soil and stressed vegetation in this area. Five distinct mounds were visible that indicated munitions debris burial from the OB/OD operation. The PDT hypothesized that the potential MEC items included mortars, small arms, smokes, flares, and simulators as both broken and unfunctioned rounds. Munitions debris was noted across the entire area. An accelerant, either gasoline or diesel fuel, was assumed to have been used to initiate the burns.

## C–4. Physical profile

*a.* The facility is in an area of gently rolling hills, with topographic relief of not more than 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.

*b.* The PDT reviewed available state records of residential drinking water wells in the surrounding area and determined that groundwater 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.

## C–5. Release profile

Using the Facility Profile information, the PDT identified the source areas 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.

## C–6. Land use and exposure profile

*a.* The PDT 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 PDT 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).

## C–7. Ecological and cultural resources 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 (for example, deer, turkeys) and other terrestrial animals. Fish and other aquatic organisms inhabit the down-stream river, which serves as a popular recreation area. No threatened or endangered species are known to utilize the area and no cultural resources are known or suspected to be on-site.

## C–8. Exposure pathway analysis

Analysis of the profile information should allow the PDT to identify all exposure pathways for the site. For MEC and HTRW/MC, a pathway must include a source, an exposure medium, an exposure route, and a receptor. For HTRW/MC, the pathway may also include a release mechanism (for example, volatilization) and a transport medium (for example, air), if the point of exposure is not at the same location as the source. In preparation for the CSM, the PDT compiled the following.

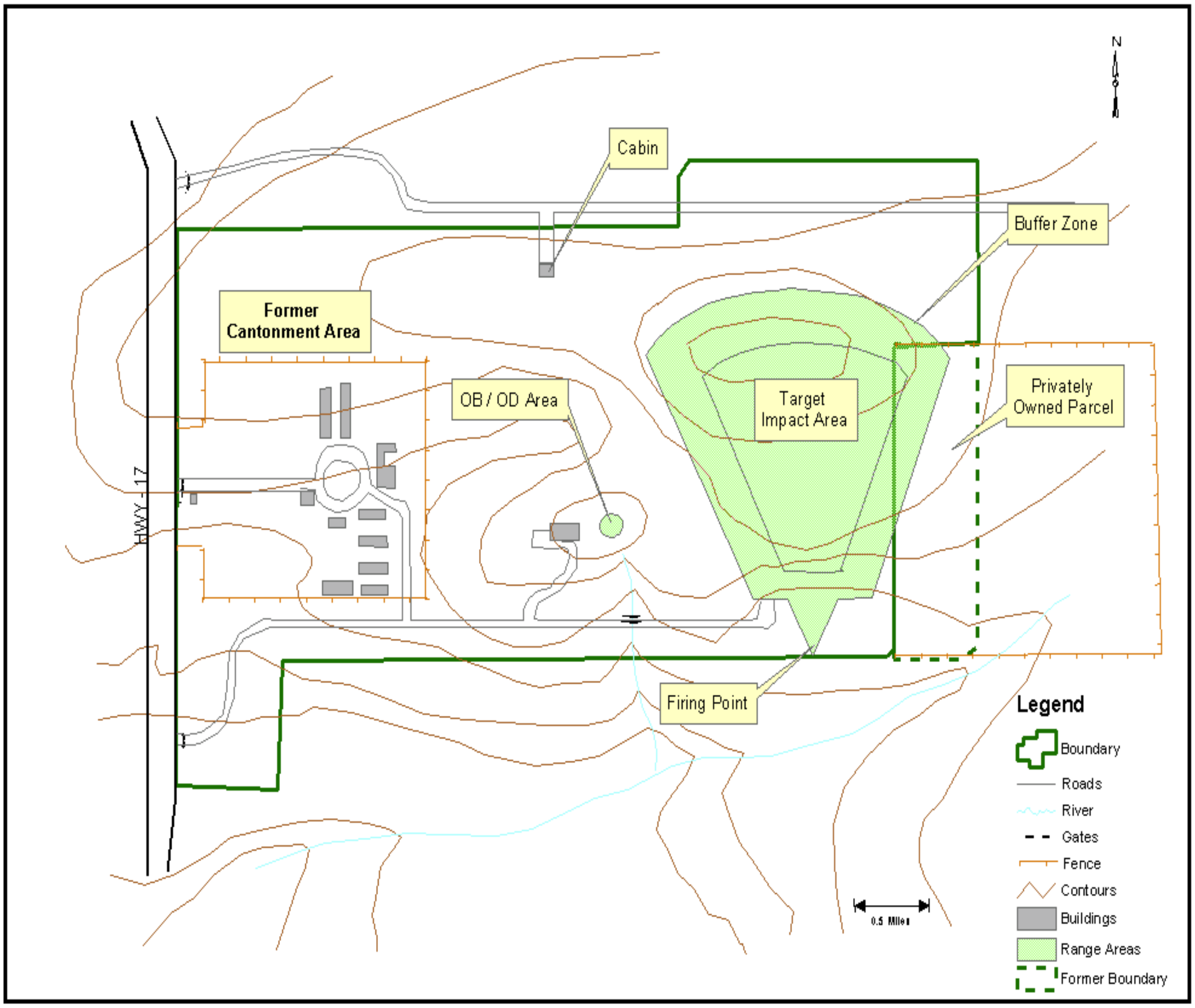



**Figure C–1. Preliminary site map**

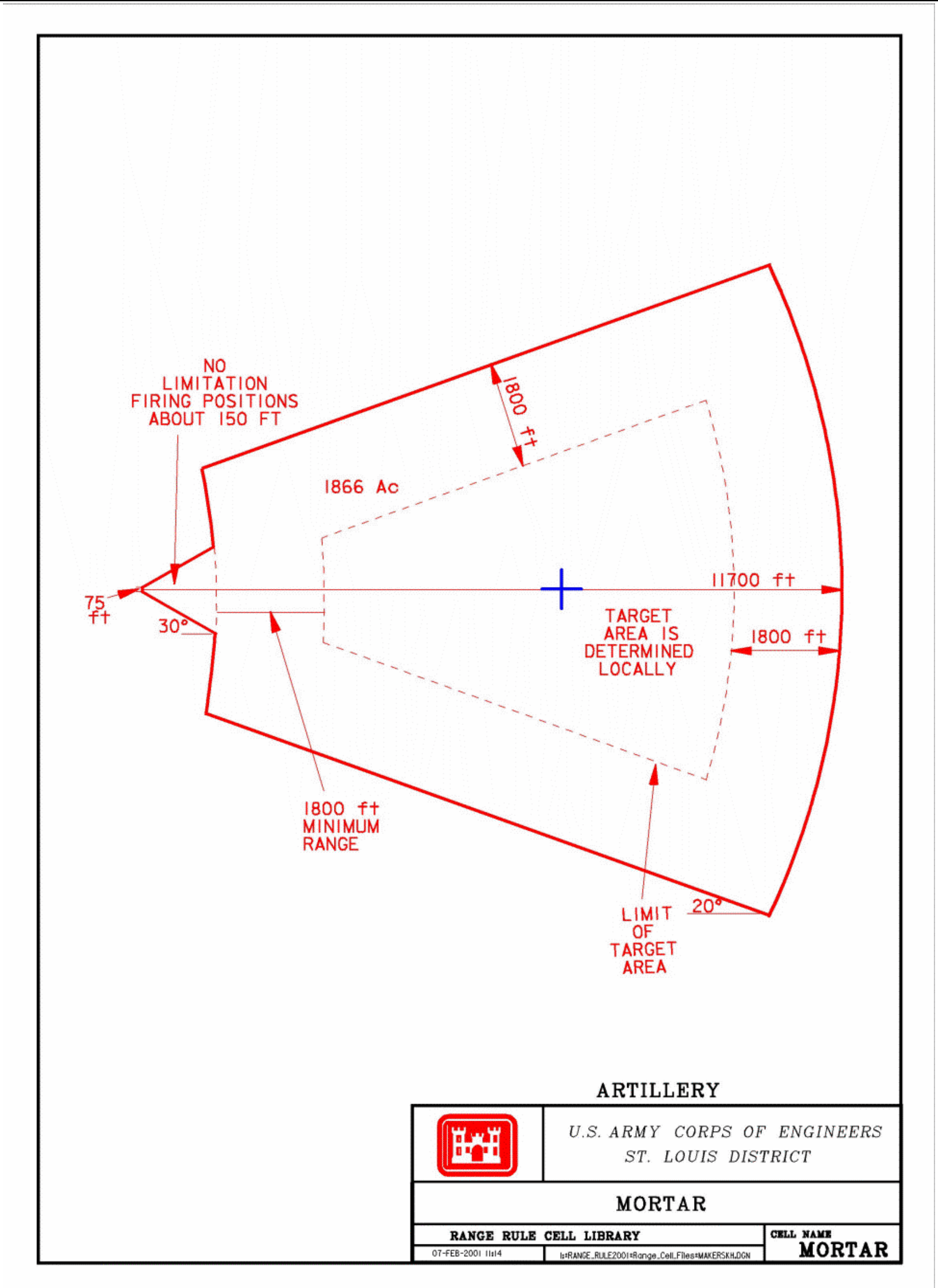



**Figure C–2. Mortar range**

*a.* MEC Sources. Three source areas were identified. They are the mortar impact area, the firing line at the mortar range, and the OB/OD area. These are described in more detail below.

(1) Impact Area: The impact area is suspected of having a serious explosive safety hazard from UXO resulting from dud-fired rounds or incomplete detonation. The PDT will evaluate site conditions to determine the expected depth of penetration of MEC at the impact area.

(2) Firing Line: 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 PDT. 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 for DMM 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.

(3) OB/OD 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 (for example, mortars, small arms rounds, smokes, and flares), due to kick-outs during operations. The potential for MEC 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.

*b.* MEC Exposure Media. The exposure media for MEC are expected to include surface and subsurface soils only. MEC (in the form of DMM) may be in subsurface soils at the firing point and MEC (in the form of UXO) are expected in both surface and subsurface soils at the impact area and OB/OD area. There are no natural processes that are expected to relocate MEC to media within or outside of the MRS.

*c.* MEC Exposure Points. Because there are no natural processes that are expected to relocate MEC to media within or outside of the MRS, the exposure points for MEC are anticipated to be at their respective source locations (the mortar impact area, the firing line at the mortar range, and the OB/OD area).

*d.* MEC Receptors and Exposure Routes.

(1) Receptors for MEC. Based on the current and reasonably anticipated future land uses (logging, hunting, metal fabrication shop, and grocery storage warehouses), the potential receptors include tree farm workers, recreational users (hunters), commercial/industrial workers, and trespassers.

(2) Exposure Routes for MEC.

*(a)* Access. Currently, there are no natural or man-made access restrictions at the site and, while the property is privately owned, access to the source areas is unlimited for tree farm workers, recreational users (hunters), commercial/industrial workers. Future access restrictions are unlikely because the reasonable future site uses are expected to remain the same.

*(b)* Activity. Current and future activities that can bring receptors into contact with MEC are tree farm activities (inspecting trees, cultivation/planting of trees, harvesting trees, and performing occasional controlled burns), recreational use (hunting and possible hiking). Commercial and industrial workers keep to parking lots, paths, and the areas within and immediately surrounding their buildings, so they are not expected to encounter or interact with MEC at the MRS.

1. On-site tree farm workers perform intrusive and non-intrusive work within the MRS and could encounter and interact with MEC on the surface or in subsurface soil.

Their activities involve weekly tree inspections (non-intrusive), annual tree planting and cultivation (intrusive to up to three feet bgs), bi-annual tree harvesting (non-intrusive), and occasional controlled burns (non-intrusive).

2. Hunters and hikers also perform non-intrusive activities within the MRS and could encounter and interact with MEC on the surface or in subsurface soil. Their activities include seasonal game hunting (non-intrusive) and hiking (non-intrusive). The precise areas where these uses occur are currently unclear.

*e.* HTRW/MC Sources. Potential MC at the firing line of the mortar range area includes trinitrotoluene, nitrocellulose, nitroglycerin, dinitrotoluene, as well as fuels and metals. There is the potential for release of HTRW (probably diesel fuel) into the surface and subsurface soils, if any burns were conducted there. The expected contaminants at the impact area include trinitrotoluene and its breakdown products. The primary HTRW source area is the OB/OD area. Both surface and subsurface soil are expected to contain fuel contamination from an accelerant used to facilitate burns. The PDT also documented the red staining at the creek so that future site investigations can verify its composition.

*f.* HTRW/MC 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 PDT identified the exposure media to be:

(1) Surface and subsurface soils at the source areas.

(2) Surface water and sediments at the creek (via the red staining at the bank).

(3) Air (via volatilization from surface soils). This would be a minor pathway as the expected accelerants would not be highly volatile.

(4) Groundwater (via leaching from surface and subsurface soils).

(5) Food chain (via plant uptake from soils, contaminated fish and wildlife consumption, and contaminated domestic animal consumption).

*g.* HTRW/MC Exposure Points. Most of the exposure points for HTRW/MC will be at their respective source locations (the mortar impact area, the firing line at the mortar range, and the OB/OD area). However, if natural processes relocate HTRW/MC to media within or outside of the MRS, the exposure points for HTRW/MC could be in ground or surface water located outside the MRS.

*h.* HTRW/MC Receptors and Exposure Routes.

(1) Receptors for HTRW/MC. Based on the current and reasonably anticipated future land uses (logging, hunting, metal fabrication shop, and grocery storage warehouses), the potential receptors in the MRS include tree farm workers, recreational users (hunters), commercial/industrial workers, and trespassers. Possible receptors outside the MRS include the residents within the 3-mile radius of the property and the recreational users (boaters, swimmers, and fishers).

(2) Exposure Routes for HTRW/MC. Current and future activities that can bring receptors into contact with HTRW/MC are tree farm activities (inspecting trees, cultivation/planting of trees, harvesting trees, and performing occasional controlled burns), recreational use (hunting and possible hiking). Commercial and industrial workers keep to parking lots, paths, and the areas within and immediately surrounding their buildings, so they are not expected to encounter or interact with HTRW/MC in soil at the MRS. The industrial area is serviced by the municipal water supply system, so these workers would also not be exposed to HTRW/MC in groundwater. Residents within the 3-mile radius of the property use groundwater as drinking water and recreational users in the nearby river might be exposed to surface water offsite that has been contaminated via runoff into the small creek traversing the site. Ecological receptors might be exposed to HTRW/MC in soil or surface water/sediment, or via ingestion of biota.

*(a)* On-site tree farm workers perform intrusive and non-intrusive work within the MRS and could be exposed to HTRW/MC in surface or subsurface soil incidental ingestion, dermal contact, or inhalation of dust. Their activities involve weekly tree inspections (non-intrusive), annual tree planting and cultivation (intrusive to up to three feet bgs), bi-annual tree harvesting (non-intrusive), and occasional controlled burns (non-intrusive).

*(b)* Hunters and hikers also perform non-intrusive activities within the MRS and could be exposed to HTRW/MC in surface soil via incidental ingestion, dermal contact, or inhalation of dust. Their activities include seasonal game hunting (non-intrusive) and hiking (non-intrusive). The precise areas where these uses occur are currently unclear.

*(c)* The residents living within the 3-mile radius of the property use the groundwater as potable water, so they may be exposed to HTRW/MC in that medium via ingestion (incidental or as drinking water) or via dermal contact if transport to groundwater is found to be occurring.

*(d)* Boaters, swimmers, and fishers using the river close to the property might be exposed to HTRW/MC in surface water or sediment via incidental ingestion or dermal contact if transport to surface water is found to be occurring.

*(e)* Ecological receptors might be exposed to HTRW/MC in soil via incidental ingestion or dermal contact, in surface water/sediment via ingestion (incidental or as drinking water) or dermal contact, or via ingestion of biota.

## C–9. Conceptual site model graphic

Once the pathway analysis was completed, the PDT developed a CSM graphic that integrated the profiles to illustrate all source-receptor exposure pathways at the site. Figure C-3 provides a graphic representation of these exposure pathways 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.

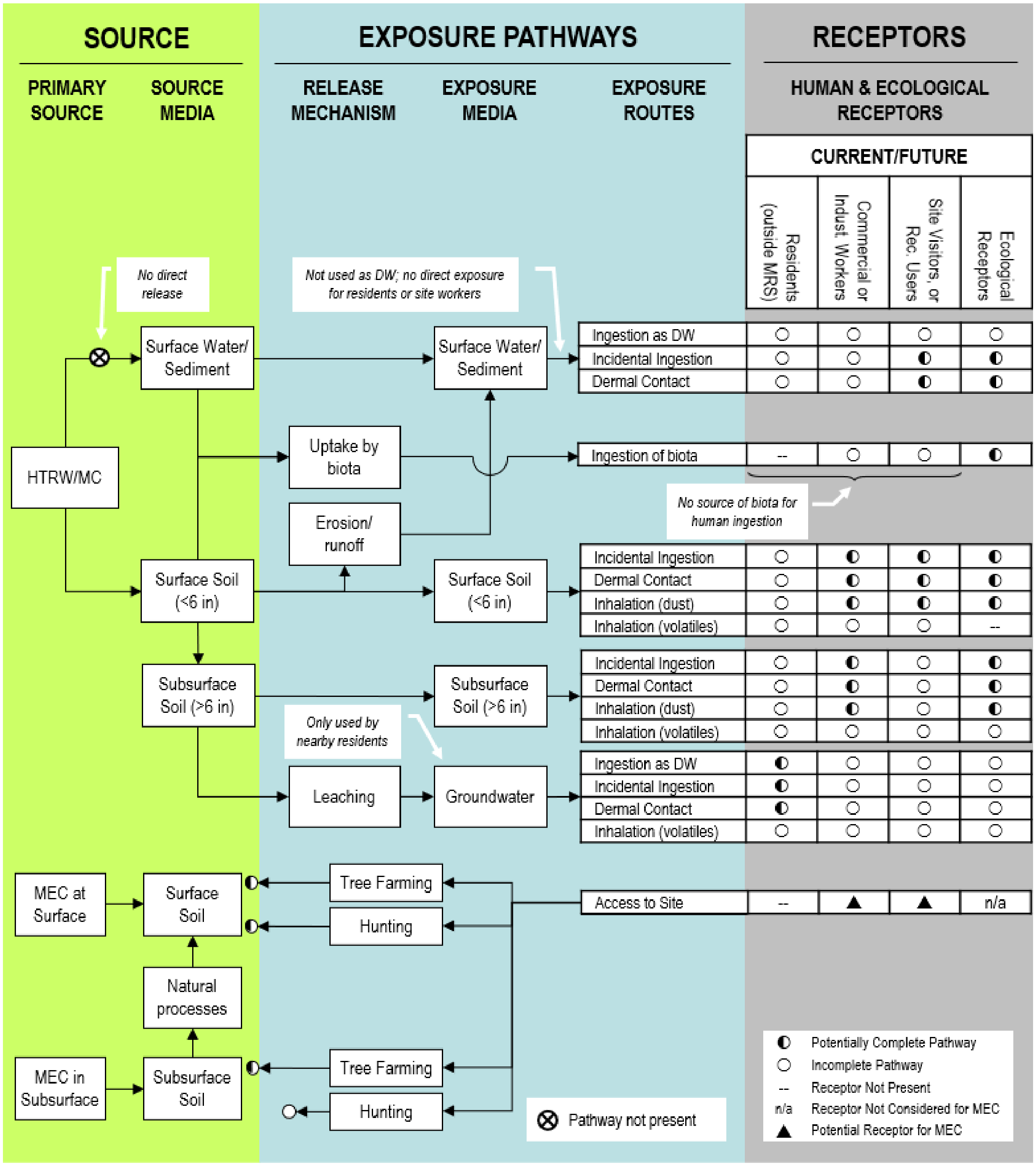



**Figure C–3. Source receptor relationships for an MRS and HTRW site**

## Appendix D
## Examples of Conceptual Site Model Descriptions and Depictions

### D–1. Introduction

As noted in Chapter 2, a CSM can be represented in various ways. Several examples have been shown throughout this document and several others are included in this appendix. The examples that follow show various exposure/migration routes and many will need to be supported to a certain extent by narrative text to describe the complete exposure pathways adequately. The following CSMs are provided:

*a.* Example 1. Narrative Description: Air to Ground Gunnery Range.

*b.* Example 2. Pictorial Presentation: Groundwater Contaminant Plume; Degradation Zone Delineation.

*c.* Example 3. Pictorial Presentation: Vapor Intrusion.

*d.* Example 4. Three-Dimensional Pictorial Presentation: Geologic CSM.

*e.* Example 5. Pictorial Presentation: Groundwater Treatment Train CSM.

*f.* Example 6. Pictorial Presentation: Pictorial CSM for Environmental Contamination (MC, HTRW).

*g.* Example 7. Graphical Representation: TCE Groundwater Plume.

*h.* Example 8. Graphical Representation: Potentiometric Maps.

*i.* Example 9. Graphical Representation: 3-D View of MEC Contamination (HUA/LUA) for Remedial Action.

*j.* Example 10. Graphical Representation: CSM Exposure Pathways (HTRW/MC).

*k.* Example 11. Graphical Representation: CSM Exposure Pathways (MEC and MC).

*l.* Example 12. Graphical Representation: Remedial Investigation Vertical Profile.

*m.* Example 13. Graphical Representation: Remedial Action Vertical Profile.

*n.* Example 14. Graphical Representation: Vertical Profile for Groundwater at an HTRW Site.

*o.* Example 15. Graphical Representation: Plan View (Top) and Profile View (Bottom) of a Groundwater Plume at an HTRW Site.

*p.* Example 16. Pictorial Presentation: Pictorial CSM for a Small Arms Range.

*q.* Example 17. Pictorial Presentation: pictorial CSM for a combat firing range

*r.* Example 18. Narrative Description: CSM Table for an MRS

*s.* Example 19. Narrative Description: CSM table for two MRSs

### D–2. Example 1. narrative description: air-to-ground gunnery range

*a.* Overview.

(1) A site-specific conceptual site model (CSM) summarizes available site information and identifies relationships between exposure pathways and associated receptors. A CSM is used to determine the data types necessary to describe site conditions and quantify receptor exposure, and discusses the following information:

*(a)* Current site conditions and future land use.

*(b)* Potential munitions and explosives of concern (MEC) and munitions constituents (MC) sources (for example, lead projectiles in an impact berm).

*(c)* Affected media.

*(d)* Governing fate and transport processes (for example, surface water runoff and/or groundwater migration).

*(e)* Exposure media (media through which receptors could contact site-related MEC and MC).

*(f)* Routes of exposure (for example, inhalation, incidental ingestion, and dermal contact).

*(g)* Potential human and/or representative ecological receptors at the exposure point. Receptors likely to be exposed to site MEC or MC are identified based on current, determined, or reasonably anticipated future land uses.

(2) The CSM is evaluated for completeness and further developed as needed through Systematic Planning Process (SPP) meetings and additional investigation.

*b.* Background. The CSM is based on information presented in the Preliminary Assessment (PA) (USACE, 2004). The CSM was updated with information obtained during the Site Inspection (SI).

*c.* History of Use.

(1) The Air-to-Ground Gunnery Range (AGGR) munitions response site (MRS) was in use from 1942 to 1945. The gunnery range, which was a 2-mile by 6 mile rectangle, was used strictly for target machinegun firing by bombers. Landowners reported that the site was never used as a bombing range and indicated that DoD personnel conducted machinegun practice from B 17 and B 24 aircraft toward wood frame and canvas covered targets located on ridges and flat pastures.

(2) A typical air-to-ground gunnery range would have aircraft flight paths parallel to the lengthwise property boundary. Targets would be in the interior of the FUDS on flat lands or on hill tops. Munitions debris associated with the flight lines of the bomber aircraft would typically consist of bullet casings, bullet links, and unfired rounds. The 2004 PA reported a series of nine targets (including a cement stock tank) was established in a line beginning in the southeast corner and extending northward (including one target location outside the FUDS boundary) over a length of approximately 7 miles. Landowners reported that machinegun strafing occurred throughout the site and up to 1 or 2 miles outside the site boundary. Real estate records indicate that no DoD-installed improvements were constructed on the site. According to landowners, DoD-installed improvements were limited to wood frame targets for machinegun practice. A local newspaper described a B-24 crash during a training flight over the target area. The area north-east of the FUDS was cleaned up before being disposed of as excess government property. On March 10, 1945, the installation was declared surplus by the War Department. The PA that research and interviews revealed no evidence of CWM activity or contamination on the AGGR MRS.

*d.* Summary of Site Characteristics.

(1) The FUDS is located within the High Plains section of the Great Plains physiographic province. The upper surface of the site consists of Quaternary deposits consisting of alluvium, loess, and eolian sand that are shaped into complex hills and valleys. The soils of the site are loose fine sand that has rapid permeability, low available water capacity, and low organic matter content. Local vegetation consists of mixed to short prairie grasses.

(2) The site is primarily drained by an intermittent stream that flows generally south and west. The area is quite sandy and significant runoff in surface streams is uncommon.

(3) The former AGGR is underlain by the High Plains aquifer. The High Plains aquifer is a water table aquifer consisting mainly of near-surface sand and gravel deposits of Tertiary and Quaternary age. Current depth to groundwater in wells at the FUDS ranges from 18 to 85 feet (ft) below ground surface (bgs).

*e.* Munitions and Associated MC. The munitions associated with the AGGR MRS were .50 caliber small arms ammunition, which generally included a combination of ball and tracer rounds. Projectiles from an air-to-ground gunnery range are generally concentrated within the vicinity of the former gunnery targets, although projectiles can be found beyond the target areas. Spent casings, bullet links and unfired rounds would typically be found under the flight lines on the northern and southern boundaries of the FUDS.

*f.* Previous MEC Finds. No MEC finds have been reported at the AGGR MRS. The only reported munitions-related finds at the FUDS were unfired .50-caliber rounds (including a partial belt found by a landowner and one live round in a field) observed during the 2004 PA site visit. Small arms ammunition up to .50-caliber is not considered to be MEC. Landowners and USACE personnel have observed munitions debris in the form of .50-caliber casings.

*g.* Previous MC Sampling. No sampling for MC has been conducted at the AGGR MRS to date.

*h.* Current and Future Land Use. The current, determined, or reasonably anticipated future use for the AGGR MRS is agricultural. All the properties are privately-owned. The typical fencing and “No Trespassing” signs provide a degree of restriction to access by the public, but do not prevent access by the landowners or their workers and guests. Parcels outside of the southeast area of the FUDS are part of the Nebraska Conservation Reserve Program-Management Access Program, which is a wildlife/game management program.

*i.* Sensitive Environments. Two small wetlands are present within the MRS, qualifying the site as an Important Ecological Place (IEP), based on a review of the Army Checklist for Important Ecological Places (USACE, 2006). Therefore, ecological receptors are considered potential receptors for migration pathways at the AGGR MRS. Land outside of the southeast area of the FUDS is part of a wildlife/game management area.

*j.* MEC Exposure Pathway Evaluation. This section provides an evaluation of the potential MEC associated with the munitions formerly used at the range.

(1) Types of MEC. Historical evidence indicates that .50-caliber (ball and tracer type) small arms ammunition was used at the range.

(2) Human Receptors. The FUDS has been privately owned since the DoD terminated leases and relinquished the land. Some residential homes are located within or adjacent to the property. Individual land parcels are segregated by barbed-wire fencing, primarily to control the movement of livestock. Gates are not locked and do not provide an effective barrier preventing human access. Potential human receptors include agricultural workers, ranchers, and hunters.

(3) Exposure Routes. The potential routes of human exposure to MEC would be by digging activities such as drilling, trenching, road building, or soil tilling.

(4) MEC Risk Assessment.

*(a)* There are no explosive hazards associated with munitions debris derived from the .50-caliber ammunition used at this range. The projectiles contain no explosive components, and, therefore, pose no explosive risk. The tracer mixture associated with .50-caliber tracer projectiles is not explosive.

*(b)* Complete .50-caliber rounds contain smokeless powder propellant charges and primers. Tampering with complete cartridges could result in injury because of firing of primers, which could cause burns. Considerable force would be necessary to discharge a live round, if found. Therefore, although some unfired small arms ammunition may be found, it is not considered to present a significant explosive hazard. Small arms ammunition up to .50-caliber is not considered to be MEC.

*k.* MC Pathway Evaluation. This section provides an evaluation of the potential MC associated with the munitions formerly used at the range. Small arms munitions are considered to be the source of MC of potential concern at the MRS. In addition, other constituents associated with the former munitions activity that lack the potential for a significant release that would threaten human health or the environment are discussed below. Potential exposure media at the air-to-ground gunnery range include soil/sediment and groundwater.

(1) Types of MC. This section provides an evaluation of the potential MC associated with the munitions formerly used at the range.

*(a)* Metals:

1. The projectiles, casings, and tracer, igniter, and primer compositions of the ammunition used contain several metals. The highest concentrations of source metals from munitions activity are anticipated where projectiles and/or casings may have accumulated at the ground surface. The metals potentially constituting a significant source include lead and antimony (from the alloy forming the body or point filler of various .50-caliber projectiles) and copper and zinc (from brass cartridge casings).

2. Other metals associated with ammunition are unlikely sources of a release. Iron, the principal constituent of steel in some projectiles and casings, is non-hazardous and relatively immobile. Nickel may have been a minor constituent of the jacketing material on some projectiles but would be present in small quantities in comparison to other metals (lead, antimony, and copper). Other metals, present in primer, tracer, and igniter compositions, were present in small quantities and widely dispersed from scattered aerial firing positions.

*(b)* Perchlorate. Perchlorate may have been present in some tracer compositions used with .50 caliber ammunition at the range. Therefore, the potential presence of perchlorate was addressed in the SI.

*(c)* Explosives. The propellant used in .50-caliber rounds consisted primarily of nitrocellulose. Small amounts of nitrogen-based explosive compounds, such as dinitrotoluene or nitroglycerine, were present in some formulations that may have been used. Some primers contained pentaerythritol tetranitrate in addition to metallic compounds. However, fixed small arms ammunition discharged from aerial firing positions or occasionally dropped to the ground surface poses little possibility for a significant release of propellant. Therefore, a significant source of explosives is not considered to be present at the MRS.

(2) Soil Exposure (Terrestrial) Pathway.

*(a)* Sources of MC. Aircraft fired .50-caliber rounds at wood- or canvas-covered targets on the ground. The MC from this operation include metals associated with .50-caliber munitions, which may have included steel and/or lead core bullets. Potential MC of concern in bullets and casings include lead, copper, antimony, and zinc. Tracer rounds used with .50-caliber ammunition may have contained small amounts of perchlorate. Surface soil sample results from the SI indicate that zinc and copper exceeded background threshold levels at some biased sample locations. Perchlorate was not analyzed in surface soils; perchlorate was not expected to persist in surface soils due to high mobility.

*(b)* Exposure Pathway. Soil is the medium directly affected by munitions activity. Metals are likely to remain sorbed to soil at high concentrations. Perchlorate is likely to have migrated due to its mobility in water.

*(c)* Land Use and Access: Most of the site is used for grazing livestock. A portion of the site is used for raising crops. Access to the lands is limited somewhat by fencing and gates. Wetlands areas are located within the MRS boundary. It is anticipated that the land use in the future will remain the same.

*(d)* Human Receptors. Potential human receptors for MC include property owners, agricultural workers, and hunters who may be exposed to contaminated soil from dermal contact, ingestion, and inhalation of soil particles during intrusive work. For purposes of human health risk screening, residential screening values are used as the most conservative case, since the objective of the SI is to evaluate the MRS for no further action with no land use restrictions.

*(e)* Human Health Assessment. Because there are potential human receptors, and metals have been found in soil at concentrations above background, the soil exposure pathway is considered to be complete. The results from sampling do not exceed human health screening values.

*(f)* Ecological Assessment. Area wildlife comprise potential ecological receptors, particularly at two small wetlands located within the MRS. The soil exposure pathway for ecological receptors is potentially complete due to the presence of metals in soil at concentrations exceeding background and ecological screening values. However, stakeholders have agreed that the scattered and isolated soil exceedances do not pose a significant MC hazard to ecological receptors.

(3) Surface Water Pathway.

*(a)* Sources of MC. The SI evaluated potential migration of metals (lead, copper, antimony, and zinc) from soil to the surface water pathway. The presence of zinc and copper in soil at concentrations above background indicates a source potentially impacting surface water transport media.

*(b)* Migration Pathway. The creek is an intermittent stream that runs in a north and south direction through the site. The area is composed of deep excessively drained, permeable soils where surface runoff is uncommon.

*(c)* Surface Water Use and Access. Surface water is not used for drinking water within or near the MRS.

*(d)* Human Receptors. Human exposure to surface water and sediment would generally be limited to incidental contact along the intermittent stream. Because the stream is intermittent, exposure to sediment is more likely than exposure to surface water. Therefore, potential exposure of human receptors (property owners, agricultural workers, and hunters) is limited to sediment.

*(e)* Human Health Assessment. Surface water was not observed in either sediment sample location, thus no surface water samples were taken. The surface water pathway is considered to be incomplete.

*(f)* Ecological Assessment. Ecological receptors are potentially present because wetlands are present on the site. Surface water was not observed in either sediment sample location, thus no surface water samples were taken. The surface water pathway is considered to be incomplete.

(4) Sediment Pathway.

*(a)* Sources of MC. The SI evaluated potential migration of metals (lead, copper, antimony, and zinc) from soil to the sediment pathway via surface water flow. The presence of zinc and copper in soil at concentrations above background indicates a source potentially impacting sediment.

*(b)* Migration Pathway. The creek is an intermittent stream that runs in a north and south direction through the site. The area is composed of deep excessively drained, permeable soils where surface runoff is uncommon.

*(c)* Sediment Use and Access. Sediment in the bed of the intermittent stream is accessible but is not used for any known purposes.

*(d)* Human Receptors. Human exposure to sediment would generally be limited to incidental contact along the intermittent stream. Because the stream is intermittent, exposure to sediment is more likely than exposure to surface water. Therefore, potential exposure of human receptors (property owners, agricultural workers, and hunters) is limited to sediment.

*(e)* Human Health Assessment. Sediment sample results did not exceed background threshold levels, and the sediment pathway is considered to be incomplete.

*(f)* Ecological Assessment. Ecological receptors are potentially present because wetlands are present on the site. Sediment sample results did not exceed background threshold levels, and the sediment pathway is considered to be incomplete.

(5) Groundwater Pathway.

*(a)* Sources of MC. The SI evaluated potential migration of metals (lead, copper, antimony, and zinc) and perchlorate from soil to the groundwater pathway. The presence of zinc and copper in soil at concentrations above background indicates a source potentially impacting the groundwater transport medium.

*(b)* Migration Pathway. Depth to groundwater is approximately 18 to 85 ft bgs at the FUDS. The direction of groundwater flow is to the southwest. Groundwater samples were not collected in the vicinity of the soil source area.

*(c)* Groundwater Use and Access. Registered agricultural wells are located on the FUDS. Registered domestic groundwater wells are located within 1-2 miles southwest (downgradient) of the FUDS. Additional unregistered wells may be present in the area.

*(d)* Human Receptors. Exposure of property owners and agricultural workers to groundwater from agricultural wells would be very limited. The potential human routes of exposure are ingestion, direct contact, and Residents using domestic wells as a water supply are the potential human receptors near the site.

*(e)* Human Health Assessment. Groundwater samples were collected for the SI from three domestic wells located downgradient of potential source soils. Groundwater sample results did not exceed background threshold levels. Because the potential points of human exposure were unaffected, the groundwater pathway is incomplete.

(6) Air Pathway. Inhalation of MC in vapor form is not a pathway of concern for non-volatile MC under normal environmental conditions, and the air migration pathway is incomplete. Potential inhalation of soil particles is considered in the development of health-based screening values for soil, which were not exceeded.

(7) Summary.

*(a)* Presence of MEC. No significant explosive hazard is posed by former use of the range for air-to-ground gunnery involving small arms ammunition.

*(b)* Presence of MC. No surface soil sample results exceeded human health screening values, and no sediment or groundwater samples collected exceeded background threshold levels. Surface soil sample results indicate that zinc and copper exceeded background threshold levels and ecological screening levels. Stakeholders have agreed that the scattered and isolated soil exceedances do not pose a significant MC hazard to ecological receptors.

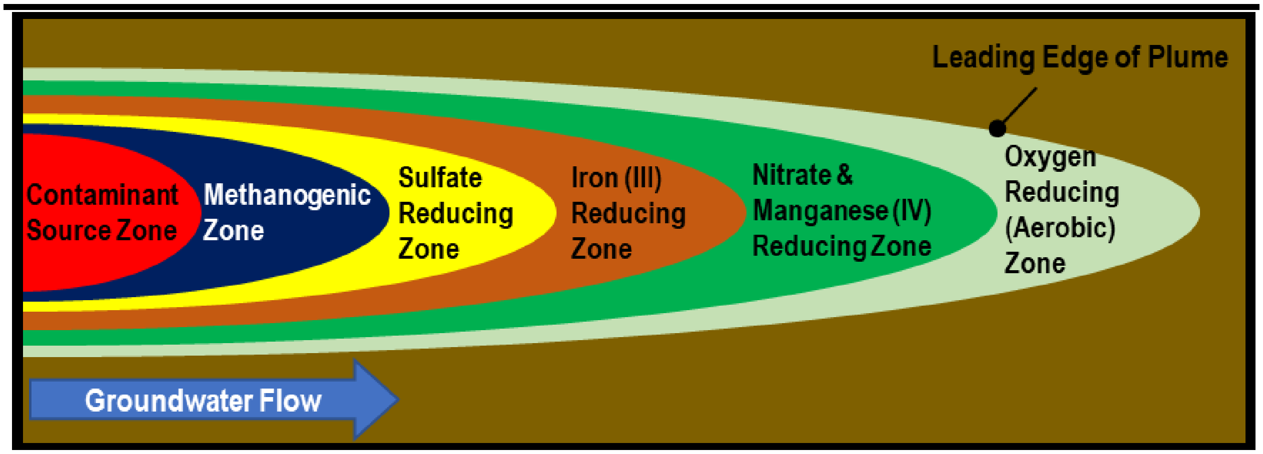



**Figure D–1. Example 2. Pictorial presentation: groundwater contaminant plume; degradation zone delineation**

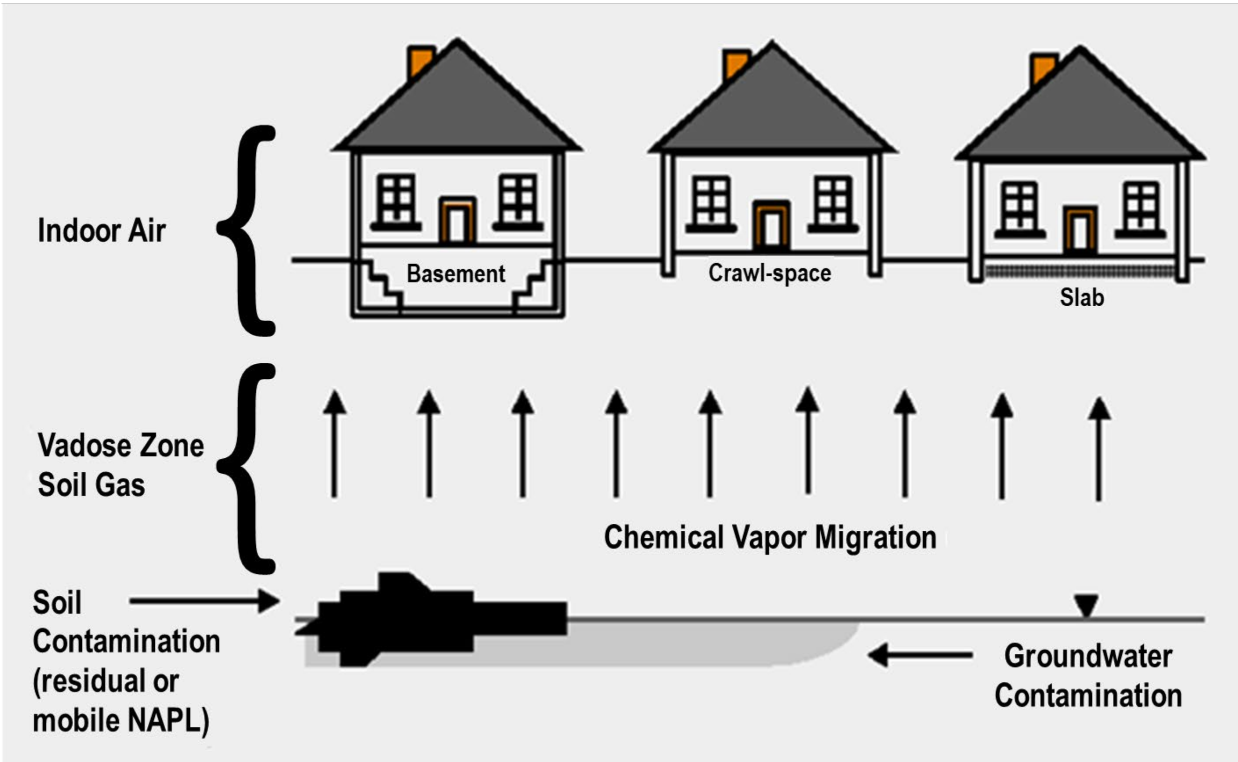



**Figure D–2. Example 3. Pictorial presentation: vapor intrusion CSM**

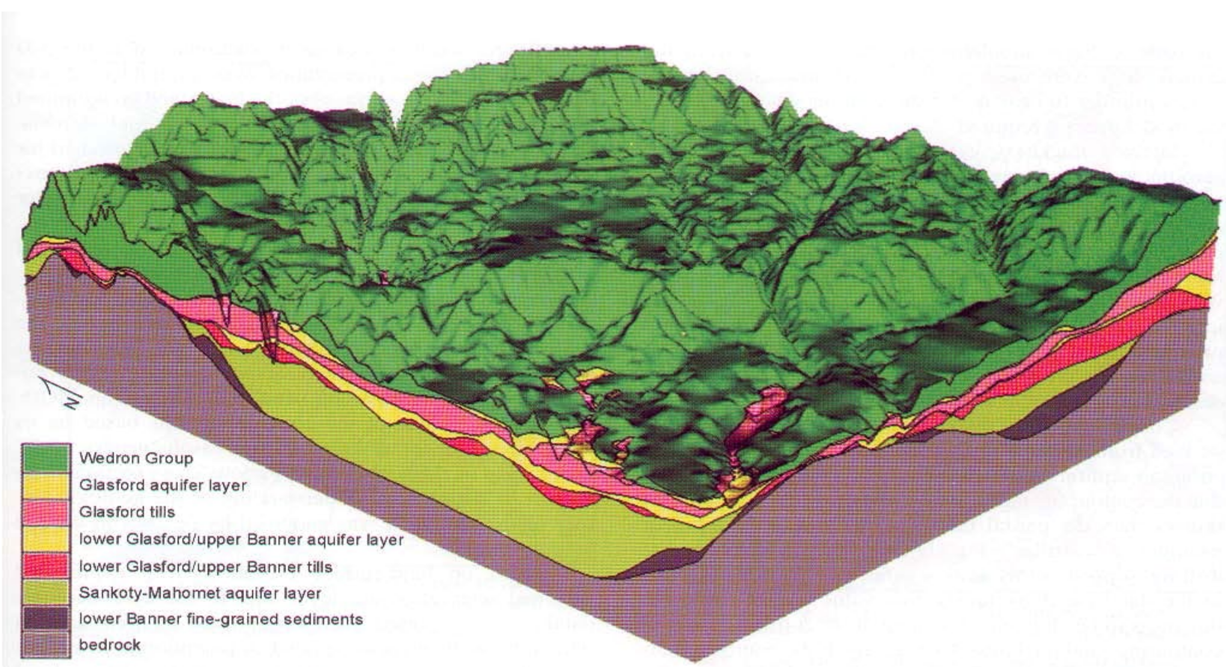



**Figure D–3. Example 4. Three-dimensional pictorial presentation: geologic CSM**

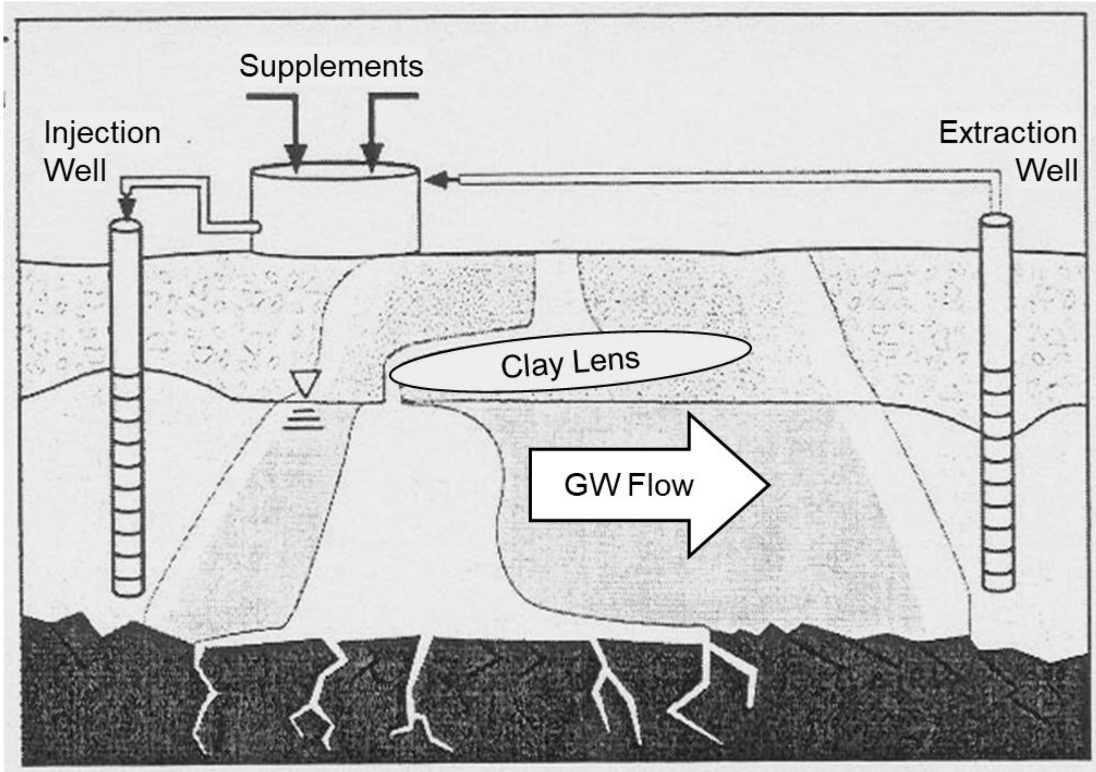



**Figure D–4. Example 5. Pictorial Presentation: groundwater treatment train CSM**

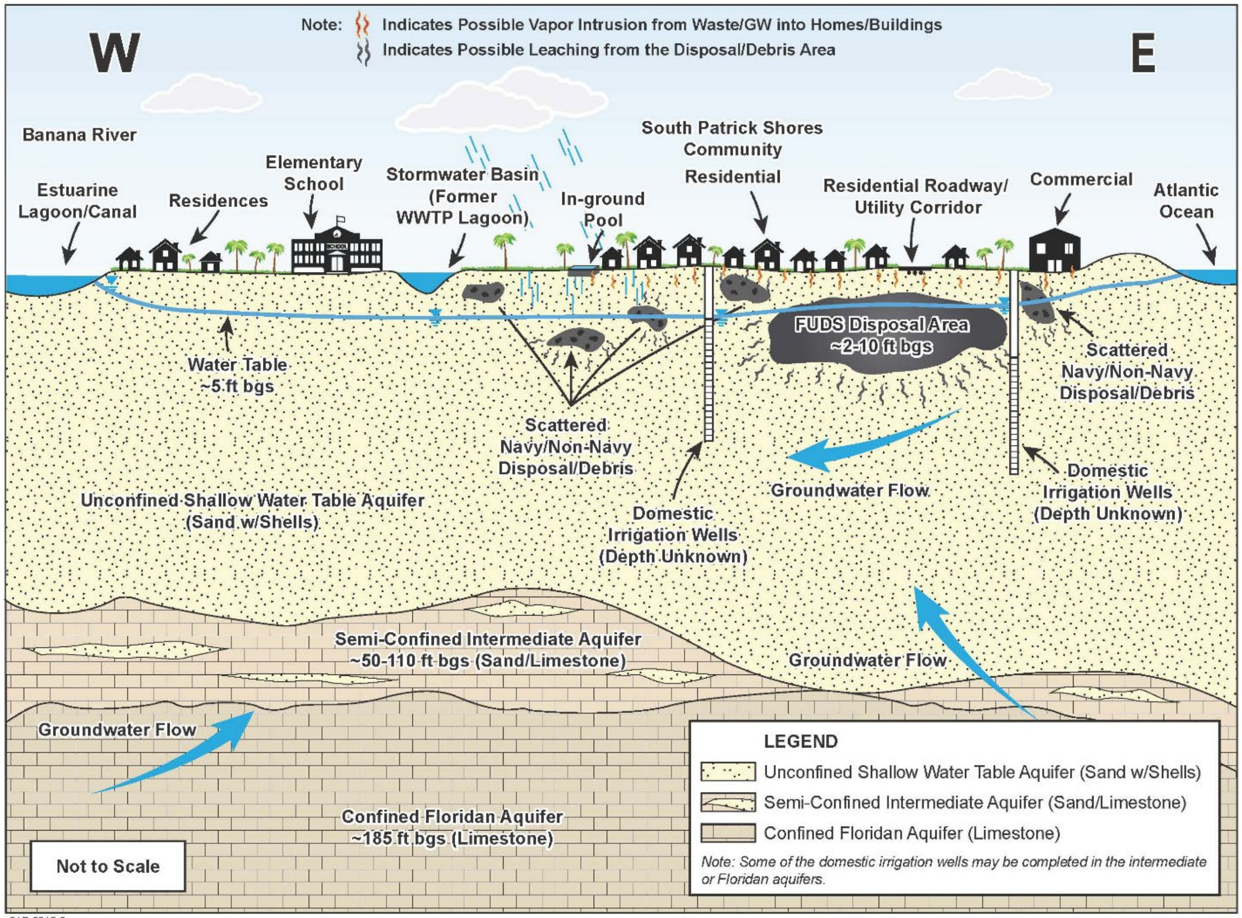



**Figure D–5. Example 6. Pictorial presentation: pictorial CSM for environmental contamination (MC, HTRW)**

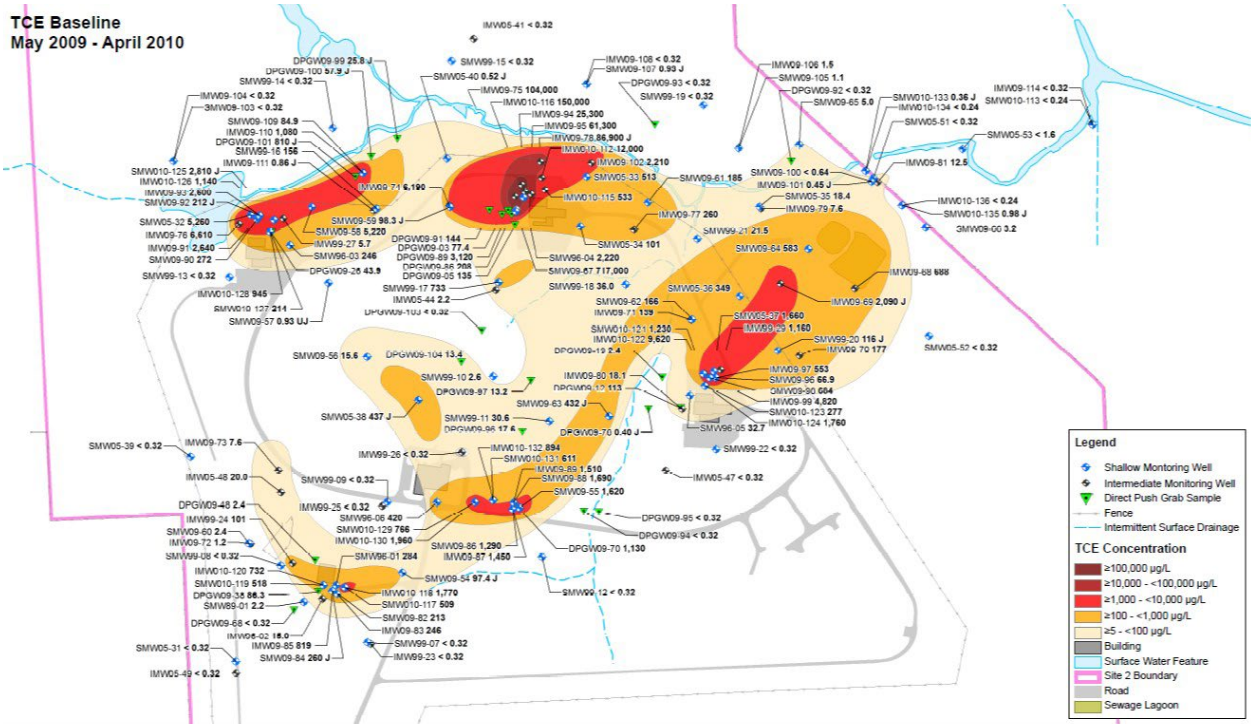



**Figure D–6. Example 7. Graphical representation: TCE groundwater plume**

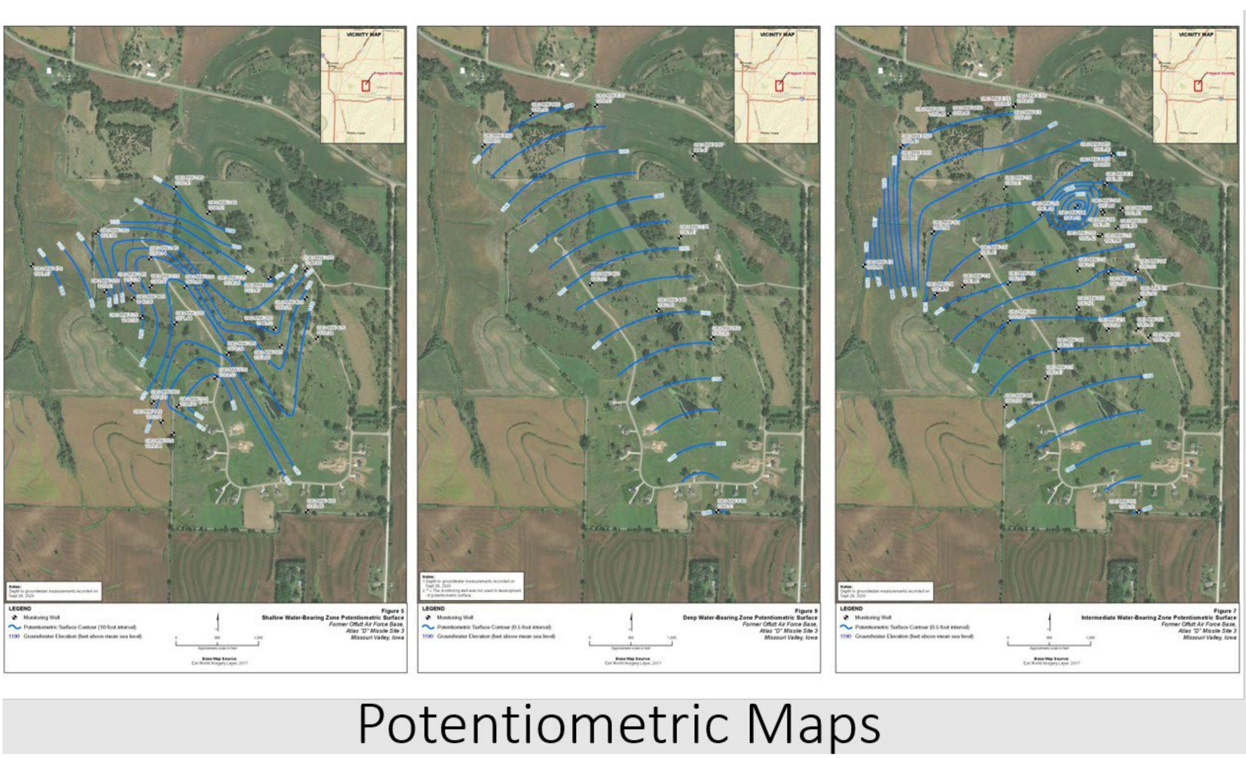



**Figure D–6. Example 8. Graphical representation: potentiometric maps**

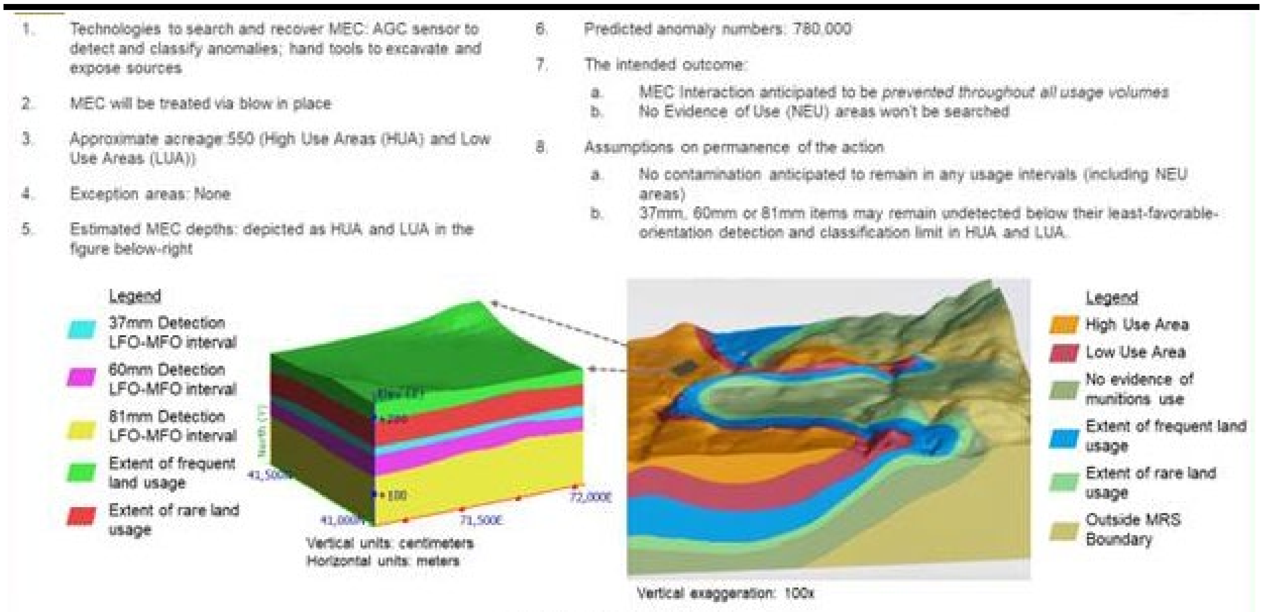



**Figure D–7. Example 9. Graphical representation: 3-D view of MEC contamination (HUA/LUA) for remedial action**

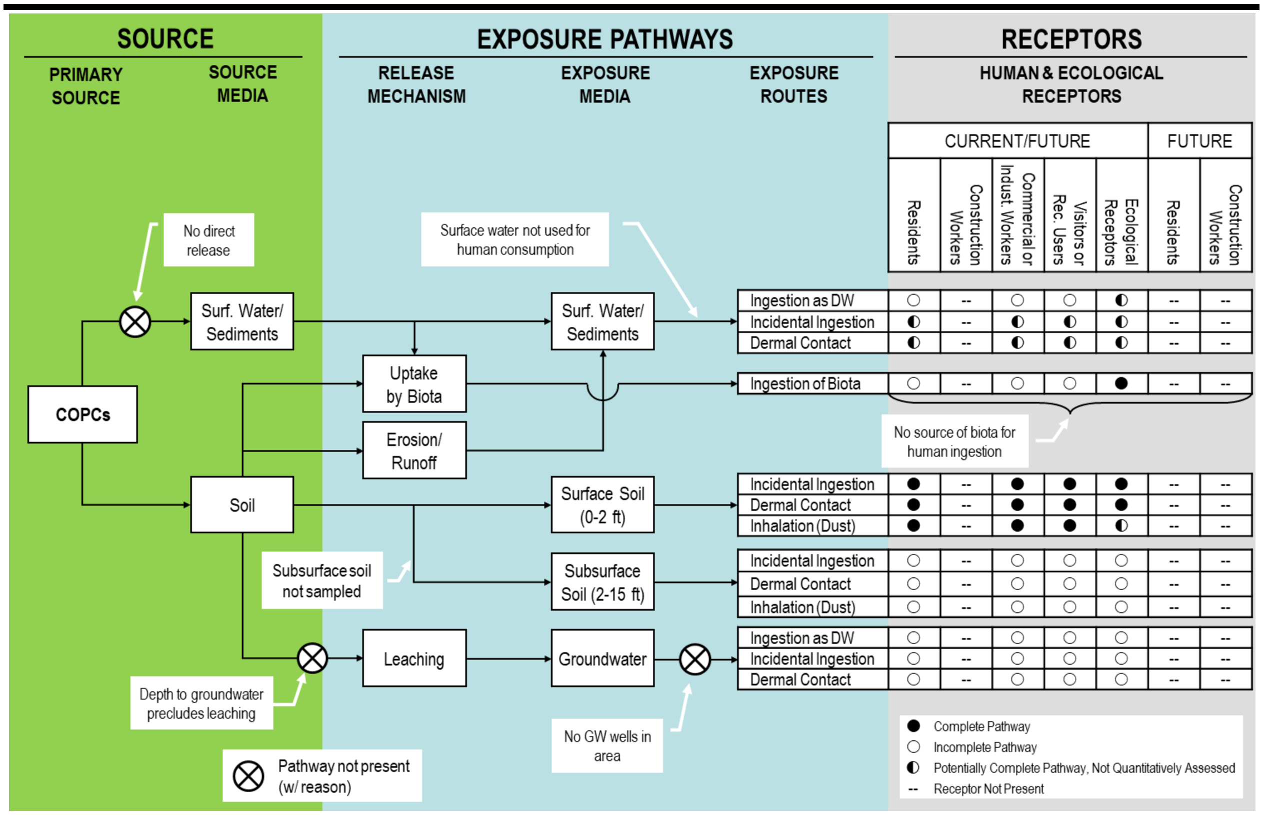



**Figure D–8. Example 10. Graphical representation: CSM exposure pathways (HTRW/MC)**

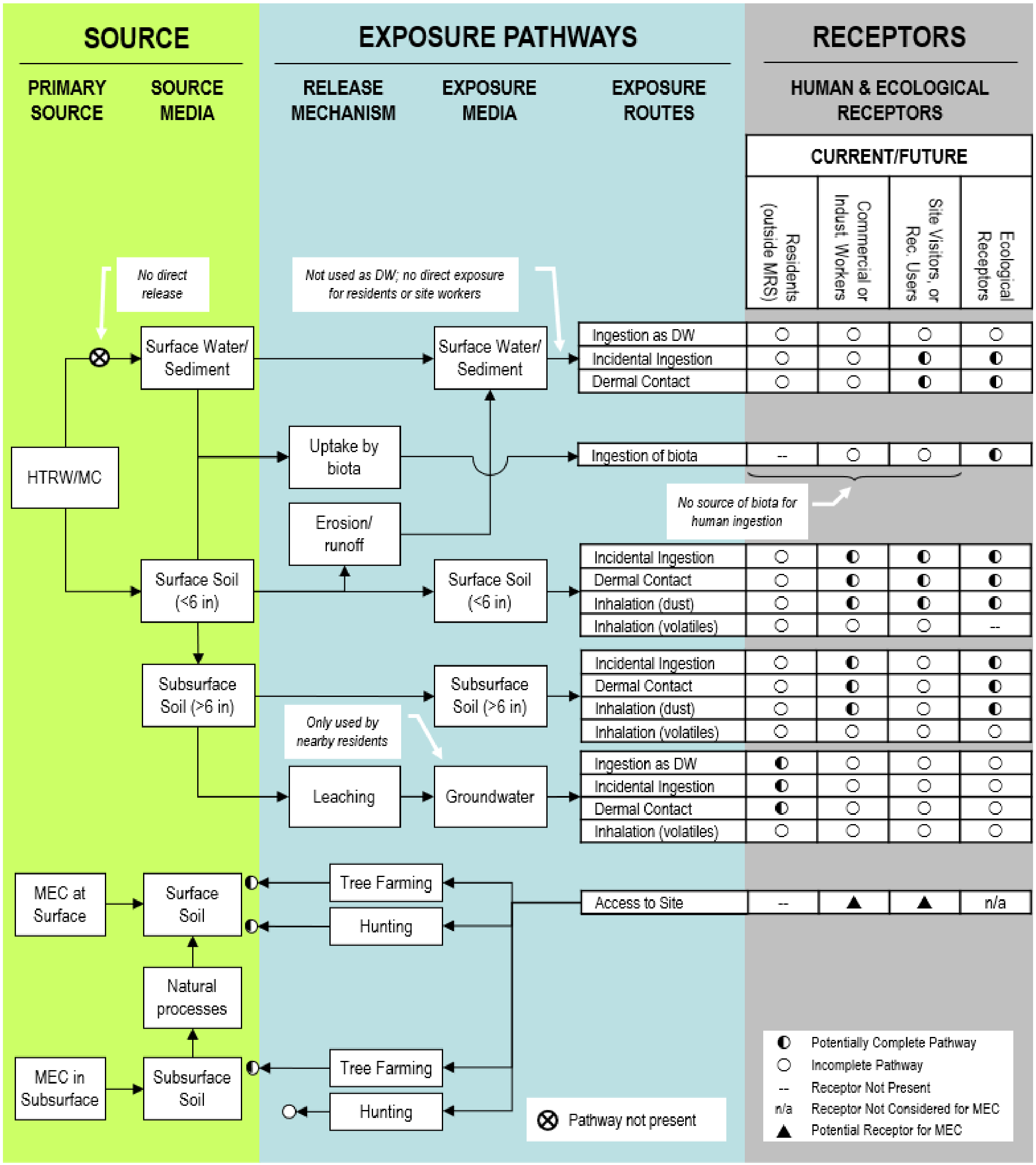



**Figure D–9. Example 11. Graphical representation: CSM exposure pathways (MEC and MC)**

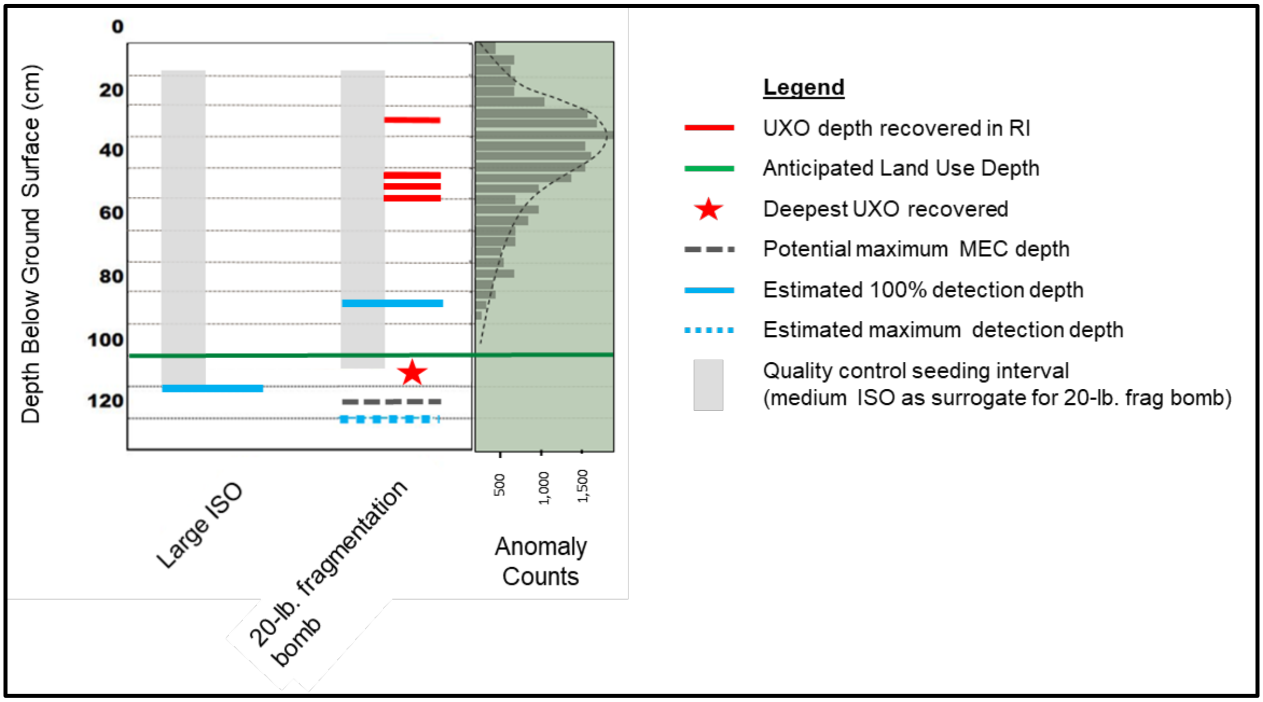



**Figure D–10. Example 12. Graphical representation: remedial investigation vertical profile**

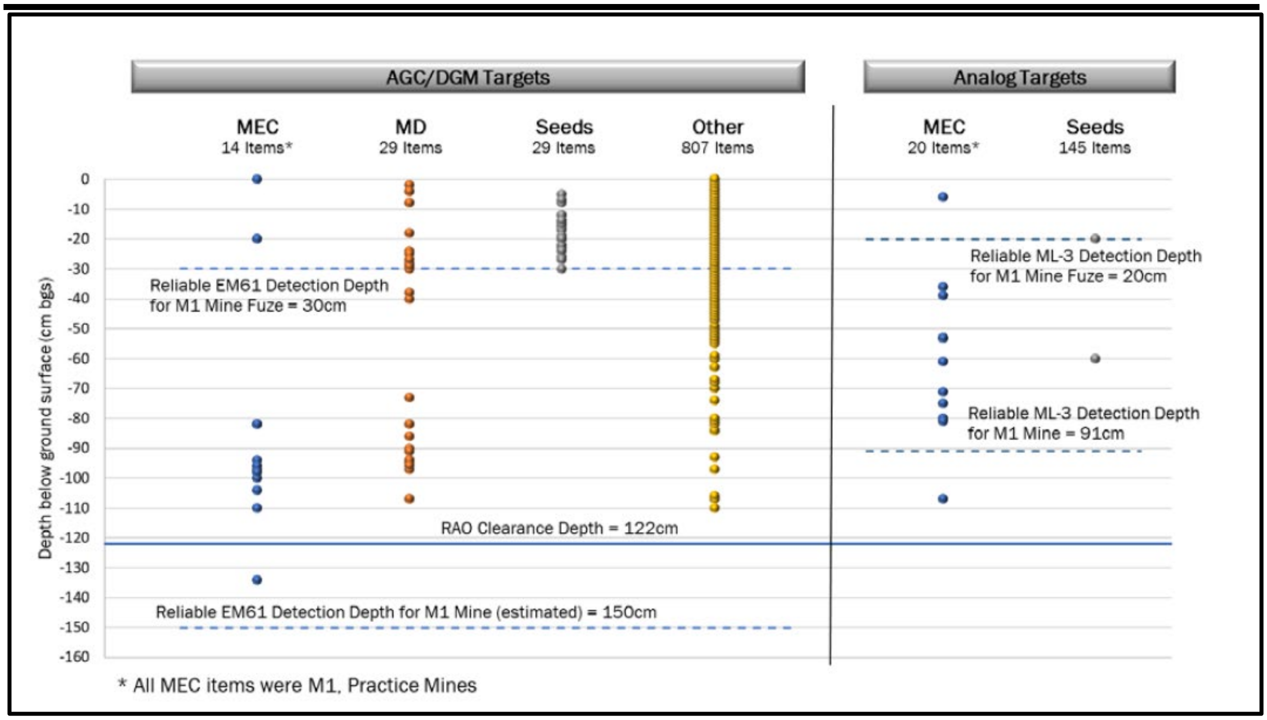



**Figure D–11. Example 13. Graphical representation: remedial action vertical profile**

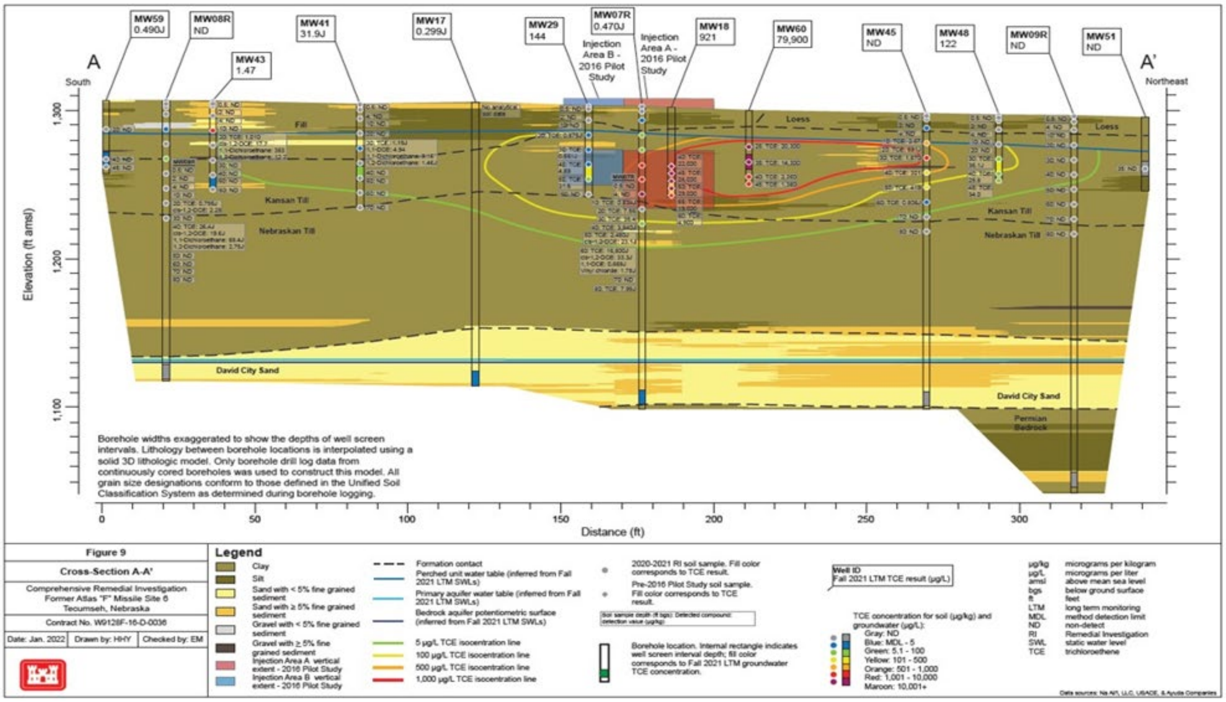
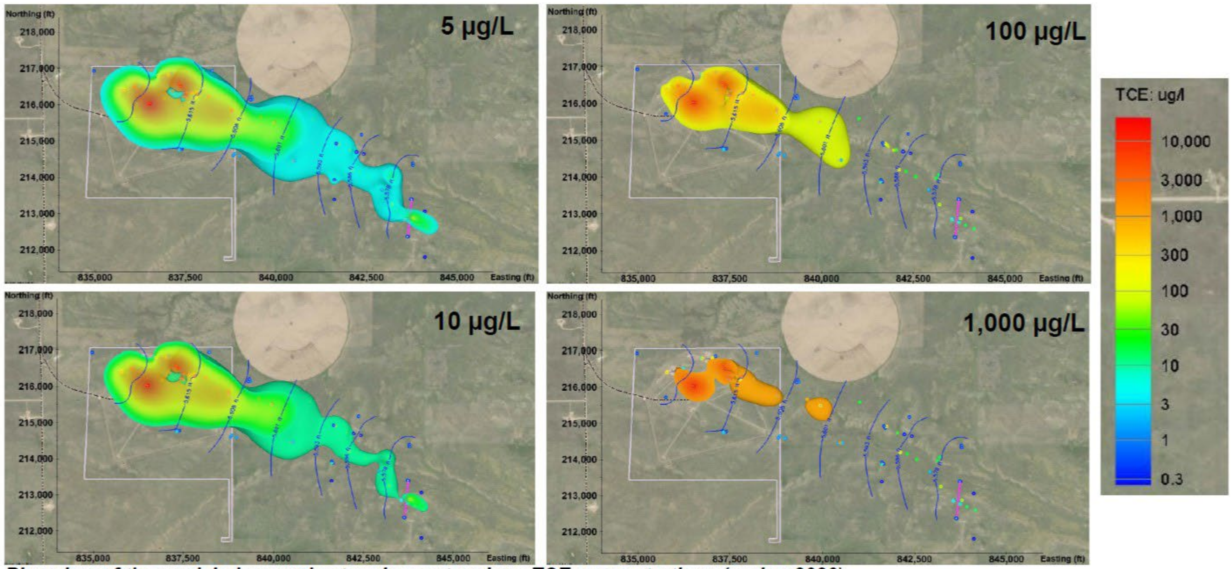
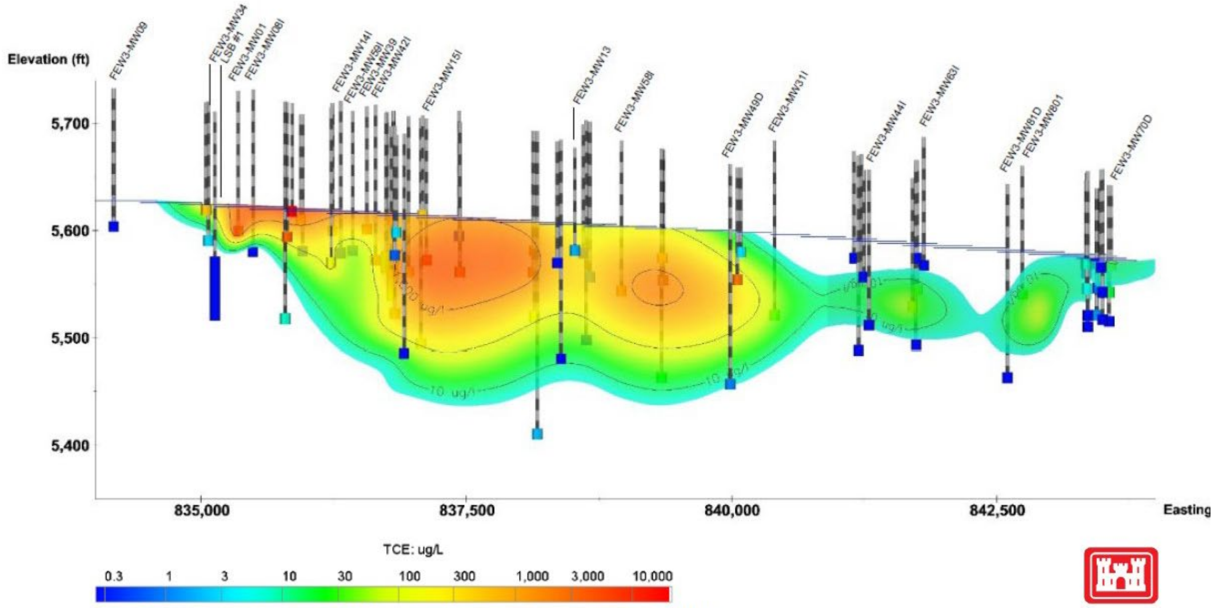



**Figure D–12. Example 14. Graphical representation: vertical profile for groundwater at an HTRW site**



*Plan view of the modeled groundwater plume at various TCE concentrations (spring 2020)*



*Profile view of the modeled groundwater plume (spring 2020)*

**Figure D–13. Example 15. Graphical representation: plan view (top) and profile view (bottom) of a groundwater plume at an HTRW site**

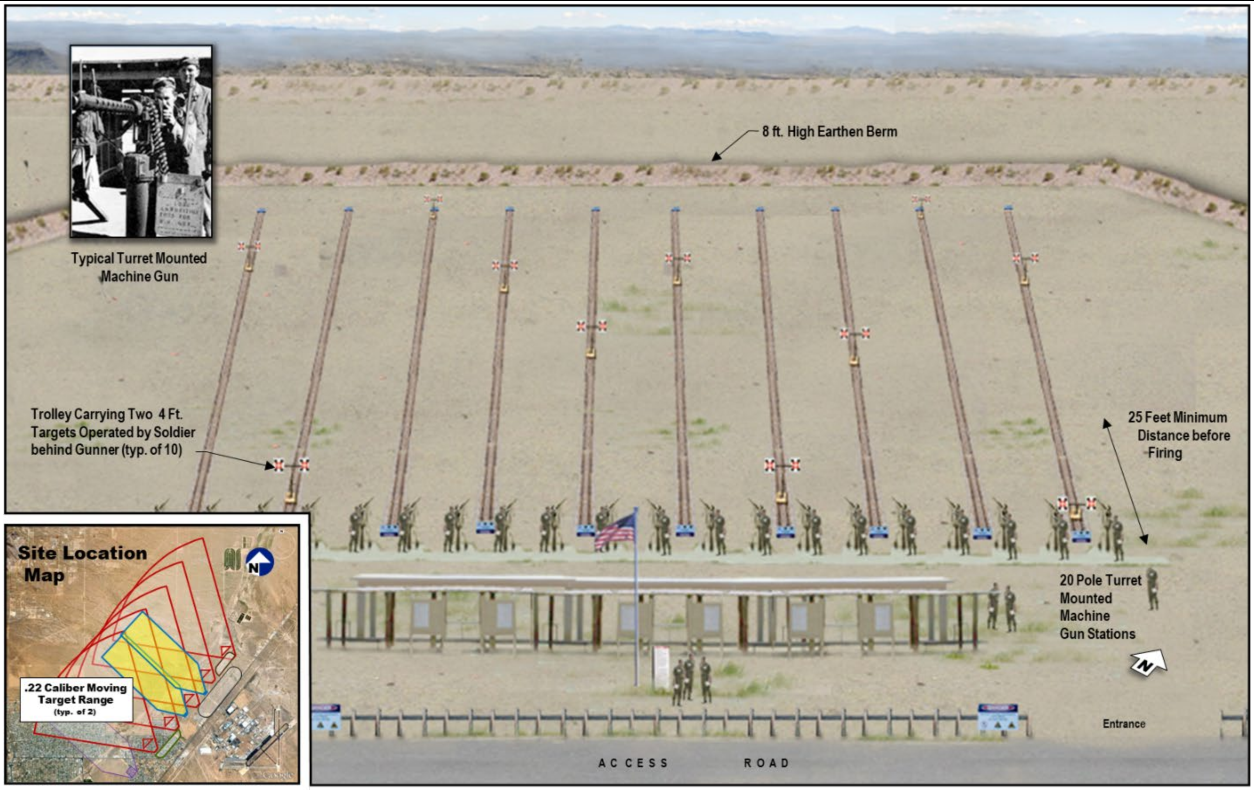



**Figure D–14. Example 16. Pictorial presentation: pictorial CSM for a small arms range**

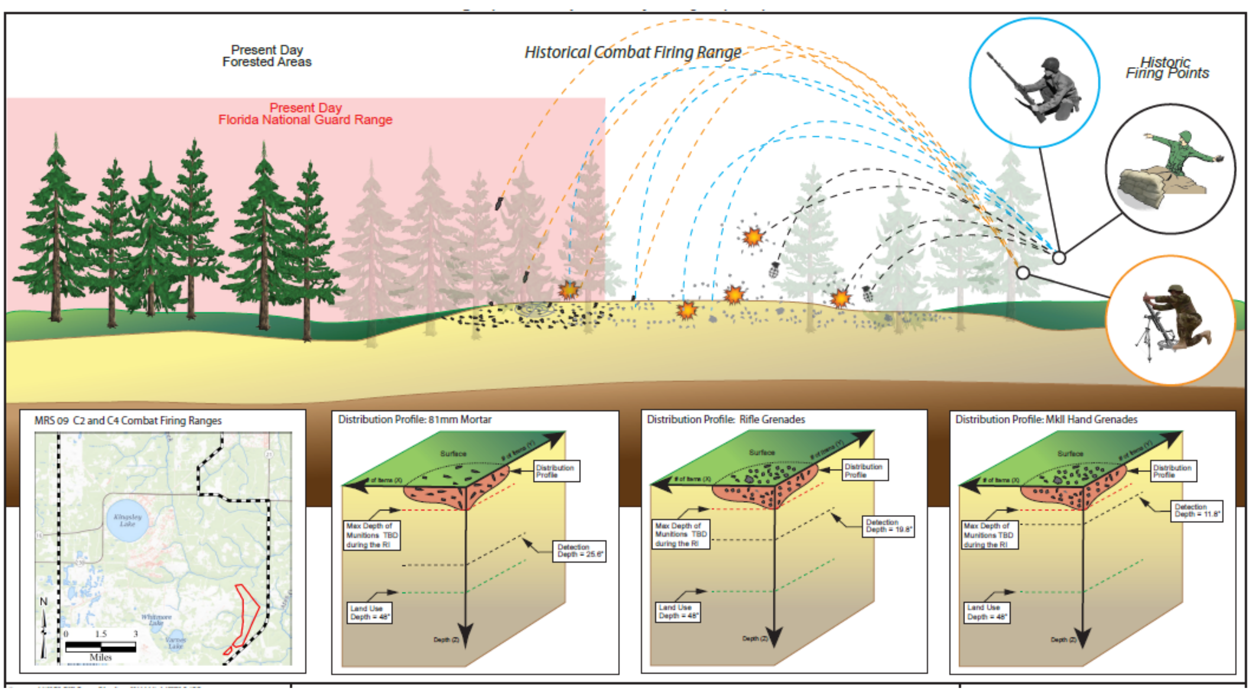



**Figure D–15. Example 17. Pictorial presentation: pictorial CSM for a combat firing range**

**Table 10-1. Overview of Preliminary Conceptual Site Model, Camp Example – MRS A**

| Site Details | Potential/Suspected Location and Distribution of MEC | Known/ Suspected Munitions | Exposure Medium | Current and Future Receptors | Exposure Pathways |
|---|---|---|---|---|---|
| Camp Example, MRS A<br><br>Boundaries and acreage: See Figure 10-2<br><br>Background anomaly density (estimated): 75/acre<br><br>Known/suspected past DoD activities (release mechanisms):<br>Bombing Target #1: Proposed, but no-evidence-of-use<br>Bombing Target #2: 100-lb practice bombs<br>Bombing Target #3: Proposed but no-evidence-of-use<br><br>Current land use: Low-density residential, agricultural, and wildlife preserve<br><br>Future land use: Future increased residential density expected in northwest area of MRS | High-use areas (HUA):<br>-Evidence of munitions handling or use (e.g., target areas)<br>-High likelihood of finding residual MEC, MD, or range-related debris (RRD)<br>-Anomaly density ≥ critical density | -Bomb, HE, M30A1<br>-Bomb, practice, 100-lb, M38A2<br>-nose fuze, AN-M103 Series<br>-tail fuze, AN-M100 Series<br>M1A1 spotting charges for 100-lb practice bombs | Surface soil and subsurface soil | Ranchers<br>Farmers<br>Hunters<br>Hikers<br>Campers<br>Residents<br>U.S. Forestry Service | HUA: Potentially complete exposure to surface and/or subsurface MEC |
| | Low-use areas (LUA):<br>-Low likelihood of finding residual MEC, MD, or RRD<br>-Anomaly density < critical density | | | | LUA: Potentially complete exposure to surface and/or subsurface MEC |
| | No-evidence-of use areas (NEU):<br>-No evidence of munition use | | | | NEU: Incomplete |

**Figure D–16. Example 18. Narrative description: CSM Table for an MRS**

| SITE DETAILS | Known or Suspected Contamination Source(s) | Potential/Suspected Location and Distribution | Source or Exposure Medium | Current and Future Receptors | Potentially Complete Exposure Pathway |
|---|---|---|---|---|---|
| NAME:<br>Rocket and Rifle Grenade Range<br><br>Acreage:<br>125 total. Only obtained ROE for 69 acres<br><br>Suspected Past United States DoD Activities (*release mechanisms*):<br>Unexploded ordnance (UXO) from rocket and rifle grenade firing range training<br><br>Current and Future Land Use:<br>Cultivated cropland and wooded areas | MEC:<br>• Rocket, 2.36-inch, practice<br>• Rifle grenade<br>• Hand grenade | MEC:<br>Potentially present throughout MRS, with greater potential quantities at HUAs | Surface and subsurface soil | Construction workers, site workers (agricultural), recreational users (hunters), and site visitors | Intentional/unintentional interaction with MEC in surface and/or subsurface soil |
| | MC:<br>• MC metals: copper, lead, and zinc<br>• Explosives | MC:<br>Not confirmed, but potentially present within HUAs | Surface and subsurface soil | Construction workers, site workers (agricultural), recreational users (hunters), site visitors, and ecological receptors | Dermal contact with surface and/or subsurface soil containing MC |
| | | MC:<br>Not confirmed, but potentially present at HUAs | Groundwater | Residents, construction workers, and site workers (agricultural) | Ingestion as drinking water or dermal contact with GW containing MC |
| NAME:<br>Mine Training Area<br><br>Acreage:<br>109 acres<br><br>Suspected Past United States DoD Activities (*release mechanisms*):<br>UXO/discarded military munitions (DMM) from engineer mine training<br><br>Current and Future Land Use:<br>Cultivated cropland and wooded areas | MEC:<br>• Mine, Practice, M1<br>• Mine, Practice, M4<br>• Mine, Fuze, M1 | MEC:<br>Potentially present throughout MRS, with greater potential quantities at HUAs | Surface and subsurface soil (most likely subsurface) | Construction workers, site workers (agricultural), recreational users (hunters), and site visitors | Intentional/unintentional interaction with MEC in surface and/or subsurface soil |
| | MC:<br>• MC metals: copper, lead, and zinc<br>• Explosives | MC:<br>Not confirmed, but potentially present within HUAs | Surface and subsurface soil | Construction workers, site workers (agricultural), recreational users (hunters), site visitors, and ecological receptors | Dermal contact with surface and/or subsurface soil containing MC |
| | | MC:<br>Not confirmed, but potentially present at HUAs | Groundwater | Potential future residents, construction workers, and site workers (agricultural) | Ingestion as drinking water or dermal contact with GW containing MC |

**Figure D–17. Example 19. Narrative description: CSM table for two MRSs**

## Glossary of Terms

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

**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 military munitions or HTRW at a property; actual, potentially complete, or incomplete exposure pathways; current or reasonably anticipated future land use; and potential receptors. The source-receptor interaction is a description output of a CSM. The CSM serves as a planning instrument, a modeling and data interpretation aid, and a communication device for use by the PDT.

**Data Quality Objective (DQO)**
A qualitative and quantitative statement developed to clarify study objectives, define the type of data needed, and specify the tolerable levels of potential decision errors. A DQO is used as the basis for establishing the type, quality, and quantity of data needed to support the decisions that will be made. (EM 200-1-15)

**Discarded Military Munitions (DMM)**
Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include unexploded ordnance, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations. (10 U.S.C. 2710(e)(3))

**Encounter (with MEC)**
A term used in MEC risk assessment or remedial action objectives (RAOs) describing a chance event during which a receptor gets sufficiently close to a MEC item that they might interact with it (note that this does not require the individual to interact with the MEC item). In many cases, a receptor may be unaware they have encountered a MEC item, either because they have not observed it or because they have not recognized it as MEC. This kind of encounter can result in an unintentional interaction.

**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 (for example, skin, lungs, organs) and available for absorption. (EPA/540/1-89/002)

**Exposure Pathway**
The course a chemical or physical agent, or contaminant, 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, or contaminants, 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 (for example, 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 (for example, ingestion, inhalation, dermal contact). (EPA/540/1-89/002)

**High Use Area (HUA)**
High anomaly density area (as determined by a geophysical investigation) where munitions use has been confirmed. Unexploded ordnance (UXO) and/or discarded military munitions (DMM) are anticipated to be present in HUAs.

**Interaction (with MEC)**
A term used in MEC risk assessment or RAOs describing when, upon encounter the receptor imparts energy to the MEC item, either intentionally or unintentionally, such that it might function (note that this does not require the receptor to physically come into direct contact with the MEC item, for example, energy transfer via hand tool, horizontal cable drilling, pressure bulb under a footstep or tire tread, etc.). (EM 200-1-15)

**Interaction Zone**
A term used in MEC risk assessment describing a volume of media (for example, horizontal and vertical extents of soil or sediment) within which a specific receptor's activity may be performed. A unique interaction zone must be associated with each receptor activity based on the associated intrusive depths. (EM 200-1-15)

**Intrusive Activity**
An activity that involves or results in the penetration of the ground surface at an area known or suspected to contain munitions and explosives of concern. Intrusive activities can be of an investigative or removal action nature. (EM 200-1-15)

**Light Detection and Ranging (LiDAR)**
Surveying performed from an aircraft platform. LiDAR surveying allows generation of digital terrain models. With proper processing, the elevation data collected by a LiDAR survey may identify targets and range areas that may not be discernible on standard aerial photography. Surveying is possible during day or night or at any sun angle, and may even be flown during overcast conditions if the ceiling is above the aircraft. Surveys may be performed over large areas in a much shorter time frame than on-the-ground

survey crews. Data can be collected on active range and training areas without requiring access to the range.

**Low Use Area (LUA)**
LUA: Low anomaly density area (as determined by a geophysical investigation) where the potential presence of munitions cannot be ruled out. Examples of LUA include buffer zones and maneuver areas.

**Material Potentially Presenting an Explosive Hazard (MPPEH)**
Material owned or controlled by the Department of Defense that, prior to determination of its explosives safety status, potentially contains explosives or munitions (for example, munitions containers and packaging material; munitions debris remaining after munitions use, demilitarization, or disposal; and range-related debris) or potentially contains a high enough concentration of explosives that the material presents an explosive hazard (for example, equipment, drainage systems, holding tanks, piping, or ventilation ducts that were associated with munitions. (EM 200-1-15)

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

**Military Munitions**
All ammunition products and components produced for or used by the United States armed forces for national defense and security, including ammunition products or components under the control of the Department of Defense, the Coast Guard, the Department of Energy, and the National Guard. The term includes confined gaseous, liquid, and solid propellants, explosives, pyrotechnics, chemical and riot control agents, smokes and incendiaries, including bulk explosives and chemical warfare agents, chemical munitions, rockets, guided and ballistic missiles, bombs, warheads, mortar rounds, artillery ammunition, small arms ammunition, grenades, mines, torpedoes, depth charges, cluster munitions and dispensers, demolition charges, and devices and components of any item specified herein. The term does not include wholly inert items, improvised explosive devices, or nuclear weapons, nuclear devices, and nuclear components, other than non-nuclear components of nuclear devices that are managed under the nuclear weapons program of the Department of Energy after all required sanitization operations under the Atomic Energy Act of 1954 (42 USC §2011, et seq.) have been completed.

**Military Munitions Response Program (MMRP)**
Formerly known as the Ordnance and Explosives Cleanup Program, and a part of the DERP, the MMRP is the program category under which DoD carries out environmental restoration activities to respond to releases to the environment of UXO, DMM, or MC at munitions response sites.

**Military Range**
Designated land or water area set aside, managed, and used to conduct research on, develop, test, and evaluate military munitions and explosives, 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. (Military Munitions Rule, 40 CFR. 266.201)

**Munitions and Explosives of Concern (MEC)**
This term, which distinguishes specific categories of military munitions that may pose unique explosives safety risks, means:

*a.* unexploded ordnance, as defined in 32 CFR §179.3;
*b.* discarded military munitions, as defined in 10 U.S.C. 2710 (e) (2), or
*c.* munitions constituents (for example, TNT, RDX) present in high enough concentrations to pose an explosive hazard. (32 CFR §179.3)

**Munitions Constituents (MC)**
Any materials originating from unexploded ordnance, discarded military munitions, or other military munitions, including explosive and non-explosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions. (10 U.S.C. 2710(e)(3))

**Munitions Debris**
Remnants of munitions (for example, penetrators, projectiles, shell casings, links, fins) remaining after munitions use, demilitarization or disposal. (OASA(I&E) Memorandum, 28 October 2003, Subject: Definitions Related to Munitions Response Actions)

**Munitions Response**
Response actions, including investigation, removal, and remedial actions to address the explosives safety, human health, or environmental risks presented by Unexploded Ordnance (UXO), Discarded Military Munitions (DMM), or Munitions Constituents (MC). (32 CFR §179.3)

**Munitions Response Area (MRA)**
Any area on a defense site that is known or suspected to contain UXO, DMM, or MC. Examples are former ranges and munitions burial areas. An MRA comprises one or more Munitions Response Sites (MRS). (32 CFR §179.3)

**Munitions Response-Quality Assurance Project Plan (MR-QAPP)**
The MR-QAPP is a workplan toolkit. At the time of publication of this guidance, the MR-QAPP Toolkit Module 1 and Advanced Geophysical Classification QAPP (AGC-QAPP) have been adopted by DoD as the workplan format for MR remedial investigations and remedial/removal actions, respectively. The AGC-QAPP is being updated and will be published as MR-QAPP Toolkit Module 2.

**Munitions Response Site (MRS)**
A discrete location within a munitions response area that is known to require a munitions response. (32 CFR §179.3)

**Munitions Response Site Prioritization Protocol (MRSPP)**
A process established in a DoD regulation that provides a tool to assign a relative priority for munitions responses to each location in the Department's inventory of defense sites known or suspected of containing UXO, DMM, or MC. (32 CFR Part 179)

**No Evidence of Use (NEU) Area**
1) Low anomaly density area for which the CSM contains no evidence munitions were used in the area, or 2) high anomaly density area determined to be not related to munitions use. All available and relevant lines of evidence supporting this delineation (for example, historical records review, historical photo interpretation, visual observations, and interviews) must be considered.

**Preliminary assessment (PA)**
Review of existing information and an on or off-site reconnaissance, if appropriate, to determine if a release may require additional investigation or action. 40 CFR 300
A limited-scope investigation that collects readily available information about a property and its surrounding area. The PA is designed to distinguish, based on limited data, between sites that pose little or no threat to human health and the environment and sites that may pose a threat and require further investigation. The PA also identifies sites requiring assessment for possible emergency response actions. If the PA results in a recommendation for further investigation, a Site Inspection is performed. (ER 200-3-1)

**Project Delivery Team (PDT)**
The PDT is a cross-functional matrixed team that includes all the necessary functional and support personnel with the requisite skills and expertise, from the District, Divisions, Centers of Expertise and/or labs, in order to deliver the project. The PDT is led by the Project Manager with responsibility for assuring that the project stays focused, first and foremost on the public interest, on the stakeholders' needs and expectations and that all work is integrated and done in accordance with a Project Management Plan and approved business and quality management processes. The PDT focuses on quality project delivery, with heavy reliance on partnering and relationship development to achieve better performance. The PDT comprises everyone necessary for successful development and execution of all phases of the project. The PDT will include the customers, the PM, technical experts within or outside the local USACE activity, specialists, consultants/contractors, stakeholders, representatives from other Federal and State agencies, and higher-level members from Division and Headquarters who are necessary to effectively develop and deliver the project actions.

**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. (EM 200-1-2)

**Range-Related Debris**
Debris, other than munitions debris, collected from operational ranges or from former ranges (for example, targets). (OASA(I&E) Memorandum, 28 October 2003, Subject: Definitions Related to Munitions Response Actions.)

**Receptor**
A receptor is an organism (human or ecological) that contacts a chemical or physical agent, or contaminant, via an exposure route.

**Receptor Activity**
A term used in MEC risk assessment describing the different land use activities occurring within an assessment area for a given receptor. (for example, one activity for a unique group of individuals having frequent intrusive activities to six inches bgs and another activity performed by the same group but having infrequent intrusive activities to 12 inches bgs). (EM 200-1-15)

**Source (when used in the context of contamination and a CSM)**
Sources are those areas where MEC, MC or HTRW has entered (or may enter) the physical system.

**Stakeholders**
Stakeholders include federal, state, and local officials, tribal officials, community organizations, property owners, and others having a personal interest or involvement or having a monetary or commercial involvement in the FUDS Property that is to undergo a remedial/response action.

**Systematic Planning Process**
Systematic planning is a process based on the widely accepted “scientific method” and includes concepts such as objectivity of approach and acceptability of results. The process uses a common-sense approach to ensure that the level of documentation and rigor of effort in planning is commensurate with the intended use of the information and the available resources. The systematic planning approach includes well-established management and scientific elements that result in a project’s logical development, efficient use of scarce resources, transparency of intent and direction, soundness of project conclusions, and proper documentation to allow determination of appropriate level of peer review. An example of systematic planning is the USEPA’s seven-step Data Quality Objectives (DQO) Process.

**Unexploded Ordnance (UXO)**
Military munitions that (a) have been primed, fuzed, armed, or otherwise prepared for action; (b) have been fired, dropped, launched, projected or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material; and (c) remain unexploded either by malfunction, design, or any other cause. (32 CFR §179.3)

**Uniform Federal Policy – Quality Assurance Project Plan (UFP-QAPP)**
The UFP QAPP fulfills the requirements of the sampling and analysis plans as defined in the NCP 40 CFR § 300.415, 40 CFR § 300.425 and 40 CFR § 300.430. The UFP-

QAPP also fulfills the requirement of the field sampling plan, which describes the number, type, and location of samples and the type of analyses; and the quality assurance project plan, which describes policy, organization, and quality processes and procedures.

# SUMMARY of CHANGE

EM 200-1-12
Environmental Quality: Conceptual Site Models

This revision, dated 11 August 2023 —

- Validates references and adds URLs.
- Updates terminology and acronyms since last publication.
- Brings formatting into compliance with ER 25-30-1.
- Major technical updates include:
  - Updating figures throughout the manual to modernize them and providing additional Conceptual Site Model examples.
  - Relating Conceptual Site Models to the systematic planning process, as described in the Uniform Federal Policy for Quality Assurance Project Plans. Adding references to the Uniform Federal Policy for Quality Assurance Project Plans and the Munitions Response Quality Assurance Project Plan Toolkits.
  - Clarifying the Conceptual Site Model profiles and their related data. Adding a discussion of the vertical profile for munitions and explosives of concern, and hazardous, toxic, and radioactive waste/munitions constituents Conceptual Site Models, including examples.
  - Clarifying the differences and similarities between exposure pathways for munitions and explosives of concern, and hazardous, toxic, and radioactive waste/munitions constituents.
  - Expanding the discussion of how Geographic Information Systems can be used to support Conceptual Site Model development.
  - Adding a summary of online information resources for preliminary Conceptual Site Model development.
  - Summarizing the expected Conceptual Site Model profile information at each phase of the Comprehensive Environmental Response, Compensation, and Liability Act process.
  - Adding maneuver areas to the Appendix B, Range Operations Overview.
  - Updating the Conceptual Site Model examples in Appendices C and D.