



Conceptual Site Models

Introduction

This guidance document explains the purpose, development and use of conceptual site models (CSMs) for assessment and cleanup of hazardous substances¹ under the DERR Remedial Response Program (Ohio's state-lead CERCLA program). CSMs are required for the Remedial Response Program, and are intended to be utilized as dynamic and systematic planning tools through all stages of a Remedial Response project. CSMs prepared for Remedial Response sites should be developed and used in a manner that is consistent with this guidance document.

CSMs are also required for the assessment and cleanup of hazardous substances under the Federal Program (CERCLA), RCRA and Ohio's Voluntary Action Program (VAP). While intended for Remedial Response sites, this guidance also may help facilitate the development and use of CSMs for Federal Program, RCRA and VAP sites or properties if used appropriately within each program's regulatory framework. CSMs prepared for Federal Program sites should follow U.S. EPA guidance, including but not necessarily limited to Environmental Cleanup Best Management Practices: Effective Use of the Project Life Cycle Conceptual Site Model (EPA 542-F-11-011, July 2011).

What is a conceptual site model, why is it needed for remedial projects, and how is it developed?

The CSM is an iterative "living" representation of a contaminated site (or property) that provides a simplified and concise summary of contamination sources and distribution; release mechanisms; exposure pathways and migration routes; and human and ecological receptors (U.S. EPA, 2011). The CSM should describe the site environmental system, identifying the physical, chemical and biological processes that control the transport of contaminants from sources through environmental media to environmental receptors (ASTM E1689-95(2014)). As required by U.S. EPA's systematic planning process for the collection and evaluation of environmental data (U.S. EPA, 2006), development of a CSM is an integral step in clarifying cleanup objectives for a site and determining appropriate data quality objectives (DQOs). CSMs provide a basic understanding of site contamination and potential exposure scenarios for all cleanup team members and project stakeholders, including potentially responsible parties (PRPs), site owners, site operators, consultants, regulators, local governments, and citizens.

Essentially, the CSM is a hypothesis with the objective of making site-specific predictions about the occurrence of contamination at a property, and its potential to adversely affect human and ecological receptors (Sayko and LaRegina, November 2014). The CSM "hypothesis" is initially developed during remedial project scoping (the determination of project objectives and DQOs in conjunction with the review of existing site data; U.S. EPA, 1988) and is continuously tested (and revised as necessary) during the site assessment and remediation process by the collection and evaluation of additional data. Every CSM is speculative to some degree. Therefore, as with any other hypothesis, a "bottom up" approach based on assumptions that provide the simplest explanation of the observed data (site conditions) is the best approach.

Development and use of a formal (*i.e.*, written) CSM is a critical step in the remedial process. A formal CSM helps ensure that Ohio EPA, PRPs, consultants and other project team members are working with the same mindset and are considering all relevant site conditions and circumstances. In the absence of a formal CSM that accurately represents site characteristics and conditions, each team member (and each project stakeholder) will potentially develop their own

¹ As defined by CERCLA § 101(14)

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“informal CSM” based on their understanding of the site (or lack thereof) leading to misunderstandings and disagreements, which can delay site assessment and cleanup, and may unnecessarily increase project cost.

Depending on the size and complexity of the remediation project, the development of area-specific CSMs within a large facility may be appropriate as opposed to a single site- or facility-wide CSM. Area-specific CSMs should be considered when the site or facility includes multiple areas of contamination with differing chemicals of concern (COCs), releases, pathways, receptors and/or surface or subsurface conditions.

Three criteria are necessary for proper CSM development, maintenance and use (U.S. EPA, 2011). First, the CSM must be applied as a systematic planning tool to all phases of an environmental cleanup project, starting with the initial site assessment activities and continuing through redevelopment and reuse of the remediated site. Second, as new data are generated during site assessment and the evaluation, design and implementation of remedial actions, the CSM needs to be iteratively updated. As data gaps are progressively filled over the course of the project, the accuracy of the CSM should increase. Third, given the first two criteria, the CSM should be maintained as a stand-alone document that is accessible to all team members and stakeholders during the course of the project. The CSM may be attached to other documents such as the remedial investigation (RI) or feasibility study (FS), but the individual components of the CSM never should be dispersed throughout multiple remedial documents.

Attachment A includes a checklist for CSM development, which has been adapted from a checklist provided by U.S. EPA (<http://www.triadcentral.org/ref/ref/index.cfm>). The checklist may be used on a voluntary basis for preparing CSMs for Remedial Program or VAP projects. All criteria on the checklist are not necessarily applicable for every cleanup project.

How should the CSM be presented and maintained?

The CSM should consist of a concise combination of graphical and written information which portrays and describes known and hypothesized site conditions in a manner that is readily understandable to all project stakeholders. The CSM should clearly distinguish between known and hypothesized site conditions. Ohio EPA recommends that a CSM include all of the following components (ASTM E1689–95(2014)):

- A pictorial model of the site conditions, including but not limited to the locations of contaminant sources, above ground and below ground structures and utilities, topographic features and surface hydrology, and geology and hydrogeology (**Figure 1**).
- A pathway network receptor diagram to support risk assessment (**Figure 2**).
- A brief written description of the CSM that includes the following components:
 - Site description (current conditions and history)
 - Contaminant source characterization
 - Migration pathway descriptions
 - Identification of data gaps
- Additional maps, tables and figures for support, if needed.

The CSM does not need to include supporting data. All supporting data should be provided in site assessment (investigation) reports, RI/FS reports or other documents.

Pathway network receptor diagrams (**Figure 2**) are often used as CSMs. Pathway network receptor diagrams are effective tools for risk assessment and remedy development, and, as such, are an important CSM component. However, these diagrams do not provide sufficient information regarding the structure and dynamics of the site hydrogeologic system through which contaminants migrate, which is needed for effective site assessment activities and for the development of appropriate remedial alternatives. In addition, pathway network receptor diagrams may not identify all CSM data gaps. Accordingly, a CSM should not be limited to a pathway network receptor diagram, but should include a pictorial model of the site and a brief narrative explanation.

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Common CSM problems that should be avoided include the following:

- Treating the CSM as an administrative task rather than a systematic planning tool.
- Using an overly generic CSM that is not sufficiently site specific to be useful with regards to predictions about site conditions.
- Using an overly detailed CSM that presents site data rather than presenting a concise synopsis of site conditions based on data evaluation (*e.g.*, presenting a detailed geologic cross section as a CSM).
- Dispersing CSM components throughout multiple remedial documents (or lack of a stand-alone CSM).

How should the CSM be utilized throughout a cleanup project?

The CSM is a systematic planning tool that should be used as the basic framework for evaluating new data as it becomes available during site assessment and remediation activities. CSMs are dynamic and iterative, and should evolve as the cleanup project progresses, increasing in detail and accuracy. U.S. EPA (2011) describes six stages for the project life cycle of a CSM. These stages do not represent six separate CSMs, but rather are successive versions of the same CSM as it evolves and matures through the defined stages of a cleanup project's life cycle:

(CSM Initial Development Stages)

1. **Preliminary CSM:** developed prior to systematic planning based on existing site data to provide a fundamental basis for the planning effort.
2. **Baseline CSM:** an outcome of systematic planning used to document stakeholder consensus/divergence and identify data gaps and uncertainties.

(CSM Evolution and Refinement Stages)

3. **Characterization CSM:** iterative improvement as new data becomes available during site assessment efforts; supports remedy decision making and technology selection.
4. **Design CSM:** iterative improvement during design of the remedy; supports remedy design development and the associated technical details.
5. **Remediation/Mitigation CSM:** iterative improvement during remedy implementation; supports remedy implementation and optimization, and provides documentation for cleanup objective attainment.
6. **Post Remedy CSM:** supports reuse planning efforts; documents institutional and engineering controls, on-site waste containment, and other key site attributes.

For a more detailed discussion of the life cycle of a CSM and its six stages, refer to U.S. EPA (2011). The CSM checklist (Attachment A) prompts the user to indicate the project life cycle stage (1-6) as described above. All criteria on the checklist are not necessarily applicable for every cleanup project stage.

As discussed, the CSM will change over time in response to new data generated during site assessment, the development of remedial alternatives, and remedy implementation. Additionally, the CSM may need to be revised in response to changes in project scope or regulatory requirements; recognition of a previously unknown contaminant, pathway or receptor; or changes in the planned end use of the site. All project stakeholders should be provided the opportunity to review, understand and provide input into proposed CSM revisions. Final revisions and supporting information should be properly documented for later reference. Table 1 provides a chart showing the progression of required work activities for the Remedial Program², RCRA and VAP with the corresponding CSM life cycle stages. This chart should be used as a general reference for updating the CSM so that it continuously evolves with the cleanup project as an effective tool for communicating existing site/property conditions, refining cleanup objectives, and supporting deliverables. For the Remedial Program, the baseline and characterization CSMs should be used to develop remedial action objectives, and an

² The required work activities for the Federal Program are equivalent to those of the Remedial Program.

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updated CSM should be provided with the pre-investigation evaluation report, the remedial investigation report, the feasibility study report, the preferred plan, the decision document and the remedial design report. In addition, an updated CSM should be available for review of remedial action reports, post-construction (O&M, monitoring and periodic compliance inspection) reports and remedy/site completion reports.

CSM References and Resources

ASTM E1689 – 95(2014), *Standard Guide for Developing Conceptual Site Models for Contaminated Sites* (Reapproved 2014)

Sayko, S.P. and J. LaRegina, November 5, 2014, *Using Conceptual Site Models to Communicate Project Understanding*, Pennsylvania Council of Professional Geologists (PCPG) Professional Development Seminar, Monroeville, PA

U.S. EPA Triad Resource Center Reference Documents/Internet Resources, Conceptual Site Model:

<http://www.triadcentral.org/ref/ref/index.cfm>

U.S. EPA, July 2011, *Environmental Cleanup Best Management Practices: Effective Use of the Project Life Cycle Conceptual Site Model*, EPA 542-F-11-011

U.S. EPA, February 2006, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4), EPA/240/B-06/001

U.S. EPA, October 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (Interim Final), EPA/540/G-89/004

Contact

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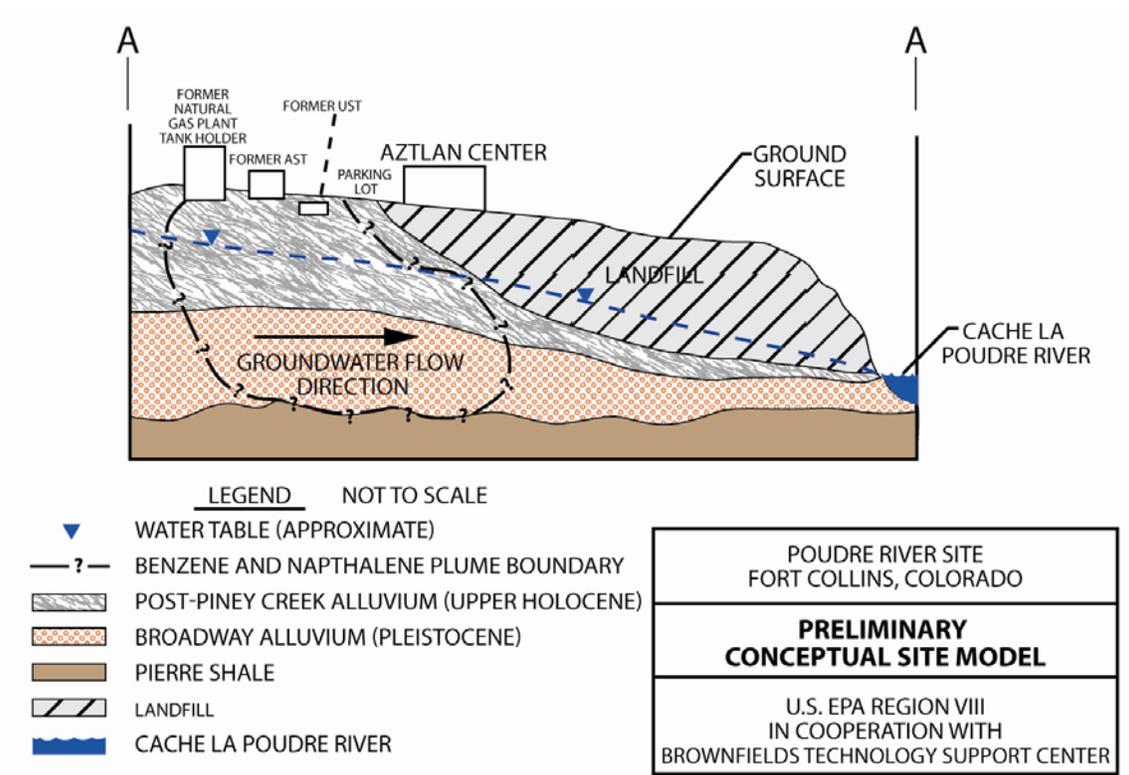


FIGURE 1 – Example Pictorial CSM Illustrating Surface & Subsurface Conditions (U.S. EPA 2011)

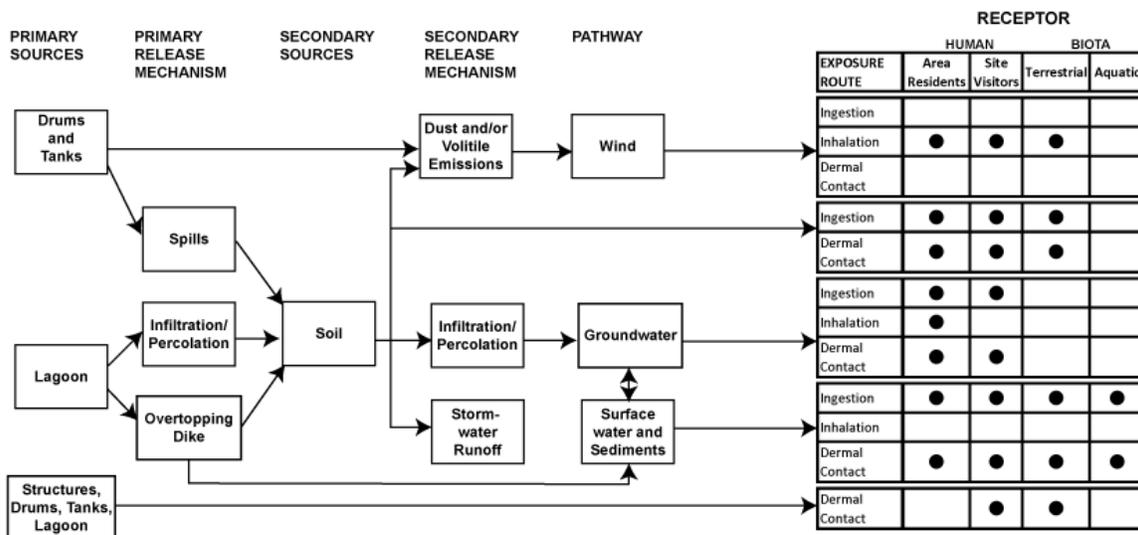


Figure 2 – Example Pathway Network Receptor Diagram (U.S. EPA 2011)

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TABLE 1

CSM Life Cycle Stages and Ohio EPA DERR Regulatory Program Stages

General Environmental Cleanup Steps	CSM Life Cycle Stage Progression	Remedial Program ³	RCRA	Voluntary Action Program (VAP)
Site Assessment	Preliminary CSM	Preliminary Assessment (PA), Site Inspection (SI)	Facility Assessment (RFA)	Phase I Property Assessment
	Baseline CSM	Pre-Investigation Evaluation Report (PER), Preliminary Remedial Action Objectives (RAOs)		Phase II Property Assessment <i>(Ohio EPA recommends iteratively updating the CSM through the Phase II process)</i>
Site Investigation and Alternatives Evaluation	Characterization CSM	Remedial Investigation and Feasibility Study (RI/FS) <i>(Ohio EPA recommends iteratively updating the CSM through the RI/FS process)</i>	Facility Investigation (RFI)	
Remedy Selection	Design CSM		Corrective Measures Study (CMS)	
		Preferred Plan (PP), Decision Document (DD)	Final Decision and Response to Comments	Remediation
Remedy Implementation	Remedial CSM	Remedial Design (RD), Remedial Action (RA)	Corrective Measures Implementation (CMI)	
Post-Construction Activities	Post-Remedy CSM	Operation & Maintenance, Long Term Monitoring and Periodic Compliance Inspections	Operation & Maintenance, On-Site Inspections and Oversight	Operation & Maintenance, VAP Audits (Post -NFA Letter Issuance Activities)
Site Completion		Construction Completion, Remedy Completion	Certification of Completion, Corrective Action Complete with Controls or without Controls	

³ The required work activities for the Federal Program (CERCLA) are equivalent to those of the Remedial Program.

ATTACHMENT A

Conceptual Site Model (CSM) Criteria Checklist

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CONCEPTUAL SITE MODEL (CSM) CRITERIA CHECKLIST (U.S. EPA 2011 Life Cycle CSM, Stage #____)			
CONCEPTUAL SITE MODEL CRITERIA		APPLICABLE FOR CURRENT CSM STAGE?	COMPLETE OR MORE DATA NEEDED?
STRUCTURES & ACTIVITIES	Current and historical facility surface and subsurface structures (buildings, underground utilities, drain systems, etc.)		
	Current and historical process areas (loading/unloading, storage, manufacturing, etc.)		
	Current and historical waste management areas and associated activities		
	<u>Other:</u>		
SURFACE & SUBSURFACE FEATURES	Topographic features (highs and lows, gradients)		
	Surface cover(s) (vegetation types, paved areas, unpaved/unvegetated areas)		
	Surface water bodies and features controlling surface water flow		
	Fill & waste disposal areas (approximate limits and type of fill or waste)		
	Geology & Hydrogeology (information from site investigations and published literature, modeling results)		
	Existing water supply wells, monitoring wells and soil borings		
	<u>Other:</u>		
COC RELEASE INFORMATION	Confirmed and potential chemicals of concern (COCs)		
	Confirmed and potential source and release areas		
	Concentration of distribution of COCs		
	COC and COPC transport mechanisms and migration routes		
	Fate and transport modeling results		
	<u>Other:</u>		

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CONCEPTUAL SITE MODEL (CSM) CRITERIA CHECKLIST (U.S. EPA 2011 Life Cycle CSM, Stage #____)			
CONCEPTUAL SITE MODEL CRITERIA		APPLICABLE FOR CURRENT CSM STAGE?	COMPLETE OR MORE DATA NEEDED?
LAND USE & EXPOSURE	Land use (site and adjacent properties)		
	Critical natural resources (ground water, wetlands, endangered species, etc.)		
	Resource use locations (water supply wells, surface water intakes, etc.)		
	Subpopulation types and locations (schools, hospitals, day care centers, etc.)		
	Exposure scenarios (residential, commercial, industrial, recreational, agricultural)		
	Exposure pathway evaluation (COC sources, releases, transport mechanisms, exposure media, exposure routes, receptors)		
	<u>Other:</u>		
RISK MANAGEMENT	Summary of risks		
	Impact of risk management activities on release and exposure characteristics		
	Performance monitoring locations and media		
	Contingencies if performance monitoring criteria are exceeded		
	<u>Other:</u>		
CLEANUP & REUSE	Cleanup requirements		
	Remedy selection and design		
	Remedy implementation and O&M (if applicable)		
	Reuse & Redevelopment		
	<u>Other:</u>		