MERLA Remediation Process and Risk-Based Site Evaluation Guidance

The Minnesota Pollution Control Agency (MPCA) has prepared this document to outline a risk-based approach to decision making for a site in the MPCA Remediation Division programs listed in the box below. The Remediation Division of the MPCA, under the authority of the Minnesota Environmental Response and Liability Act (MERLA), uses a Risk-Based Site Evaluation (RBSE) approach to evaluate and manage actual and potential risks associated with contamination at a site. The key principles of RBSE involve assessing risks to human health and the environment posed by contaminants present, and determining appropriate actions based on the level of risk identified. Rather than using a one-size-fits-all approach to remediation, RBSE considers site-specific exposure scenarios in making cleanup and mitigation decisions, which allows for the safe use of property and the efficient use of resources.

This guidance applies to the following Remediation Division MERLA programs:

- Site Assessment
- Superfund
- Voluntary Investigation and Cleanup (VIC) Program
- Resource Conservation and Recovery Act (RCRA) Remediation Program
- Closed Landfill Program (CLP)

This document provides guidance regarding the following:

- MERLA remediation process and phases.
- Preparing appropriate documents and reports.
- Developing a Conceptual Site Model (CSM).
- Conducting site investigations.
- Making site management decisions using the RBSE process to evaluate exposure pathways and receptors.
- Determining the need for additional investigation or response actions.
- Selecting and implementing remedies that protect human health and the environment.
- Conducting operation, maintenance, and monitoring (OM&M).
- Obtaining site closure.

This document is not meant to provide guidance to cover all situations or scenarios that may be encountered, nor is it intended to replace or supersede program or site-specific requirements. Guidance for evaluating human health risks associated with specific media (e.g., soil, groundwater, surface water, soil vapor, indoor air, sediment) and the evaluation of risks to ecological receptors can be found on MPCA's Cleanup guidance and assistance webpage.

The key programs relevant to MERLA within the Remediation Division may have program-specific requirements that must be followed when conducting work at a site. Different programs sometimes use different terms to describe similar processes and actions, frequently based on applicable statutory language or historical usage. Terms used in this document were chosen for broadest applicability and understanding to describe general processes and actions. For example, the term "response action" was used to encompass corrective actions, cleanup actions, removal actions, mitigation actions, and remedial actions.

Figures

1.0 MERLA overview and statutory authority

The Minnesota Pollution Control Agency (MPCA) Minnesota Environmental Response and Liability Act (MERLA) programs are established under the authority of State laws and adhere to Minnesota Statutes for Environmental Response and Liability (Minn. Stat. § 115B), and other applicable Minnesota statutory criteria, regulations, and policies. Applicable Minnesota Statutes include:

- **MERLA** (Minn. Stat. § 115B.01 through Minn. Stat. § 115B.20): An environmental law enacted in 1983 aimed at addressing contamination and pollution issues within Minnesota in order to safeguard human health and the environment. It establishes the MPCA as the regulatory authority overseeing the application of MERLA and grants MPCA the authority to respond to releases or threatened releases of hazardous substances, conduct investigations, and oversee cleanup efforts Minn. Stat. § 115B.02, subd. 3a return land to economic or other beneficial use. To implement MERLA, the MPCA established the Minnesota's State Superfund program, which identifies, if possible, the responsible party (RP) for the contamination of sites posing environmental risk to human health and the environment and works to achieve cleanup of those sites. A MERLA also has provisions for spills or releases of agricultural chemicals as defined by Minn. Stat. § 115B.02, subd. 3a. These provisions are administered by the Minnesota Department of Agriculture per Minn. Stat. § 115B.02, subd. 3 and not discussed further herein.
- **The Land Recycling Act** (Minn. Stat. § 115B.175): A MERLA was amended in 1992 to create MPCA's Voluntary Investigation and Cleanup Program, which encourages cleanup of contaminated land for reuse and provides conditions for non-responsible parties to conduct response actions at a site, potentially qualifying for liability protection.
- **Landfill Cleanup Program** (Minn. Stat. § 115B.39 through Minn. Stat. § 115B.445): Enacted in 1994, this statute allows the MPCA to monitor and manage certain mixed municipal solid waste landfills in perpetuity to protect human health and the environment. The MPCA's Closed Landfill Program (CLP) provides resources to manage closed landfills without using the complex legal-liability framework of the Superfund process. It provides guidelines and procedures for addressing contamination issues associated with landfills, ensuring the proper management of closed waste disposal sites that are eligible to enter the CLP.

Additional provisions under Minn. Stat. 115B address financial considerations associated with environmental response and compensation including:

- **Harmful Substance Compensation** (Minn. Stat. § 115B.25 through Minn. Stat. § 115B.37): Establishes mechanisms for compensating individuals or entities for damages resulting from harmful substance releases. Procedures for filing claims and eligibility criteria are outlined, indicating a potential financial recourse for those affected. Specific Statutes related to reimbursement may also play a role in addressing financial aspects tied to harmful substance releases.
- **Dry Cleaner Environmental Response and Reimbursement Law** (Minn. Stat. § 115B.47 through Minn. Stat. § 115B.53): Establishes a framework for responding to environmental contamination from dry cleaning operations. This law provides criteria to reimburse owners and operators of dry-cleaning facilities for the cost of soil, groundwater, and soil vapor contamination remediation and emphasizes the financial aspect in managing and mitigating the impacts of a hazardous substance.

A MERLA requirements align with Federal Superfund program laws governed by U.S. Environmental Protection Agency's (EPA's) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), federal regulations outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and federal authority under EPA's Resource Conservation and Recovery Act (RCRA) laws and regulations. Together, these rules and regulations provide the legal framework for managing contaminated sites and responding to releases or threatened releases of hazardous substances, allowing Minnesota the flexibility to implement goals in a manner tailored to local needs and conditions.

1.1 MPCA programs under MERLA authority

The MPCA Remediation Division works to protect human health and the environment by managing contaminated sites and responding to releases or threatened releases of hazardous substances. The MPCA Remediation Division oversees the investigation and cleanup of contaminated sites and evaluates risks from the identified contamination, with the goal of fully understanding contamination and its sources and applying best management practices to protect human health and the environment. For more information see the MPCA's Remediation Division General Policy (c-rem2-03).

The MPCA Remediation Division administers various programs and processes operating within the framework of MERLA to address releases and threatened releases of hazardous substances or pollutants and contaminants. Typically, investigation and cleanup of contaminated or potentially contaminated sites is overseen by the appropriate program based on the type of site and whether there is a party responsible for the release or threatened release. Key programs relevant to MERLA within the MPCA Remediation Division include:

- **Site Assessment program**: The Site Assessment program (Site Assessment) evaluates initial reports of hazardous substance, pollutant, or contaminant releases; conducts risk assessment to determine actual and/or potential exposures; and may identify the presence of potential RPs. Site Assessment receives Minnesota Duty Officer reports, referrals from other regulatory programs, and citizen complaints – evaluating existing site data to determine the level of risk from the site to nearby receptors and determining whether MPCA resources should be used to assess exposure risk to human health and/or ecological receptors. When observed conditions indicate that an exposure threat is present, State resources are allocated to complete necessary site investigations or response actions to reduce those risks. Site Assessment may also conduct further investigation before a site is referred to other MPCA Remediation Division programs or added to the federal or State Superfund lists. Under Site Assessment, a site is assigned an SA# (Site Assessment ID #) and an MPCA Site Assessment project manager.
- **State Superfund program**: The State Superfund program (Superfund) oversees the investigation and cleanup of sites where there is a release or threatened release of a hazardous substance or pollutant or contaminant that poses an actual or potential threat to human health or the environment. Superfund oversees specific investigation and cleanup processes and identifies RPs as legally responsible for the cleanup. In addition, Superfund conducts investigations and conducts response actions at sites where no viable RP or potential RP exists. The investigation scope at a Superfund site includes defining the extent and magnitude of all contaminants associated with the release or threatened release in all environmental media and assessing the risk to receptors. A Superfund site encompasses the area of contamination and is not confined by property boundaries. Superfund sites may enter a formal hazard ranking process for possible addition to the State Superfund list (Minnesota Permanent List of Priorities, "PLP"), primarily to access funding when an RP is not available or is unwilling or unable to conduct the necessary site investigation and cleanup. Under Superfund, a site is assigned an SR# (Superfund Remediation ID #) and an MPCA Superfund project manager.
- **Voluntary Investigation and Cleanup Program:** The VIC Program provides technical assistance and liability assurance letters to non-RPs to promote investigation, cleanup, and redevelopment of property that is contaminated with hazardous substances. The VIC Program is a voluntary, fee-based program and one component of the MPCA Brownfield Program. The boundary of a VIC site is chosen by the voluntary party (VP) based on their area of interest. The investigation scope at a VIC site depends on the proposed actions and the type of assurance letter being requested, however, a VP must always investigate and manage risk related to their current or proposed actions at the site. A VIC site is closed when on-site risks are addressed or if the VP withdraws from the program. If unresolved on- or off-site risk remains, the site is referred to Site Assessment. Under VIC, a site is assigned a BF# (Brownfields site ID #) and a VIC project manager.
- **Resource Conservation and Recovery Act Remediation Program**: The RCRA Remediation Program regulates the investigation and cleanup of hazardous waste releases at facilities that treat, store, or dispose of hazardous wastes. This program follows processes described in MERLA, while adhering to

State and federal laws governing facilities engaged in hazardous waste operations, including Minn. R. 7045 and EPA's RCRA laws and regulations. Scenarios that typically fall under the oversight of the RCRA Remediation Program include cleanups at hazardous waste generator sites and sites where the release of hazardous waste occurred after 1980. Additionally, cleanups addressing releases of hazardous or solid waste at RCRA permitted treatment, storage, or disposal facilities are conducted under the RCRA Remediation Program, irrespective of when the release occurred. Under the RCRA Remediation Program, a site is assigned an MND# (EPA ID #) and a RCRA Remediation Program project manager.

- **Closed Landfill Program**: The Closed Landfill Program (CLP) oversees the investigation, remediation, and management of Minnesota's eligible closed landfills to address environmental impacts and protect surrounding areas. The CLP monitors and maintains closed mixed municipal solid waste (MSW) landfills that meet the eligibility requirements specified in Minn. Stat. § 115B.39. Before a qualified facility is accepted into the CLP, certain duties must be completed by the landfill owner/operator of the qualified facility and the State. Once these duties are fulfilled, a Notice of Compliance is issued to the owner/operator of the landfill and the MPCA is then responsible for long-term care of the qualified facility and the related environmental response actions. CLP continues to use the SW# (Solid Waste ID #) from the landfill permit for site ID once in CLP and a CLP project team consisting of an engineer, hydrologist, and land manager is assigned to the site.
- **Emergency Response Program**: The Emergency Response Program (ERP) addresses environmental emergencies and initial responses for all types of spills and releases by assessing impacts and coordinating response efforts to protect human health and the environment. While the ERP is not housed in the MPCA's Remediation Division, ERP follows MERLA processes where applicable. The ERP works with RPs and cleanup contractors to ensure spills are contained and cleaned up properly and assists local governments and businesses in preparing for environmental spills and emergencies. In situations where no RPs are identified, State Superfund dollars are used for the cleanup and stabilization of emergency conditions.

NOTE: The Petroleum Remediation Program oversees responses to releases from petroleum storage tanks under the Petroleum Tank Release Cleanup Act (Minn. Stat. § 115C) that are not regulated under MERLA. If contamination originating from a petroleum tank release is identified, including at a site in Site Assessment, Superfund, or ERP, contact MPCA staff to determine if the site should be referred to the Petroleum Remediation Program. For guidance related to investigation and cleanup of petroleum tank releases, see MPCA's Petroleum Cleanup Guidance webpage.

1.2 Legal responsibility

The MPCA recognizes that both responsible and non-responsible persons may be involved in environmental cleanups, each following a unique path based on the site-specific situation or program. Descriptions of the different types of investigating parties include:

- **Responsible Party**: Per Minn. Stat. § 115B.03, an RP is legally responsible for a release or threatened release of hazardous substances or pollutants or contaminants if certain statutory criteria are met. An RP is legally responsible for the investigation and cleanup of a contaminated site, including full characterization of all environmental releases for which they are responsible. Examples of RPs may include but are not limited to past and present owners and operators of the facility where a release occurred, persons who owned or possessed the hazardous substance and arranged for the disposal, treatment or transport of the hazardous substance, and persons who knowingly transported or disposed of hazardous substances in a manner contrary to law.

  An RP enrolls into Superfund through the e-Services portal by identifying as a potential RP for the release. If an RP is unwilling to take action and work with the MPCA under Superfund, then the MPCA may direct the investigation and cleanup through more formal actions. The MPCA may invite an RP to enroll in Superfund; issue a Request for Information (RFI) letter; issue a Commissioner's Notice letter outlining why they are considered an RP and MPCA's intent to list the site on the PLP; issue a Request

for Response Action (RFRA) specifying the work to be performed and a cleanup schedule for the site; and if necessary, issue a Determination of Inadequate Response to undertake the work and seek recovery of its costs from the RP. The MPCA will score and list the site on the PLP if MPCA is undertaking the work and may refer the site to the EPA for listing on the federal Superfund List (National Priorities List, "NPL"). If an RP agrees to undertake the cleanup, the MPCA and the RP may enter into a Consent Order, which is a legal agreement that describes actions the RP will take to clean up the site under MPCA oversight.

- **Cooperative Responsible Party**: A Cooperative Responsible Party (CRP) is an RP who enrolls in Superfund to undertake investigation and cleanup of their release or threatened release under MPCA oversight and is working cooperatively with MPCA. While the MPCA's expectations and requirements for the investigation and cleanup for a CRP remain the same as an RP, the administrative procedures and costs can be significantly streamlined. If a CRP ceases cooperation, the MPCA may initiate formal actions. An RP acting as a CRP enrolls into Superfund through the e-Services portal by identifying as a potential RP for the release and subsequentially working cooperatively with MPCA.
- **Unknown or unviable RP**: In cases where the RP is unknown, or when an RP is unable to conduct the necessary site investigation and cleanup, the MPCA may take on the role of conducting the necessary investigation and cleanup work. The MPCA conducts investigations and cleanups using State Superfund dollars to address the concerns associated with the site. To access funding, a site's risk is assessed using the Superfund Hazard Ranking System and the site is listed on the PLP, and potentially referred to the EPA for listing on the federal Superfund NPL. Simultaneously, the MPCA actively searches for potential RPs.
- **Voluntary Party**: Applicants enrolled in the VIC Program are referred to as voluntary parties (VPs) because they are not responsible for the identified contamination per Minn. Stat. § 115B.03. Instead, a VP will typically complete an investigation and cleanup in the context of a property transfer, refinance, or redevelopment project. A VP enrolls in the VIC Program through the e-Services portal by identifying as not responsible for the release. The VIC Program evaluates the potential RP status of the applicant before acceptance into the program. Once enrolled, a VP must investigate and manage risk related to their current or proposed actions on the site. If the VIC Program determines that an applicant is a potential RP, then they cannot enroll in the VIC Program.
- **RCRA Regulated Party**: RCRA Regulated Parties are subject to requirements under RCRA laws and regulations, including obtaining permits for hazardous waste management activities, maintaining compliance with waste management standards, and participating in cleanup efforts in accordance with RCRA. Typically, site investigations and response actions are performed under oversight of the RCRA Remediation Program.

2.0 MERLA remediation process overview

The remediation process is typically initiated with site discovery or notification to MPCA of possible releases of hazardous substances to the environment. Contaminated sites are discovered in a number of ways, such as from referrals from Minnesota Duty Officer reports, direct notification to MPCA, during environmental audits or construction, enrollment in an MPCA Brownfield Program, or if evidence of a release is traced back to a property (especially if there are impacts to drinking water, indoor air at private homes, or surface water). Sometimes, the MPCA re-opens previously closed sites for reevaluation based on updated or new knowledge regarding the extent of the release and potential impacts to receptors. After site discovery, the MPCA evaluates the potential for the release of hazardous substances to impact human health and the environment.

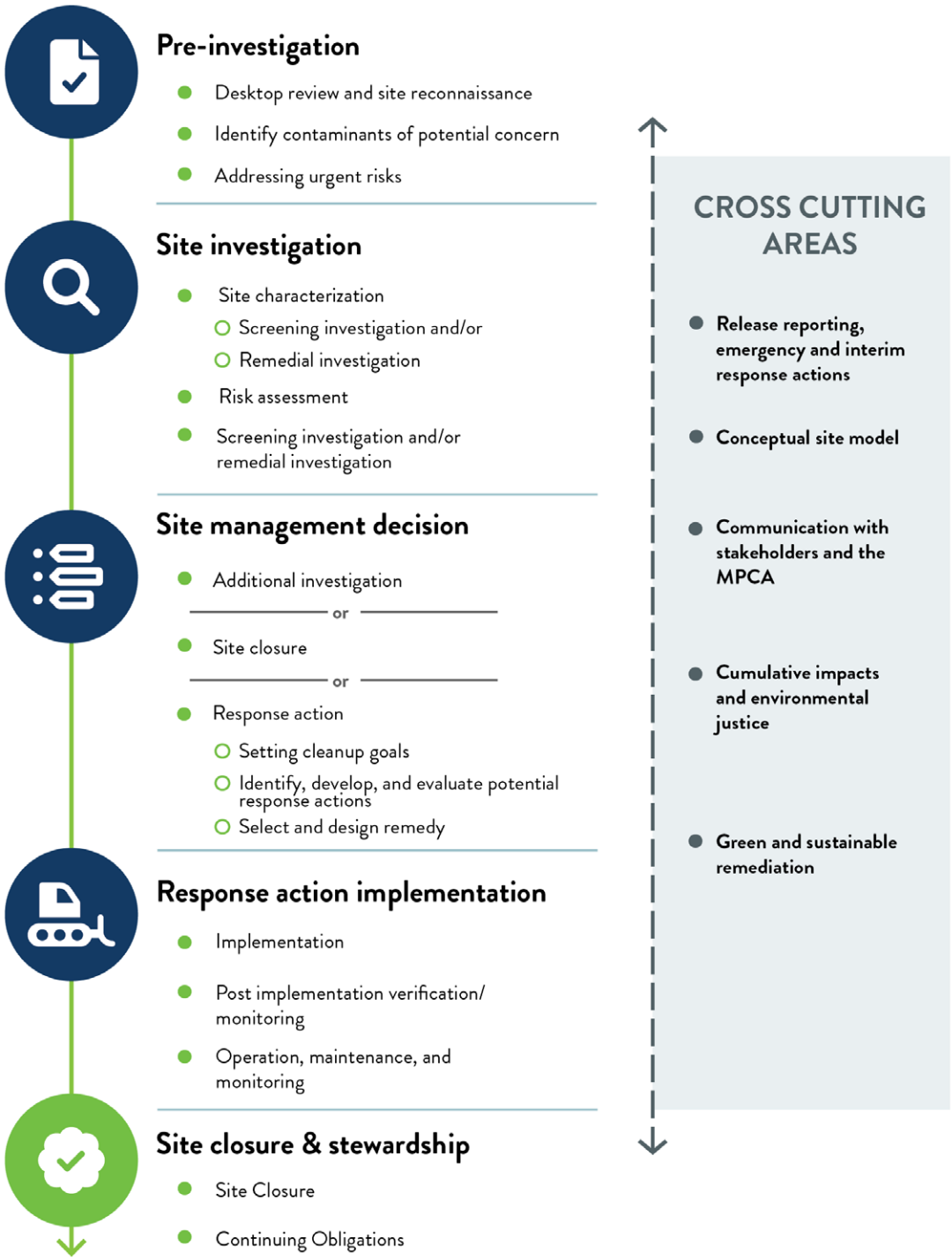
Contaminated sites progress through a remediation process. At some sites, this process is linear, while at most others the process is iterative (particularly when new issues emerge), and at some sites not every step is necessary. In every case the remediation process begins with a recognition that contamination does or could exist. This is followed by the evaluation of all relevant potential exposure pathways, gathering data from environmental media (including soil, groundwater, soil vapor, surface water, or sediment, as appropriate), to define the extent and magnitude of contamination. Based on this evaluation, the need for a response action is determined and then implemented, reducing contamination and exposure potential to an acceptable level based on proposed land use. The process ends with a decision that no additional work is needed based on current or planned conditions.

- **Federal Remediation Process under CERCLA:** The federal remediation approach is typically associated with CERCLA NPL sites led by the EPA (including sites where MPCA may serve as the lead agency) or more complex sites on the PLP. This approach involves a prescriptive decision-making processes, detailed regulatory requirements, and significant involvement of federal agencies. For more information on the traditional remediation approach, see EPA's Superfund Cleanup Process webpage.
- **Remediation Process under MERLA:** The MPCA allows for a more flexible process where a range of approaches can be used to expedite the investigation and cleanup of contaminated sites and where MERLA serves as the guiding framework for managing contamination at sites – emphasizing risk-based decision-making, stakeholder collaboration, and flexibility in selecting response actions. This process is dynamic, allowing for adaptability based on changing conditions and the evolving understanding of a site. It follows phases to identify the extent of contamination and apply best cleanup practices, leading to a more efficient and adaptable process. Below is a summary of the MERLA remediation process and its phases. Figure 1 illustrates an overview of the MERLA remediation process.
- **Pre-investigation:** The site has been recognized as a potential environmental problem and an initial understanding of the scale and scope of contamination is established. Cross-cutting areas start in this phase and are carried throughout, as necessary. Release reporting and emergency and interim response actions may be especially critical during the pre-investigation phase at some sites.
- **Site investigation:** The site is characterized, the extent and magnitude of contamination are defined, exposure pathways and receptors are determined, and the risks to human health and the environment are assessed and understood.
- **Site management decision:** The site investigation results are used to determine further steps, e.g., conduct additional investigations, close a site, or conduct response actions. If response actions are necessary, cleanup goals are established and remedies are identified, developed, and evaluated. This information is then used to select, design, and document a response action decision.
- **Response action implementation:** The selected response action is implemented, verified to be operating as designed, and tracked to determine when cleanup goals have been met and when the site is ready for closure. This phase often includes operation, maintenance, and monitoring (OM&M)

to ensure the response action continues to be effective for as long as it is necessary to protect human health and the environment.

- **Site closure and stewardship:** The site is closed once no additional work is needed based on the current conditions or planned site use. Closed sites may have continuing obligations such as institutional controls (ICs), contamination notices, land use restrictions, or ongoing OM&M to ensure that protectiveness goals continue to be met.

Figure 1 – Overview of the MERLA Remediation Process



NOTE: This is an iterative process. Not all sites will progress through each phase linearly. The process may skip stages or return to earlier stages based on the information gathered at each phase.

2.1 Cross-cutting areas

Cross-cutting areas should be considered during all phases of the MERLA remediation process.

2.1.1 Release reporting, emergency and interim response actions

Regardless of which phase a site is in during the MERLA remediation process, when a release, urgent risk, or emergency condition is identified, **it should be reported to the Minnesota Duty Officer at 651-649-5451 or 1-800-422-0798 as soon as possible**. Depending upon the urgency and hazard, the situation may need to be addressed immediately in coordination with the MPCA. There are two fundamental response types:

1. **Emergency response actions:** These actions are initiated when contamination or site conditions pose an imminent threat to human health or the environment, or when fast and effective response actions can minimize environmental and human impact. These actions may include immediate removal activities to stabilize or clean up threats swiftly to ensure public safety. The MPCA must be notified as soon as possible when emergency response actions are necessary. Examples of emergency response actions include immediate cleanup of recent spills or releases, providing bottled water, or point-of-use potable water treatment when drinking water supplies have been impacted. Emergency response actions are typically managed initially by the ERP, and, in most cases, the ERP will be the site lead for the duration of the emergency. The ERP's role primarily involves advising and overseeing cleanup performed by RPs or CRPs. Additional guidance on emergency response actions is located on the MPCA's ERP Spill Cleanup Policy (c-er4-13).
2. **Interim response actions:** These actions should be implemented when site conditions pose risks to human health or the environment and expedited measures can reduce those risks in advance of a final response action selection. Interim response actions cover a broad range of measures to control, minimize, eliminate threats, or mitigate exposure pathways. Examples of interim response actions include implementing engineering controls such as: ventilating a building or installing a sub-slab depressurization system soon after vapor intrusion risks are identified; installing restricted access fencing or a temporary impermeable cap to limit direct exposure to impacted soil; excavation or source area removal; installing a recovery/extraction system to remove non-aqueous phase liquid (NAPL) and reduce the contaminant migration; as well as preparing the ICs required to formally and legally document and maintain them. Interim response actions are important for reducing risk in a timely manner, sometimes reducing the overall cost of future investigation or response actions. These actions should be consistent with final remedies and, in some cases, may evolve into a final response action, which underscores the importance of selecting actions that meet response action performance standards.

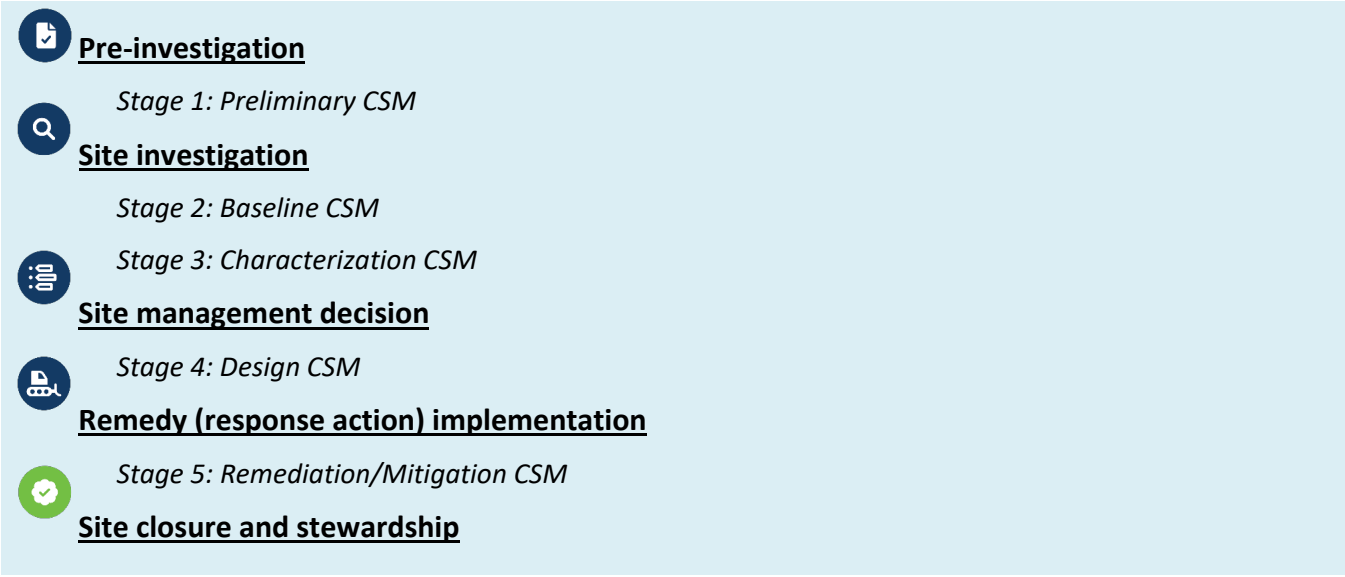
See **Section 5.3** for additional information on conducting response actions and for response action expectations. Emergency or interim response actions should be documented in an Interim Remedial/Response Action Implementation Report. Completion of emergency or interim response actions indicates that the known urgent or imminent risks have been prevented, even though not all risks or the final cleanup goals may have been attained and the full extent of contamination may not be defined. A complete site investigation is still required to determine if further response actions are necessary.

2.1.2 Conceptual site model

A CSM uses written and graphical representations to summarize the current understanding of the physical setting; past, current, and intended property use; potential release areas and sources; contaminant media, fate, and transport; potential exposure pathways; potential receptors; decision criteria; technologies and approaches; and completion strategy. In other words, a CSM serves as a framework that integrates information about the release and the site's geology, hydrogeology, chemistry, and other relevant factors to identify where the contamination is, how it is behaving, who or what might be impacted now and in the future, and the framework and strategy for site completion. The CSM provides the basis for assessing risk and making site management decisions. The MPCA uses EPA's Effective Use of the Project Life Cycle CSM fact sheet for creating and refining

CSMs. **Figure 2** identifies the six stages where the project life cycle CSM that should be developed iteratively throughout the MERLA remediation process.

Figure 2 – EPA's Six Stages of the Project Life Cycle CSM



Each CSM life cycle stage is described in detail in the applicable sections of this document.

The CSM plays a crucial role in risk-based decision-making at each stage of the remediation process. The phase of the project and the adequacy of the existing CSM and project data will indicate what CSM stage is most appropriate. As each phase of the MERLA remediation process is completed, the CSM should be updated to reflect new information. The CSM becomes increasingly quantitative as its utility for decision-making shifts from identifying areas for investigation to establishing response action effectiveness. Later, the CSM becomes progressively more complex as it incorporates additional information and leads towards an appropriate site management decision. If response actions are conducted, the CSM provides the framework necessary to ensure that the response action is implemented properly and continues to be effective for as long as necessary.

2.1.3 Communication with stakeholders and the MPCA

Communication includes promptly providing information to appropriate stakeholders about potential health risks, areas where investigations are planned or underway, and remedies which are being maintained. It is important to identify who will need to receive information and who will lead communication efforts. The MPCA expects proactive and consistent communication between MPCA project staff; investigating parties or their environmental contractors; residents, business owners, or adjacent property owners; and local and State agencies.

The remediation process can be lengthy and time-consuming; therefore, effective and proactive communication should be used to build trust and promote cooperation between all stakeholders, particularly when indoor air or drinking water supplies may be impacted. Regardless of the complexity of the site, regular communication between all involved parties is encouraged to ensure that all pertinent site concerns are addressed. Discuss communication expectations with the MPCA project staff at all stages.

- **Emergency Response:** In addition to notifying the Minnesota Duty Officer, MPCA project staff must be notified as soon as possible when urgent or imminent risks are identified. In the event that emergency or interim responses are warranted, stakeholders must be notified promptly. State resources may be provided to answer community questions (e.g., health communication with the Minnesota Department of Health [MDH]) and additional communication should be led by MPCA and its representatives.

- **Pre-investigation:** Present information on the known site conditions, potential options for risk reduction, and the anticipated decision-making processes that will follow to the MPCA and relevant stakeholders. Oftentimes, communication at this stage is conducted via reporting.
- **Site investigation:** The MPCA may assist in obtaining access agreements as needed with property owners and occupants. Stakeholders and the MPCA should be made aware of the planned investigation activities and, when warranted, should be provided an opportunity to participate or provide comments during the planning process. Communication should evolve based on the input from stakeholders and the MPCA and on investigation results.
- **Site management decision:** If response actions are required, the MPCA will determine if and when community notification or request for public comment will occur. Public communication at this stage can have substantive impacts to the success of the project; therefore, the MPCA should direct the method, frequency, and content of communication. The MPCA recommends that a summary of past and present work be provided to pertinent stakeholders. Response action evaluation must also consider if any ICs are needed to maintain the response action and which stakeholders must be involved. For sites on the PLP, Minn. Stat. § 115B.17 requires written notice and publication of the proposed response action before a final response action is selected, and the public must be provided an opportunity to submit comments. In some cases (such as for non-PLP sites and RCRA permitted facilities), a public notice period may be beneficial.
- **Response action implementation:** Provide stakeholders with information about the site and the selected response action, including the rationale behind the selection, the response actions being taken, any OM&M work planned, or additional protective measures that are necessary such as ICs. The MPCA will help determine the stakeholder notifications necessary regarding project timelines, scheduled work, and modifications to the response action design prior to and during implementation. Work with stakeholders and the public on accommodating construction activities and providing information on potential impacts to the community during implementation.
- **Site closure and stewardship:** The MPCA will ensure stakeholders are informed of site closure and continuing obligations, when necessary. In some circumstances, the MPCA will provide a site-specific summary of what the problem was, what the solutions have been, and the data to support site closure. Sites with remaining contamination may require ICs to ensure current and future property owners are notified.

Throughout the entirety of the remediation process, ensure that communication is transparent, and information is accessible to stakeholders and the public. Ensure that translation and interpretation services are available if a non-English speaking community or stakeholders are identified. If further translation assistance is required, the MPCA can assist in coordinating services.

- **MPCA Communication Updates**: The MPCA project staff will update relevant webpages (e.g., What's in my Neighborhood, Minnesota Groundwater Contamination Atlas, or MN Geospatial Commons IC webpages). Additionally, Superfund project staff will document the specific date of key milestones of each MERLA remediation phase. These milestones include: the start date for receiving applications, notifications, or registrations; the date for completing assessments; the date for completing site investigations; the date for selecting a response action; the date for implementing the response; the date for deciding that no further action is needed; and the end date for closing the site.

2.1.4 Cumulative impacts and environmental justice

Cumulative impacts refer to the potential human health and environmental effects from combined pollutant exposures from various sources and media. Focusing on cumulative impacts will enhance the MPCA's efforts to decrease inequity and target the most impactful sources of pollution. *Environmental justice (EJ)* refers to the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

The State legislature has tasked the MPCA to identify, develop, and implement strategies to eliminate and reverse environmental and health inequities and disparities in EJ areas by enforcing a cumulative impacts law. These EJ areas are the focal points for developing cumulative impact analysis criteria and processes for some air permit decisions. Draft rule is scheduled for publication by May 18, 2026. For additional information see MPCA's Cumulative Impacts webpage.

The primary goal of the MPCA's EJ framework is to identify and address disproportionate impacts on lower income Minnesotans and people of color and to ensure communities have opportunities for meaningful involvement in the decision-making process that impacts them. Studies from across the country and the MPCA's data indicate that people of color and those in lower-income areas face disproportionate risk from environmental pollution as well as other non-pollutant stressors. The Minnesota State legislature has defined an EJ area of concern as a census tract that meets at least one of the following criteria:

- 40% or more of the population is non-white.
- 35% or more of the households have an income at or below 200% of poverty.
- 40% or more of the population over the age of five has limited English proficiency.
- Located within Indian Tribal Lands.

These criteria are used for cumulative impact rulemaking throughout the State to identify EJ areas of concern. The MPCA's interactive EJ map should be reviewed, and site plans should clearly state whether a site is in an EJ area. If a site is in an EJ area, MPCA staff should be engaged to ensure proper communication, outreach, and consideration are applied at the site. For additional information, the MPCA's Environmental Justice Framework (p-gen5-05) lays out strategies for equitable decision-making.

2.1.5 Green and sustainable remediation

The role of green and sustainable remediation (GSR) is to increase sustainability and minimize environmental impacts from contaminated site management and cleanup while maintaining the overall protection of human health and the environment. A GSR is the site-specific use of products, processes, and technologies that mitigate risks to receptors while making decisions that are cognizant of environmental, social, and economic impacts. It is important to understand any community sustainability goals and values concerning a site, and how they relate to land use and development issues. The MPCA encourages the use of GSR during investigation and cleanup of contaminated sites. A GSR considerations can add value to a project or community. These actions align with core initiatives to address climate change, sustainability, increase resilience, prioritize cumulative impacts analysis, and promote EJ.

The greatest benefit of using GSR processes and techniques is realized by employing them early in a project and maintaining them where possible. If GSR goals have not yet been identified for the site, the remediation process should use the CSM to identify appropriate GSR goals. Once the GSR goals are established, a GSR evaluation may be performed that integrates GSR results with the CSM. At no point in the evaluation should the risk to receptors be undermined or manipulated to lessen the protectiveness of the remediation to accommodate GSR techniques. If the results of the GSR evaluation conflict with existing guidance or policy, that guidance or program-specific policy supersedes GSR evaluation results. A GSR is not a means of justifying no action or justifying less remediation. For additional information regarding details on planning, implementation and evaluation, and reporting refer to the MPCA's Green and Sustainable Remediation (c-rem3-30).

2.2 Documentation and reporting

Because there are multiple MPCA Remediation Division programs, each adhering to its own guidance and set of rules or policies, documentation and reporting procedures at each phase of the MERLA remediation process may differ. **Figure 3** illustrates the relationship among various MPCA Remediation programs and the typical reporting document used at each phase. Note, while the RCRA Remediation Program follows the MERLA remediation process, its reporting benchmarks more closely follow the CERCLA structure. Additionally, sites under the oversight of the CLP do not follow a typical reporting process, and as such are not included in the figure below. Refer to **Appendix A** for a printable version of this figure.

Figure 3 – Typical Reporting Documents per Remediation Phase

Federal Remediation Process	Federal Superfund Program (CERCLA)	RCRA Remediation Program	MERLA Remediation Phase	Site Assessment	Superfund	VIC
Site Assessment	•Preliminary Assessment/Site Inspection •*NPL Site Listing** •*No Further Remedial Actions Planned (NFRAP)**	•RCRA Facility Assessment (RFA)	**Pre-Investigation**	•Site Summary Report •Investigation Summary Report •*Listing on PLP*** •*Enrollment in Superfund***	•Phase I Environmental Site Assessment (ESA) •*Listing on PLP*** •*Enrollment in Superfund***	•Phase I ESA
Site Characterization	•Remedial Investigation/ Feasibility Study	•RCRA Facility Investigation (RFI) •Corrective Measures Study (CMS)	**Site Investigation**		•Phase II ESA •Remedial Investigation (RI)	•Phase II ESA
Remedy Decisions	•Proposed Plan •Record of Decision	•Statement of Basis •Final Decision and Response to Comments	**Site Management Decision**		•Feasibility Study (FS) •Remedial/Response Action Plan (RAP) •Minnesota Decision Document (MDD) •Remedial Design •Construction Contingency Plan (CCP)	•RAP •CCP
Remedial Design/Remedial Action	•Design documents and work plans •Remedial Action Implementation Report •Construction Completion Report •Monitoring and Verification Reports	•Corrective Measures Implementation (CMI) Report	**Response Action Implementation**	N/A	•RAP Implementation Report •Operation, Maintenance, & Monitoring (OM&M) Plan •OM&M Report	•RAP Implementation Report •OM&M Plan •OM&M Report
Post-Construction Completion	•Closure Memorandum •*Deletion from NPL**	•RCRA Corrective Action Completion Determination	**Site Closure and Stewardship**	•Site Assessment Risk-Based Closure Form	•No Action (NA) / No Further Action (NFA) Letter •*Delisting from PLP**	•Various assurance letters for closure

** Item is not considered a document, but rather an event.*

***Item is an event that may occur during any remediation phase.*

Figure does not include all potential planning documents that may be required.

Discuss reporting requirements with the MPCA project manager to clarify what is required for a particular site.

Documentation and reporting are essential for ensuring transparency, regulatory adherence, and effective communication with the MPCA and stakeholders. While specific documentation and reporting requirements may differ for each program, the typical elements of each report are described in the subsections below. References to other MPCA Remediation Division guidance for reporting requirements on specific documents is also available at MPCA's Cleanup guidance and assistance webpage.

2.2.1 Pre-investigation documents and reports (and the programs they apply to)

Site Summary Report (Site Assessment) – A Site Summary Report compiles essential information about a site into a comprehensive overview of a site's operational history, geographic, geologic, and hydrogeologic setting, potential environmental concerns, and key findings from previous assessments or investigations historically conducted at a site.

Investigation Summary Report (Site Assessment) – An Investigation Summary Report compiles the results and key findings of recent site investigations or sampling events conducted at a site to present a clear summary of the known information, including data collected, potential risks identified, investigation conclusions, and any recommendations for further action.

Phase I Environmental Site Assessment (Superfund, VIC) – A Phase I Environmental Site Assessment (ESA) is typically conducted for environmental due diligence during real estate transactions to assess if current or historical property uses may have impacted the environment and could pose risks to human health or the environment. To obtain protection from potential liability under CERCLA as an innocent landowner, contiguous property owner, or bona fide prospective purchaser, "all appropriate inquiries" must be conducted in compliance with the ASTM International Standard E1527-21 for Phase I ESAs, or the current standard. It involves site inspections, historical research, interviews, regulatory reviews, and document reviews to identify *recognized environmental conditions*. If these concerns are identified, a recommendation for further assessment (e.g., a Phase II ESA) is often included. A Phase I ESA is a required step for a VP applying to the VIC Program and for a CRP enrolling in the Superfund Program. Under both programs, a comprehensive review and reporting of current and past property uses, ownership, and operational activities is necessary to provide evidence relating to the likelihood and potential sources of a release, exposure pathways, and potential risks to receptors. The MPCA Brownfield Program has developed Phase I ESA Report for Brownfield Program enrollment (c-brwnfld4-03) which provides information about how to prepare a Phase I ESA that meets the needs of the Brownfield Program. These same elements along with additional project site-specific information needs are also required for Phase I ESAs at Superfund sites.

RCRA Facilities Assessment (RCRA Remediation Program) – A RCRA Facility Assessment (RFA) is a document used to identify releases or potential releases requiring further investigation at facilities subject to RCRA. The three components of the RFA are a file reviews, visual inspections, and sampling events. Typically, the RFA is conducted by MPCA staff or by an EPA contractor to identify the release areas (referred to as solid waste management units and areas of concern), and to evaluate their potential to release hazardous wastes or constituents.

2.2.2 Site-investigation documents and reports

Phase II Environmental Site Assessment (Superfund, VIC) – A Phase II ESA is typically conducted in response to findings from a Phase I ESA associated with property transfer and due diligence investigations. A Phase II ESA involves sampling of soil, water, or air to confirm the presence and/or extent of contamination. The results, interpreted in a report, provide information for making informed decisions about site cleanup or redevelopment. The ASTM International standard E1903-19, or the current standard, provides guidance on conducting a Phase II ESA to determine the presence of and potential risks associated with contamination at a site. A complete Phase II ESA typically requires more than one mobilization. The initial sampling effort is often intended as a screening investigation to determine if a release has occurred and determine if emergency/interim actions are necessary. Further investigation to define the extent and magnitude of identified releases at a site are typically reported in a Phase II Addendum or supplemental investigation report (for VIC) or a Remedial Investigation Report (for Superfund).

Remedial Investigation (Superfund) – A Remedial Investigation (RI) fully characterizes the site, defines the nature and extent of contamination, identifies current and future exposure pathways and receptors, and assesses the risk to human health and the environment. An RI is a comprehensive investigation of a site specifically geared towards developing a remediation plan for addressing identified contamination. It provides a thorough assessment of the extent and magnitude of contamination in all media at the site and presents data collected through analysis of soil, water, air, and other relevant media samples. The data collected is used to identify and estimate or quantify risks to human health and the environment, which are used to determine whether response actions are necessary.

RCRA Facility Investigation (RCRA Remediation Program) – The results from the RFA determine if a RCRA Facility Investigation (RFI) is necessary. A RFI is conducted by the owners or operators with technical oversight and approval by MPCA to determine the nature and extent of releases of hazardous wastes or hazardous constituents from regulated units, solid waste management units, and other source areas at a hazardous waste generator site and to gather all necessary data to support the environmental indicator determinations. A RFI involves investigations, sampling, and analysis aiding in the development of evaluating human health and/or ecological impacts of contamination.

2.2.3 Site management decision documents and reports

Feasibility Study (Superfund) – The purpose of a Feasibility Study (FS) is to develop, screen, and evaluate potential response actions to provide adequate information to inform selection of a response action for the site and ultimately obtain MPCA approval of the proposed remedy. A site may present multiple potential response actions and an FS is structured to assess these alternatives based on technical feasibility, effectiveness, and potential impacts of each response action, considering factors such as cost, ability to implement, and community acceptance, as discussed in **Section 5.3.3.** The FS encompasses the initial development of cleanup goals, an assessment of remedial technologies, and outlines elements for each considered alternative. Stakeholder input may be included. Proposed remedies presented in a FS are typically modified and redeveloped several times before a response action is accepted. When necessary, additional activities such as treatability studies and pilot studies, may be included in the FS. A focused-feasibility study (FFS) may be used when considering only one response action or two versions of one response action, or in very simple cases a FS may not be needed. Alternatively, a more detailed FS that is similar to the EPA's feasibility study process under CERCLA may be necessary at more complex or NPL and PLP sites.

Remedial/Response Action Plan (Superfund, VIC) – The purpose of a Remedial/Response Action Plan (RAP) is to provide details of the proposed response actions and describe how they will be conducted. It outlines specific steps and activities that will be taken to implement the response action, such as the methods and technologies to be used during the cleanup process, how the effectiveness of the response action will be evaluated, and how contaminated materials will be managed. The RAP includes a defined schedule with milestones and deadlines for the response actions. The RAP references a separate Health and Safety Plan for workers involved in the response action activities. Additionally, the RAP may address site restoration/closure, the need for an IC, and the need for future submittal of an OM&M Plan. For sites enrolled in the VIC Program, the guidance document Brownfield Program Response Action Plans (c-rem4-43) provides additional information on the expected content of a RAP.

At some Superfund sites (e.g., where there are community concerns or where more than one remedial alternative is evaluated), completion of a FS prior to the RAP is necessary in order to document the rationale of the selected response action. At simpler Superfund sites (where only one response action is evaluated), the RAP documents the response action evaluation considerations without the need for a FS. **Minnesota Decision Document (Superfund)** – Superfund sites listed on the PLP may have a Minnesota Decision Document (MDD) prepared by the MPCA to help document the final response action decision for addressing contamination at the site. The MDD is prepared after the remedial alternatives are evaluated and a final response action is selected and approved. A MDD may be used to MPCA fulfil the requirement of Minn. Stat. § 115B.17, subd 2.b to provide written notice to the public and provide an opportunity for submission of comments on the proposed remedial

actions when State Superfund dollars are being used. A MDD may also be used for sites when State Remediation Fund dollars are not being used to help document decisions.

Remedial Design (Superfund) – A Remedial Design is the design and implementation plan prepared after a response action has been selected when the remedy design(s) cannot be fully described in a RAP. It encompasses the detailed planning and engineering specifications necessary for the implementation of response actions. The remedial design provides specific details regarding how the response actions will be executed, translating the RAP into practical and technical terms. It may include components such as specifications for equipment, materials, and construction methods, accompanied by illustrative drawings and diagrams. It incorporates protocols and procedures necessary to ensure the effectiveness of the response actions, including the appropriate planning documents for post-implementation verification and monitoring and a submission schedule for future documents (e.g., RAP Implementation Report, OM&M Plan, OM&M Report, and IC documentation). The Remedial Design is often used as the basis for preparing project specification and contractor bid solicitation documents.

Construction Contingency Plan (Superfund, VIC) – A Construction Contingency Plan (CCP) is developed to anticipate and address unforeseen events or uncertainties that might arise. A CCP acknowledges the difficulty in fully characterizing or identifying all contamination at a site before construction activities or RAP implementation. It acknowledges the potential for unexpected challenges, and as a result, provides instructions and contacts for on-site contractors in the event of encountering a potential risk or uncertainty. A CCP addresses various potential situations (such as the unexpected discovery of an underground storage tank, buried debris, or contaminated soil), when to notify a qualified person to evaluate the situation, health and safety considerations, waste handling, and sampling and analysis. A CCP may be a stand-alone document, or it may be a component of a RAP.

Corrective Measures Study (RCRA Remediation Program) – If warranted by the results of the RFI, a Corrective Measures Study (CMS) determines feasible alternatives for the removal, containment, treatment and/or other remediation of the contamination based on the objectives established for the corrective action.

Statement of Basis (RCRA Remediation Program) – The Statement of Basis is prepared by the MPCA as part of the public notice package to document the evaluation of remedial alternatives and set forth the preferred RCRA corrective action. In the case of a CMS for hazardous waste generator sites, public notice is not required for the MPCA staff to issue approval.

Final Decision and Response to Comments (RCRA Remediation Program) – This document finalizes cleanup decisions and addresses public comments received during the decision-making process.

2.2.4 Response action implementation documents and reports

RAP Implementation Report (Superfund, VIC) – A RAP Implementation Report provides documentation of all implementation work performed and enables the MPCA staff to evaluate whether the response actions have been satisfactorily completed. It includes an explanation of how the response action was executed, describes the various tasks and activities that were undertaken to implement the response action (such as contaminated media disposal), presents results to demonstrate that cleanup goals have been achieved and the response actions are effective (such as verification sampling and monitoring), and if site restoration is complete. Site delisting or the issuance of assurance letters is contingent upon the MPCA staff approval and confirmation of the completion of the response action. If it is determined that the response action is incomplete, MPCA will notify the investigating party of the deficiencies needing correction. It also describes the future plans, tasks and monitoring activities necessary to ensure the response action continues to perform as intended. The RAP Implementation Report includes by reference or as a separate attachment the various documents (e.g., Construction Completion Report, Excavation Report, Monitoring Report, System Verification Report, Interim RAP Implementation Report, or OM&M Plan).

Operation, Maintenance, and Monitoring Plan (Superfund, VIC) – An Operation, Maintenance, and Monitoring (OM&M) Plan describes the activities that will be conducted after a response action has been implemented to ensure the response action continues to perform as intended and remains protective of human health and the

environment. An OM&M Plans provide details of the routine operational and maintenance requirements, monitoring of the response action (e.g., treatment system monitoring, aquifer chemistry monitoring, etc.) immediate- to long-term monitoring of impacted media, emergency response and shut-down procedures, record-keeping templates, and decision-making criteria, and include a completion schedule for all associated activities, record keeping, and reporting. An OM&M Plan may also describe activities for documenting, inspecting, and maintaining ICs as well as any other long-term activities associated with response action operation. A draft OM&M Plan may be required when submitting a RAP or Remedial Design document. The final OM&M Plan should be submitted to the MPCA for review and approval in a timely manner following the completion of response actions and may be included as part of the RAP Implementation Report or submitted separately.

Operation, Maintenance and Monitoring Reports (Superfund, VIC) – An OM&M Report documents the ongoing activities associated with a response action and provides data on the implemented response action's performance over time. The OM&M Report provides an opportunity for identifying and recording changes at the site, updating the CSM, and assessing or reassessing the remedies to ensure receptors remain protected from unacceptable risk. This report plays an important role in the response action implementation and stewardship phases, ensuring that remedies continue to perform as intended while providing an opportunity to evaluate and optimize remedies when appropriate. Through ongoing documentation, the OM&M Report contributes to the overall goals of ensuring human health and the environment are protected, stakeholders are informed, and remedies are effective in terms of cost, performance, and sustainability. Common types of OM&M Reports include Annual Monitoring Reports, Field Monitoring Reports, Monitoring Reports, or Progress Reports.

Corrective Measures Implementation Report (RCRA Remediation Program) – The CMI Report documents the implemented corrective measures and provides an overview of the design, construction, operation, maintenance, and monitoring of the corrective measure. The CMI Report also includes a summary of the daily inspection reports, inspection data sheets, and documentation of deviations from design and material specifications.

2.2.5 Site closure documents and reports

Site Assessment Risk-Based Closure form (Site Assessment) – A Site Assessment Risk-Based Closure form is a document used to formally assess and document the closure of a site that has been subject to contamination. The form typically includes information on the Site Assessment process, the risks identified, and the measures taken to mitigate these risks to acceptable levels. A Site Assessment Risk-Based Closure Form may be issued by MPCA staff after unacceptable risk has been addressed through investigations and response actions, when the site is referred to another Remediation Division program, or when a previously unknown or unviable RP is identified and invited to enroll in Superfund.

No Action / No Further Action Letter (Superfund, VIC) – No Action (NA) Letters and No Further Action (NFA) Letters are available when the MPCA concludes that the extent and magnitude of the release has been defined per program requirements and that the identified contamination does not pose a risk to human health or the environment, given the current or proposed property use. A NA Letter may be issued when no response actions are necessary. A NFA Letter may be issued after response actions have successfully managed risk to human health and the environment. These letters state that the MPCA will take no action (or no further action) with regard to a specific identified release of contaminants. Each incorporates standard disclaimers, including a reopener clause if new information is received or if risk-based values or site conditions change. In Superfund, a NA/NFA Letter is the only assurance letter available to RPs and CRPs.

Various Assurance Letters (VIC) – Other additional types of closure letters and/or liability assurance letters besides NA/NFA Letters are available for a VP when on-site risk has been addressed. Refer to Brownfield Program Services (c-brwnfld4-01), for a description of letters available through the VIC Program.

RCRA Corrective Action Completion Determination (RCRA Remediation Program) – Once the corrective actions are completed and applicable changes are made to facility permits, correspondence is sent to a RCRA Regulated

Party indicating the successful completion of corrective actions and that the remediation goals have been achieved to hazardous waste generator sites.

2.3 Work Plans and other planning documents

Planning is important to ensure the effectiveness of a project and maintain processes consistent with MERLA requirements. A clear set of project-specific objectives is needed in all project planning documents. To determine the appropriate planning documents necessary, consult with the MPCA project manager. The MPCA project manager will review the project details, regulatory requirements, and site-specific considerations to provide guidance on the necessary planning documents. For sites enrolled in Superfund or the RCRA Remediation Program, the MPCA requires planning documents to be submitted and approved prior to beginning work to ensure programmatic consistency. Undertaking work with the appropriate and approved planning document in place provides the investigating party with confidence that the MPCA is in general concurrence and that the amount of work is appropriate to meet objectives. Any work conducted at a Superfund or RCRA Remediation Program site without MPCA-approval may be at the investigating party's own risk. For the VIC Program, review and approval of a work plan is less common but available upon request or may be required in specific circumstances.

Investigation Work Plan (Site Assessment, Superfund, VIC, RCRA Remediation Program) – An Investigation Work Plan outlines the overall investigation, sampling, and data evaluation strategies to ensure the investigation is well thought-out and capable of meeting the site objectives. Typically, the Investigation Work Plan provides the background details, goals, and objectives of a site, identifies the regulatory framework and stakeholders, and provides detail on the proposed activities and methods that will be used including the drilling methods, subcontractors, budget, and schedule. It may include supporting elements such as a ***Sampling and Analysis Plan (SAP)*** that provides the technical details for field work by defining the sampling and data-gathering methods to be used; a ***Quality Assurance Project Plan (QAPP)*** that describes the policy, organization, functional activities, and QA/QC protocols; the ***data quality objectives (DQOs)*** necessary for ensuring the data collected are of the expected quality for their desired use; and/or a ***Health and Safety Plan (HASP)*** that supports workers involved in the field effort. A standalone SAP or QAPP may also be needed – consult with MPCA staff to determine planning document requirements. Media- and contaminant-specific guidance available in **Appendix B** should be used to ensure these processes are conducted appropriately, considering the unique characteristics of each environmental media and contaminant and providing a structured approach and enhancing stakeholder confidence.

Sampling and Analysis Plan (Superfund) – A SAP is a document that can be developed to guide the collection of data at locations of concern, particularly those associated with storage, potential use, or releases of contaminants. SAPs encompass procedures, methods, and laboratory specifications, sometimes integrated into the broader Work Plan. The SAP provides additional technical detail and specific procedures to address the project objectives including investigation and sampling strategy and rationale, detailed descriptions of all procedures, preservation and handling of samples, lab and lab methods and detections levels. SAPs are recommended for Superfund sites and should be submitted for MPCA review and approval prior to beginning site investigations, especially in cases where NFA Determinations are being sought. Guidance on SAPs is available on the EPA's SAP Guidance and Template webpage.

Quality Assurance Project Plan (Superfund) – A QAPP is a comprehensive QA/QC document that covers not only sampling and analysis, but the development, collection, and analysis of all other data. It documents the planning, implementation, and assessment procedures for a particular project, as well as any specific quality assurance and quality control activity. It integrates all the technical quality aspects of a project in order to provide a blueprint for obtaining the type and quality of environmental data and information needed for a specific decision or use. Additional information on QAPP development can be found at MPCA's Quality Assurance Project Plan Guidance (p-eao2-13) and EPA's Quality Assurance Project Plan Standard. In the future the MPCA plans to introduce a Remediation Division -specific Quality Assurance Program Plans to outline minimum data quality requirements for the Remediation Division. Minimum required QC sampling criteria are

also located at the MPCA's Laboratory Quality Control and Data Policy (p-eao2-09a), but note that some projects may have project-specific QC requirements beyond those outlined.

Data Quality Objectives (Site Assessment, Superfund, VIC RCRA Remediation Program, CLP) – Data Quality Objectives (DQOs) are qualitative and quantitative statements that specify the objective of a proposed project, define the most appropriate type of data to collect, determine the appropriate conditions for data collection, and establish acceptable decision error limits that specify the quantity and quality of data needed for decision-making. DQOs ensure that environmental data collected is of adequate quality and quantity to support intended assessment or regulatory decisions, and, when necessary, legally defensible. It is recommended to establish and reevaluate DQOs for each phase of the remediation process, as every project is unique, and the DQO process should yield project-specific objectives. For additional information of the DQO process, see the MPCA's Data Quality Objectives (p-eao2-14) and the MPCA's Quality Management Plan (p-eao2-15).

Health and Safety Plan (Site Assessment, Superfund, VIC RCRA Remediation Program, CLP) – A Health and Safety Plan (HASP) is a site-specific document outlining the health and safety procedures all contractors and subcontractors will follow while on-site. The HASP also documents the appropriate level of health and safety training required for all contractors and subcontractors and must comply with all applicable State and federal laws and regulations. A HASP is prepared by the contractor working on the site and is submitted to the MPCA project manager for documentation only.

3.0 Pre-investigation

MERLA Remediation phase	Site assessment	Superfund	VIC
Pre-Investigation	•Site Summary Report •Investigation Summary Report •*Listing on PLP*** •*Enrollment in Superfund***	•Phase I Environmental Site Assessment (ESA) •*Listing on the PLP*** •*Enrollment in Superfund***	•Phase I ESA

** Item is not considered a document, but rather an event.*

***Item is an event that may occur during any remediation phase.*

In the pre-investigation phase, sites are assessed to determine if a release has or is likely to have occurred, establish an initial understanding of the scale and scope of contamination, and, if possible, determine the potential risk that contamination poses to human health or the environment. The pre-investigation phase lays the groundwork for the subsequent phases of the MERLA remediation process, ensuring that actions are well-informed. It guides the site evaluation strategy by identifying priority sampling areas, the location and type of sampling and analysis necessary, and the need for emergency or interim response actions. The pre-investigation includes the following:

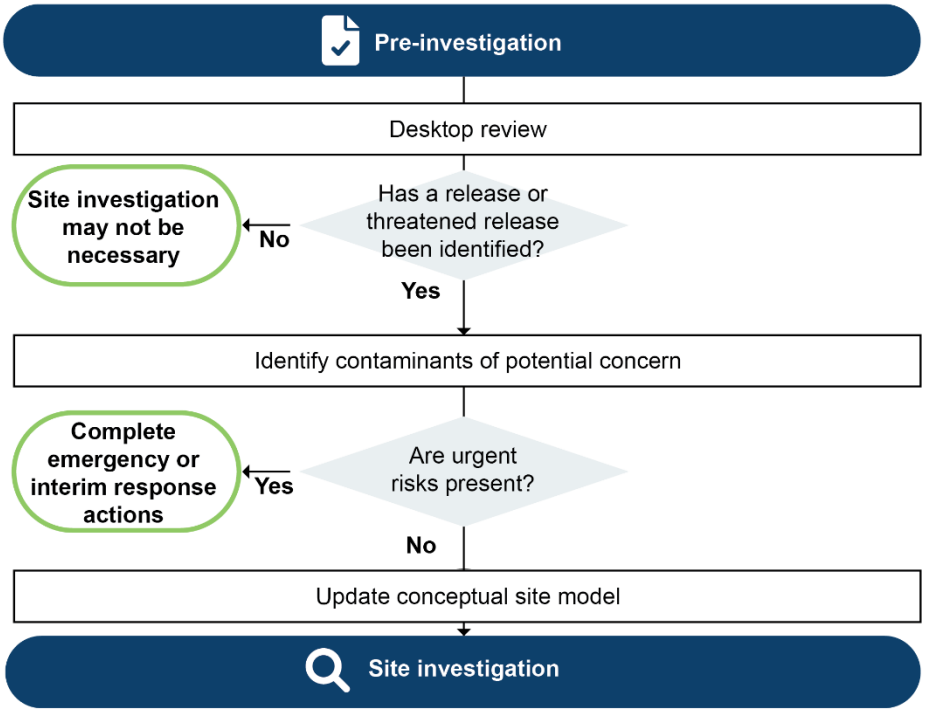
- Desktop reviews and a site reconnaissance to evaluate whether the site may pose a threat to human health and the environment and to observe the conditions at the property.
- Identification of contaminants of potential concern (COPCs) to assess whether a release may have occurred.
- Identification of urgent risks, and an initial evaluation of their potential exposure pathways or potential receptors to determine if significant contamination is present that may require release reporting, emergency and interim response actions.

Depending on the type of site, the source of contamination, and the specific MPCA program, the pre-investigation phase may also include:

- **Site Assessment:** Investigation Summary Reports which compile current results and key findings based on the known information about a site. Site Assessment may also conduct screening-level investigations, which are more limited in scope and are not intended to fully characterize the nature and extent of impacts associated with a site. These screening-level investigations are conducted to identify and evaluate whether a site poses a risk to receptors and to ascertain whether referral to another MPCA Remediation Division program is warranted.
- **Superfund:** Identifying RPs and informing them of cleanup requirements for the site, offering them an opportunity to enroll as a CRP. Superfund also collects information about the site that helps MPCA to evaluate the extent and magnitude of risks posed by the site using the Superfund Hazard Ranking System and decide if the site should be listed on the PLP. The Hazard Ranking System scores are used to establish relative priorities among sites and to determine a site's eligibility for state Remediation Fund dollars.
- VIC: See the guidance document Phase I ESA Report for Brownfield Program Enrollment (c-brwnfld4-03) for additional information.

Regardless of the program requirements, the pre-investigation phase will begin by evaluating current and past land use, existing site conditions and reports, and/or referrals related to releases or threatened release of contaminants. Pre-investigation activities are typically reported in the documents presented in the figure above. Follow-up work should be included in Phase I ESA updates or at the direction of MPCA project staff.

Figure 4 – Pre-investigation



3.1 Desktop reviews and site reconnaissance

The pre-investigation phase often begins by reviewing essential information about a potential release before investigation and remedial efforts begin. Desktop reviews are most commonly reported in a Phase I ESA or a Site Summary Report, which include an initial description of the site and its physical setting, identification of RECs or potential releases based on known information. They include descriptions of the historical and current site uses, the materials used and produced at the site, known or potential sources of contamination, and other relevant information which provide the initial data needed for the preliminary CSM stage.

CSM stage #1 – Preliminary CSM stage

The preliminary CSM stage is used as a foundation for compiling existing information, building stakeholder consensus, and identifying data for a comprehensive overview of a site in the early stages of assessment. It may not be possible to create a complete CSM based on the existing data available prior to beginning an assessment or investigation, however the CSM is necessary to identify data needs, understand the site, and to focus the investigation efforts.

- Primary data sources: Prior site reports; existing data; regional geologic/hydrogeologic information (physical setting); historical and regulatory records; aerial photographs; environmental databases; city directories; fire insurance maps; user/stakeholder interviews.
- Typical level of complexity: Low.
- Use in decision-making: Develop investigation strategy and assess priorities.

Later, the findings from the desktop review are further refined and validated through site investigations. The goal and outcome of the desktop review is to determine whether sampling may be necessary and inform the need for, scope, and design of the site investigation at the site.

3.2 Identify contaminants of potential concern

The process of determining specific COPCs relies on available site information regarding the typical types of releases associated with different industries. This will often include not just review of prior analytical data, but a review of the historical and/or current property use, site-specific operations, chemicals used, waste generated, safety data sheets, and other site-specific sources of information identified to determine what COPCs may be present. A site's current and historical use of COPCs and the proximity to other COPC sources should be evaluated to guide subsequent site investigations. For a general resource, see the Typical contaminants based on site use and processes (c-rem3-35) fact sheet for common site uses and related categories of potential contaminants. The table is not intended to be all inclusive, and it may not be relevant for every site. The EPA also maintains a list of Typical Wastes Generated By Industry Sectors.

The rationale for identifying or not identifying COPCs should be clearly documented. An understanding of Minnesota's regulatory screening criteria at this early stage can be particularly helpful for determining COPCs and other environmental media that are applicable to a site. This ensures potential risks are understood allowing for a comprehensive understanding of potential contaminants and the necessary precautions, leading to a more thorough site investigation.

3.3 Urgent risks

An urgent risk typically refers to a situation where the presence of a COPC poses the potential for an immediate hazard to human health or the environment, requiring immediate action to mitigate the threat. Urgent risks can arise from various factors, including:

- **Exposure:** Direct exposure to hazardous substances in soil, groundwater, sediment, or surface water can lead to acute health effects, such as poisoning or respiratory issues.
- **Migration:** COPCs migrating through soil or groundwater, potentially contaminating drinking water sources or sensitive ecological habitats.
- **Vapor intrusion:** Vapors from subsurface contamination infiltrating buildings, posing health risks to occupants.
- **Impacts on ecosystems:** COPCs harming wildlife, plants, and aquatic organisms, disrupting ecosystems and ecological processes.
- **Threats to public safety:** COPCs posing physical hazards, such as unstable structures or toxic fumes, endangering the safety of nearby communities.

Urgent risks might be apparent from visible signs during the site reconnaissance (e.g., odors, puddles, or leaking drums/tanks) or may be identified from the review of historical site information (e.g., previous environmental assessments, review of closed sites, or vapor intrusion data). Based on the initial site evaluation, identifying any urgent risks associated with COPCs as soon as reasonably possible is crucial. A follow-up site reconnaissance and a thorough review of potential exposure pathways and potential receptors (such as nearby water wells or buildings with vapor intrusion risks) must be conducted. Begin to conduct receptor evaluations as soon as urgent risks are identified and continue to consider risks to those receptors throughout the remediation process.

If urgent risks associated with the COPCs have been identified, the MPCA requires prompt initiation of site investigation activities including sampling of potential receptors that may be at risk in order to assess the extent of any significant contamination. The findings from these investigations will determine if immediate action is necessary and help guide the subsequent response actions at the site. If significant contamination is present, emergency and interim response actions should be implemented quickly; refer to **Section 2.1.1** for the required steps.

4.0 Site investigation

MERLA Remediation Phase	Site Assessment	Superfund	VIC
Site Investigation	N/A	•Phase II ESA •Remedial Investigation (RI)	•Phase II ESA

The site investigation phase consists of two primary components, **site characterization** and **risk assessment**.

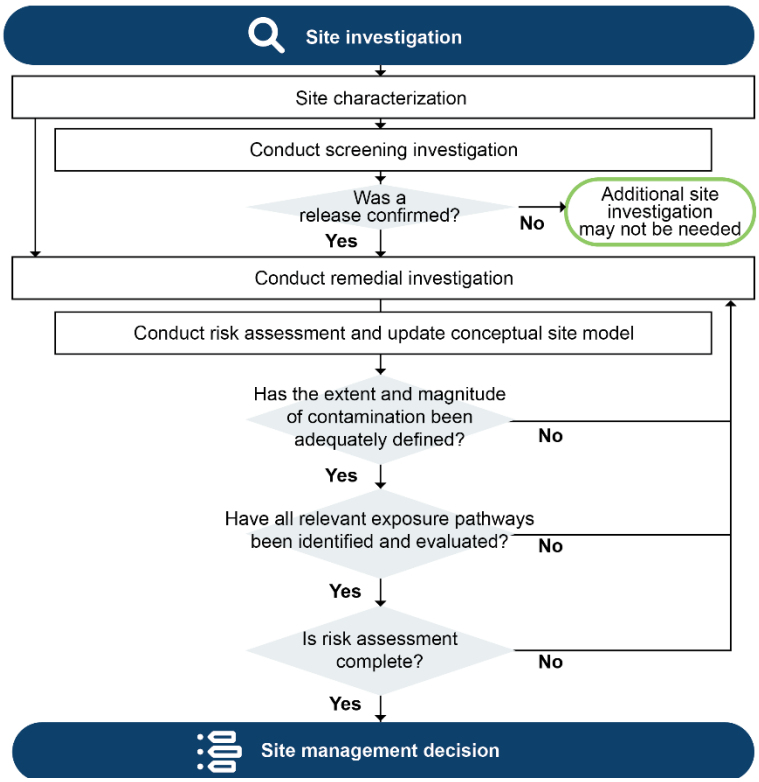
- **Site characterization:** Combines information from a variety of sources with the collection of data from environmental media (e.g., soil, groundwater, soil vapor, surface water, and sediment) to provide information about the site description, physical setting, nature and extent of contamination, receptors, and exposure pathways.
- **Risk Assessment:** Describes and estimates the risks that contaminants pose to human health and the environment. In a risk-based approach, response actions are driven by evaluating contaminated media, exposure pathways, and impacts to current and future receptors using a screening level risk evaluation or a site-specific risk assessment.

Site characterization should be conducted in a flexible approach where the data obtained from one step of the investigation are used as rationale and justification for subsequent steps. There are two types of site investigations:

1. **Screening investigation:** A screening investigation (often known as a Phase II ESA) is conducted to confirm whether a release has occurred and identifies the presence or absence of COPCs. The results of the screening investigation are used to determine what steps need to occur at the site by providing a preliminary estimate of the potential impacts to human health and the environment and identifying if urgent risks are present that may warrant interim or emergency response actions. For a VIC site, a thorough Phase II ESA (and possible Supplemental Phase II ESA) is typically adequate to complete the site investigation phase by identifying the nature and extent of contamination at the site, relevant exposure pathways, and unacceptable risks that warrant response actions relative to the proposed use or development of the property. For sites under Superfund, if the screening investigation identifies contaminants at concentrations exceeding their risk-based values (RBVs), then an RI is required. When additional characterization is needed, results of the screening investigation can inform the scope of the RI.
2. **Remedial investigation:** The RI is a comprehensive investigation of a site specifically geared towards developing a remediation plan for addressing identified contamination at Superfund sites. Investigating parties in Superfund are required to define the full extent and magnitude of contamination, develop a complete CSM, evaluate all potentially impacted media, and assess all risks for which they are responsible. Therefore, once a release has been confirmed, the RI must be completed to fully characterize releases to the environment, migration pathways, and potential receptors, and determine if unacceptable risk exists at the site. The RI should document the activities and results of the investigation and provide recommendations following the site management decision phase to either conduct additional investigation, complete response actions, or close the site. If unacceptable risks are identified, the RI should provide the basis for conducting the FS and/or developing a RAP to mitigate, remove, or reduce risk to an acceptable level.

Regardless of the type of site investigation being conducted, the site characterization and risk assessment components should always be addressed.

Figure 5 – Site investigation



Additional Considerations

An Investigation Work Plan should be prepared before beginning Superfund site investigations. The scope of a site investigation is determined based on information gathered in the pre-investigation phase, from previous investigations, and the overall objectives developed in the Investigation Work Plan. Contact the MPCA project manager to determine the type of investigation and the level of investigation necessary. It is recommended, and sometimes required, that investigating parties complete all appropriate planning documents (e.g., Investigation Work Plan, SAP, QAPP) and submit them to the MPCA project manager for approval prior to beginning an investigation.

The baseline CSM stage should be updated to identify key data gaps and included in planning documents to build stakeholder consensus.

CSM stage #2 – Baseline CSM stage

A baseline CSM is used as an improved and detailed revision of the preliminary CSM to summarize the initial evaluation, identify potential RPs, determine if site investigation is needed, define investigation objectives, and document stakeholder consensus. For many sites, a baseline CSM will be adequate to provide a basis for the planning effort.

- **Primary data sources**: Pre-investigation data; stakeholder input; technical analysis of potential data gaps, uncertainty, and site challenges.
- **Typical level of complexity**: Low to moderate.
- **Use in decision-making**: Provide initial evaluation; develop investigation strategy and planning.

After the field portion of an investigation is complete, the CSM should be updated and any significant data gaps or limitations should be identified along with recommendations for completing subsequent investigations, when appropriate. Refer to the EPA's Smart Scoping for Environmental Investigations Technical Guide for information on developing a robust CSM and scoping best practices.

4.1 Site characterization

Site characterization is focused on systematically gathering data to understand the environmental conditions and potential risks at a site. Building upon information from the pre-investigation phase, the site characterization serves as the basis for obtaining data and integrating information into a CSM that summarizes all pertinent information of a site's environmental conditions, contaminant sources, receptors, and pathways. The characterization CSM stage then provides the framework for conducting a risk assessment, selecting a response action, and engaging stakeholders.

CSM stage #3 – Characterization CSM stage

The goal of the characterization CSM stage is to provide a detailed understanding of the nature and extent of contamination and a thorough identification of receptors and exposure pathways. This CSM stage is used to support key site decision-making steps, such as determining if additional investigation is necessary or whether unacceptable risk exists.

When necessary, the characterization CSM stage may require an in-depth summary of site data to support tasks such as a complex exposure scenario assessment, remedy evaluation (i.e., FS or RAP), or preparation of a decision document (i.e., RAP).

- **Primary data sources:** Sampling and analysis of site media; profiling and modeling; geophysical surveys; human and ecological receptor surveys; high-resolution site characterization techniques.
- **Typical level of complexity:** High.
- **Use in decision-making:** Support risk assessment; determine need for response actions; select remedies; support stakeholder involvement and public communication.

Site characterization and the CSM are used to achieve the following objectives:

- Confirm whether a release has occurred, refine the COPCs.
- Define the location and mechanisms of all releases and magnitude and extent of all source areas.
- Evaluate the concentrations, physical and chemical nature, and horizontal and vertical extent of contamination.
- Identify receptors that may be at risk.
- Determine the exposure pathways and levels of exposure to site contaminants.
- When response actions are necessary, support the evaluation and selection of a response action.
- When response actions are complete, verify that cleanup goals have been achieved through post-implementation investigation or monitoring.

Site characterization may include a geological and/or hydrogeological assessment to identify soil types, groundwater flow patterns, aquifer properties, and potential pathways for contaminant migration, building upon the information obtained from a desktop review or hydrogeologic assessment. Site characterization includes the field screening, sampling, and laboratory analysis of environmental media (e.g., soil, groundwater, soil vapor, surface water, sediment, and air) to understand the distribution and movement of contaminants.

Data can be obtained through numerous methods, from low-cost field screening and field analytical methods to more robust laboratory analyses. The selection of appropriate analytical parameters should be based on whether a reasonable potential exists for a particular contaminant to be present at a site. The methods and parameters selected for an investigation should be based a variety of sources, such as historical data, land use data, visual or olfactory evidence of contamination, professional judgement, field screening data, or previously obtained data. The level of site characterization necessary will be based on the type of investigation being conducted and the potential risks associated with the site, among other unique considerations for a specific site. While a screening investigation may only provide a limited site characterization, this information may be

necessary to make site management decisions in a timely manner and communicate those decisions with stakeholders.

4.1.1 Site description

When this information is not already known from the pre-investigation phase, or additional relevant information may be obtainable, the site investigation should include the necessary activities to provide a complete description of the site, such as conducting additional interviews with former site operators or additional research of regulatory records.

The site description should provide an overview of the site's current and historical context, including the following:

- Land use and demography of site and surrounding area.
- Current and historical site operations and whether they have created or have the potential to create a release.
- Historical and current chemical storage, use management, and waste generation and disposal practices.
- Known hazardous substance releases and potential sources of hazardous substances.
- Location and extent of release and source areas.
- Extent of contamination and migration pathways.

4.1.2 Physical setting

Further information should build upon any general physical setting records identified during the pre-investigation phase to obtain a comprehensive understanding of a site's physical setting such as determining if the extent of contamination is adequately defined based on the site geology, or if exposure pathways are likely, based on site hydrogeology.

The physical setting should identify the following:

- Physical site characteristics
- Surface features (e.g., elevation, site and area topography, nearby surface water bodies)
- Soil stratigraphy
- Geology (e.g., depth to bedrock, bedrock type and sequence, the degree of weathering or fracturing)
- Hydrogeology (e.g., local and regional water tables, seasonal variation, hydraulic conductivity, effective porosity)

An emphasis should be added for identification of any potential sensitive conditions present which may require additional consideration, such as wellhead protection areas, shallow bedrock aquifers, sole-source aquifers, or shallow sand and gravel aquifers. Refer to the MPCA's Assessment of sensitive groundwater conditions (c-prp4-18) for definitions, reporting requirements, and investigation requirements. Note that this guidance is prepared under the Petroleum Remediation Program and may require additional consideration for sites under MERLA.

4.1.3 Nature and extent of contamination

Site investigations should identify a comprehensive understanding of contamination at a site at a given time, and include the following:

- **COPCs which includes all identified and suspected contaminants** based on site data as well as potential contaminants that may be present based on the site's historical context and knowledge of common co-contaminants.
- A **source assessment** on how and where releases occurred, whether they are from controlled areas of storage and transport, impacted media (e.g., soil, soil vapor, groundwater) and phase of contamination,

as well as the horizontal and vertical extent, contaminant mass, and volume for each release and source area.

- **Contaminant fate and transport** including dominant and potential migration pathways, and the changing nature of impacts (e.g., weathering, dissolution, degradation). Includes potential migration pathways in groundwater, overland flow, erosion, wind, and vapor migration.
- The **background concentrations**, which are anthropogenic or naturally occurring compounds present in the environment that are not related to a release at the site.

The screening investigation should determine whether a release has occurred (or is likely), the magnitude of contamination, the relevant COPCs, and whether the investigation has defined the extent of the release.

The RI must identify the full extent of the release in all media and provide information regarding the source, fate and transport, and background concentrations as appropriate to the objectives of the investigation. Identifying and understanding contaminant migration pathways is critical for identifying current and possible future receptors.

4.1.4 Identify receptors

Identifying receptors is a critical component of characterizing a site. The information in the sections above are evaluated together to identify the COPCs that may pose a risk to receptors. The below sections provide information used to determine the type and scope of receptor surveys that should be conducted based on site-specific considerations (e.g., contaminant mobility, likelihood of private water wells, or land use) to identify all potential receptors.

A receptor is a human; plant, animal, habitat, or ecosystem; or a groundwater or surface water resource, which can be adversely affected by exposure to environmental contaminants. In a risk-based approach, the identification of potential receptors is a key step to understanding the environmental hazards present, the risks they pose, and determining the need for a response action. The three primary receptor categories include:

- **Human Receptors**: Human receptors are individuals or groups of populations that may be exposed to COPCs (e.g., residents, workers, recreational users, sensitive populations, EJ communities, or any other human population present in the vicinity of a site).
- **Ecological Receptors:** Ecological receptors are living organisms or components of ecosystems that may be impacted by COPCs (e.g., plants, animals, microorganisms, or entire ecological communities).
- **Groundwater and Surface Water Resources:** which are protected under Minnesota statutes from pollution to maintain quality for a range of current and potential future beneficial uses.

Complete receptor surveys

Receptor surveys are assessments aimed at identifying and evaluating all potential human and ecological receptors within a specific area surrounding the release or extent of impacts. All potential receptors on- or off-site that may be exposed to site contamination should be identified by completing receptor surveys. Receptor surveys should also attempt to identify the most sensitive receptors that may be exposed in order to address any high-risk situations. Types of receptor surveys include:

- **Land use survey:** Aimed to identify current land uses at the site and within the specified radius of the site boundary such as residences, schools, childcare centers, other sensitive population. Understanding land use helps in assessing potential exposure pathways and risks to receptors.
- **Water well receptor survey:** Focuses on identifying water wells that may be at risk and provides information regarding the geology and groundwater use near the release site. This survey should prioritize sampling potentially impacted drinking water wells and municipal water supply wells as soon as reasonably possible.
- **Utility survey:** Involves identifying and mapping the depth of all subsurface utilities and structures that could serve as preferential migration pathways for contaminants. This information aids in understanding

commonly overlooked pathways, such as vapor intrusion pathways or water supply line permeation pathways.

- **Surface water and sediment survey:** Involves mapping the locations of surface water bodies and surface water features at sites where contaminants pose potential risks to surface water quality, such as when a release occurs in a shallow, permeable aquifer. It includes identifying pathways such as ditches, drain tiles, and storm sewers that may lead to surface water features.
- **Vapor receptor survey:** Involves identifying the location and type of nearby vapor receptors. This survey helps in assessing the potential risks associated with vapor intrusion into buildings or other structures.
- **Surface soil receptor survey:** Focuses on evaluating potential risks posed by contaminated soil in accessible and potentially accessible zones. It involves using exposure assumptions based on specific land use categories to describe different soil depths that a receptor is expected to access.
- **Ecological receptors survey:** Focuses on identifying environmentally sensitive organisms and natural resources present on or adjacent to the site. It aims to determine if contamination from the site may impact or has impacted ecological systems. It should be noted that ecological conditions can also influence human health outcomes.

Investigating parties are strongly encouraged to complete receptor surveys early during the site investigation phase to focus and prioritize sampling efforts. Information from these surveys is also a key driver to identify urgent risks in a timely manner and determine whether emergency or interim response actions are needed (refer to **Section 2.1.1** for additional information). Depending on the site-specific considerations, receptor surveys may be a required component of the site investigation. Investigating parties must complete receptor surveys to identify all on-site and off-site potential exposure pathways.

4.1.5 Identify exposure pathways

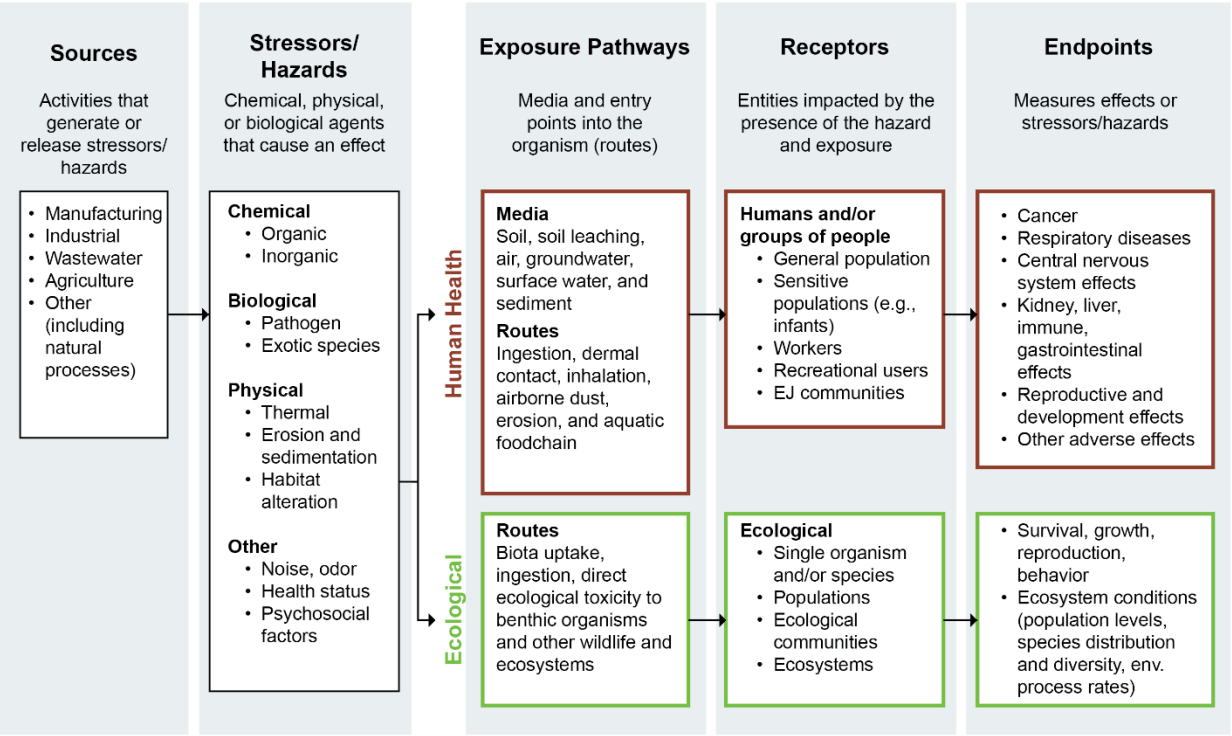
- An exposure pathway is a direct or indirect physical association between a contaminant originating from the site and a human or ecological receptor. Exposure pathways may be specific to the impacted media or contaminants present at a site. Identifying all potential exposure pathways is necessary to understand how contaminants may reach receptors and potentially cause harm.

Typical human and ecological exposure media and routes include the following:

- **Soil** – Ingestion, dermal contact, inhalation (via fugitive dust or volatilization to outdoor air), or direct ecological toxicity to plants, soil invertebrates, and wildlife (referred to as biota uptake).
- **Air** – Inhalation via vapor intrusion (indoor air or ambient air), airborne dust, or erosion of particulate matter (inhalation of indoor and outdoor air).
- **Groundwater** – Ingestion of drinking water, inhalation of water vapor, or dermal contact.
- **Surface water** – Ingestion of drinking water, aquatic food chain (fish consumption), incidental ingestion or inhalation during recreation activities, or dermal contact, or direct ecological toxicity to aquatic organisms and ecosystems.
- **Sediment** – Ingestion, dermal contact, inhalation, or direct ecological toxicity to benthic organisms and other aquatic wildlife and ecosystems.
    - All existing information and data about the site should be used to identify the potential exposure pathways that should be evaluated during the site investigation. The presence or likely presence of any preferential pathways that may exist and have significant impact on exposure pathways, such as underground utilities, buried former streambeds, or fractured bedrock, should be identified. In addition, the exposure pathway evaluation must consider current and future receptors as well as exposure pathways that may be created by a planned change in property use.

Figure 6, below, shows an example of how exposure pathway information can be integrated in the CSM to aid the process of identifying and summarizing exposure pathways. Additional examples of how receptor/exposure pathway information can be visually represented are provided in **Appendix C**.

Figure 6 – Generalized Conceptual Site Model



Note: Ecological conditions can also influence human health outcomes.

A MPCA guidance for exposure pathways is often specific to each media. Media- and contaminant-specific guidance should be used to ensure these processes are conducted appropriately, considering the unique characteristics of each environmental media and contaminant. Media-specific guidance is available in **Appendix B** and on MPCA's Cleanup guidance and assistance webpage.

4.1.6 Data gaps and limitations

Check for data gaps and address them before moving on to conducting the site risk assessment. Examples of data gaps include:

- Source of contamination not identified or defined.
- Extent of contamination is poorly defined or undefined.
- Analytical uncertainty.
- Preferential pathways that have not been assessed.
- Applicable site investigation reports should discuss any data gaps and recommend additional investigation/s required to address them.

4.2 Risk assessment

A risk assessment is conducted to identify and evaluate potential risks to human health and the environment to determine whether response actions are necessary. Essentially, the risk assessment answers the question: does unacceptable risk exist?

Risk assessments consist of the following:

- A **screening level risk evaluation** uses the results of the site characterization (e.g., nature and extent of contamination, potential receptors, and potential exposure pathways) to evaluate each exposure pathway and compare contaminant concentrations with applicable RBVs. The screening level risk

evaluation is the first step, and for many sites, may be the only step necessary to determine if response actions are warranted and establish cleanup levels, if necessary.

- A **site-specific risk assessment** often involves a more intensive investigation, analysis, and/or modeling and can be used to establish site-specific criteria when RBVs are not available or applicable, when complex exposure pathways exist, or when a more detailed evaluation is preferred. In some cases, site-specific RBVs may be developed based on site-specific exposure scenarios. An MPCA human health or ecological risk assessor must review and approve any site-specific or adjusted RBVs developed for a specific project site.

Risk assessments are typically conducted concurrently with site investigations and are reported in the site investigation report; however, risk assessments may be completed at any stage of the remediation process. Risk assessments must be based on valid assumptions and a sufficient quality and quantity of site data; therefore, thorough planning and implementation of the site characterization process is important. The risk assessment may require additional receptor surveying and sampling (e.g., from drinking water, indoor air, or surficial soil) after the site characterization is complete to resolve data gaps or uncertainties and establish a complete CSM.

4.2.1 Risk-based values

Risk-based values (RBVs) are concentrations of a contaminant in various media (e.g., soil groundwater, surface water, sediment, soil gas) that are not likely to result in an appreciable risk of harmful effects during a specific exposure duration (e.g., different land uses). RBVs include human health RBVs and ecological RBVs.

- *Human health RBVs* are derived using target or acceptable risk levels, which are most commonly a total or cumulative excess lifetime cancer risk not to exceed 1 in 100,000 (i.e., 1 x 10^{-5}) or a non-cancer chronic risk not to exceed a hazard quotient (HQ) of 1 per contaminant and a hazard index (HI) of 1 for multiple contaminants with similar health endpoints.
- *Ecological RBVs* consider the potential impacts of contaminants on plants, animals, and their habitats, species sensitivity, exposure pathways, bioaccumulation potential, and ecological significances, and are based on the levels of contaminants that ecosystems or specific species can tolerate without significant harm.

RBVs are developed by the MDH and the MPCA using established risk assessment methods and serve as benchmarks for regulatory and non-regulatory purposes. While RBVs themselves are not designed as cleanup levels, they inform the decision-making process related to remediation efforts, and may be used as cleanup levels or as a basis for risk management actions if deemed appropriate by risk managers.

Table 1 lists RBVs per media; refer to the link to values/tools for RBV derivation and application. Each category of RBV has a specific application and is intended to be used as an integrated piece of the overall risk assessment. RBVs are not available for all contaminants or media. In such cases, investigating parties should work in close coordination with the MPCA to determine if other strategies or values can be used, such as ambient background values or surrogate values, or if a site-specific risk assessment is necessary. Similarly, it may be appropriate to use the natural background value instead of the RBV if a chemical's RBV is less than a natural background value (e.g., areas where there are high levels of naturally occurring arsenic in soil).

Table 1 – Typical exposure media, pathways, and RBVs

Exposure media – Exposure route	Receptor	Risk-based values and other tools	Link to values/tools
Soil – Ingestion, dermal contact, inhalation (via fugitive dust or volatilization to outdoor air)	Human	Soil Reference Values (SRVs)	MPCA SRV spreadsheet (c-r1-06), SRV Technical Support Document (c-r1-05)

Exposure media – Exposure route	Receptor	Risk-based values and other tools	Link to values/tools
Soil Leaching – Protection of groundwater for ingestion	Human*	Soil Leaching Values (SLVs)	MPCA SLV spreadsheet and SLV guidance document
Air – Inhalation via vapor intrusion (indoor air or ambient air), airborne dust, erosion of particulate matter (inhalation of indoor air)	Human	Intrusion Screening Values (ISVs) or Expedited ISVs (EISVs)	MDH/MPCA ISV spreadsheet (aq1-36), ISV Technical Support Document (c-rem3-12), and Vapor BMPs (c-rem3-06e)
Air – airborne dust, erosion of particulate matter (inhalation of outdoor air)	Human	The MPCA/MDH Inhalation Health Benchmark Hierarchy	MPCA Ambient Air Toxicity Values which incorporate MDH Air Guidance Values, Air Emissions Risk Analysis (AERA) RASS spreadsheet, and MNRISKS
Groundwater – Ingestion of drinking water, inhalation of water vapor, dermal contact, and other commercial and industrial uses	Human*	Health Risk Limits (HRL), Health-Based Values (HBV), Risk Assessment Advice (RAA), or EPA Maximum Contaminant Levels (MCLs)	MDH Human Health-Based Water Guidance Table which incorporate EPA National
Surface Water – Ingestion of drinking water, inhalation of water vapor, dermal contact, aquatic food chain (fish consumption), incidental ingestion or inhalation during recreation activities, dermal contact, irrigation, and other commercial and industrial uses	Human*	Water Quality Standards (WQS) or site-specific Water Quality Criteria (WQC)	MPCA Surface water and sediment evaluation at remediation sites (c-rem3-31) and WQS in Minn. R. Ch. 7050 and Minn. R. Ch. 7052
Sediment – Ingestion, dermal contact, inhalation	Human	Site-specific values	MPCA Surface water and sediment evaluation at remediation sites (c-rem3-31)
Soil – Direct ecological toxicity to plants, soil invertebrates, and wildlife (biota uptake)	Ecological	Site-specific values	Derived on site-specific basis
Surface Water – Direct toxicity to aquatic organisms and ecosystems	Ecological	MPCA WQS or site-specific WQC	MPCA Surface water and sediment evaluation at remediation sites (c-rem3-31) and WQS in Minn. R. Ch. 7050 and Minn. R. Ch. 7052
Sediment – Direct toxicity to benthic organisms and other aquatic wildlife and ecosystems	Ecological	MPCA Sediment Quality Targets (SQTs)	MPCA Surface water and sediment evaluation at remediation sites (c-rem3-31) and SQTs (tdr-gl-04)

The EPA has established relevant values for various exposure media and route. For sites under oversight of EPA, consult these values directly from EPA resources.

** Groundwater and surface water resources must always be considered even if there are no primary receptors.*

4.2.2 Exposure pathway evaluation

Potential exposure pathways are evaluated once there is analytical data for a site to determine if a completed exposure pathway exists. Typical environmental media and exposure pathways are identified in **Table 1**. When potential receptors have been identified or when impacts to receptors have been confirmed (e.g., COPCs are present at concentrations exceeding RBVs in a drinking water well), the site investigation should assess the relevant exposure pathway between the source of contamination and the receptor in order to understand the fate and transport of COPCs at the site.

If a completed exposure pathway has been identified, the exposure pathway should be evaluated further to determine if unacceptable risks are present. Any new potential pathways not previously identified should be updated with the CSM as needed. Exposure pathways may be added or removed to the CSM accordingly, based on the results. An exposure pathway is considered complete if a receptor can come into contact with a site contaminant through a route of exposure, even if concentrations are below RBVs.

Figure 6, above, shows an example of how exposure pathway information can be integrated in the CSM to aid the process of identifying and summarizing exposure pathways. Additional examples of how receptor/exposure pathway information can be visually represented are provided in **Appendix C**.

4.2.3 Screening level risk evaluation

A screening level risk evaluation involves comparing site analytical data to the appropriate RBVs to determine whether a completed exposure pathway poses a risk to its receptors. Completed exposure pathway evaluations based on analytical detections should be refined to indicate which completed exposure pathways do not pose a risk according to the screening level risk evaluation. The CSM should be updated accordingly.

If contaminant levels are less than applicable RBVs and releases are defined, the site may not require further detailed assessment, mitigation, or remediation. When the exposure pathways and unacceptable risks can be adequately addressed with straightforward response actions (e.g., shallow soil excavation, installation of a sub-slab depressurization system), it may be cost-effective to proceed directly to response action selection to determine the appropriate response actions. Depending on the level of risks identified, it may be necessary to implement interim or emergency response actions to eliminate or reduce exposure in a timely manner (e.g., installing a vapor mitigation system as soon as possible when sub-slab sampling results exceed 33x EISVs). If a site scenario is more complex, a more detailed site-specific risk assessment may be necessary before determining the next steps (see the section below for situations that may require a site-specific risk assessment).

4.2.4 Site-specific risk assessment

Unlike screening level risk evaluations that use generic RBVs, site-specific risk assessments offer a more precise evaluation of risks by considering a site's unique physical setting, exposure pathways, and analytical data. This approach provides a quantitative estimate of actual or potential risk but is often more time consuming and may still rely on typical or conservative exposure scenarios or assumptions. Depending on the level of complexity at a site, a site-specific risk assessment may involve detailed toxicity and exposure assessments to determine the appropriate site management decision.

Site-specific risk assessments are most commonly conducted for soil, sediment, and surface water contamination and should be completed in accordance with the applicable media-specific guidance document listed in **Table 1**. Not all RBVs can be adjusted for site-specific situations (e.g., drinking or surface water standards, soil vapor ISVs). Situations that may require site-specific assessments include, but are not limited to:

- ✓ When RBVs are not available (e.g., sediment values are always site-specific, and not all contaminants have surface water standards and thus need site-specific surface water values to be created).
- ✓ When RBVs are not representative of risk at a site (this typically refers to soil; see the SRV Technical Support Document (c-r1-05)).
- ✓ When background concentrations of COPCs need to be evaluated.
- ✓ If it is more appropriate to use exposure areas to reflect exposure across a site rather than exposure points for risk evaluation. Exposure area concentrations can be calculated when there is sufficient sampling data from areas with similar contamination (e.g., using the 95% upper confidence limit of the mean to compare to SRVs). See the MPCA's SRV Technical Support Document (c-r1-05) for additional information.
- ✓ When multiple exposure pathways exist and therefore cumulative risk needs to be addressed.

- ✓ When unique exposure pathways exist.
- ✓ If remediating contaminated media may not be feasible or could result in significant ecosystem damages that out-weigh environmental benefits of potential response actions.
- ✓ If there is an inability to adequately control exposure or meet cleanup goals.

A site-specific risk assessment should be done in **consultation with MPCA Remediation and Environmental Analysis and Outcomes Division (EAO) staff**. All screening values, criteria, and site-specific data used must be reviewed and approved by the MPCA to ensure acceptability. The MPCA Remediation Division project staff should contact MPCA EAO staff when site-specific assessments arise using an internal request form.

Site-specific risk assessments often include one or more of the following aspects:

- **Consultation with MPCA staff** – Consult with the MPCA prior to proceeding with a site-specific assessment. MPCA staff provide guidance during the assessment process.
- **Data Collection** – Collection of additional data (e.g., more detailed site characterization). This may include sampling environmental media using targeted and/or probabilistic sampling methods to acquire detailed information that reflects the unique characteristics of the site.
- **Sampling expansion** – Increase sampling events and locations for situations where seasonal or other periodic effects make a difference and to fill in data gaps.
- **Analysis** – Use a more refined risk assessment process with assessments, models, and assumptions based on the particular conditions and exposure pathways of the site. This may require moderate modeling efforts and more thorough characterization of the potential receptors affected by the contaminated media. Useful resources include:
- **Interstate Technology Regulatory Council's (ITRC's)** forward risk calculation method webpage can be used to evaluate complex exposure pathways by facilitating calculation of single contaminant aggregated through multiple exposure pathways and cumulative risk (applies when there are multiple contaminants through multiple exposure pathways).
- EPA's Framework for Cumulative Risk Assessment document.
- **Toxicity Assessment** – Considers the adverse effects associated with contaminant exposure, the relationships between the magnitude of exposure and the adverse effects, and related uncertainties to determine toxicity values. The toxicity assessment involves hazard identification (determining whether exposure can cause an increase in adverse effects), and dose-response assessment (quantifying the relationship between the degree of exposure and incidence or severity of adverse effects).
- **Exposure Assessment** – Quantifies the magnitude, frequency, and duration of actual or potential exposure to contaminants. The exposure assessment follows the exposure pathway evaluation process described in Section 4.2.2 but may use site-specific data to develop site-specific exposure factors.
- **Modeling** – Advanced modeling of contaminant transport and fate used to support toxicity and exposure assessments. This may include the simulation of remediation scenarios and using Geographic Information System data for spatial analysis.
- **Stakeholder Engagement** – Active engagement with stakeholders, such as property owners, residents, and workers, to collect relevant information about exposures and provide transparent communication about risks and plans.
- **Uncertainty Analysis** – Uncertainty refers to the lack of knowledge of how well the calculated risk results represent the actual risks. Uncertainties are always present in the risk assessment process and happen for a variety of reasons, such as the inherent nature of risk calculations (which are typically based on generalized exposure scenarios and conditions), the quantity and quality of available site data, lack of knowledge of a site, and natural variability. An uncertainty analysis should be conducted during a site-specific risk assessment to identify the possible sources of uncertainty,

the impacts they have upon any conclusions, and whether those impacts are likely to lead to an over- or under-estimation of risk.

- **Outcome** – Determines whether risks are acceptable, where response actions are necessary, or whether additional data is needed to refine the assessment. Additionally, site-specific management plans may be developed at this stage. Submit the risk assessment and proposed outcome to the MPCA for review and approval prior to moving on with site work.

Sites where potential risks do not exceed acceptable target risk levels need no further investigation or response actions. However, if residual contamination is left in place, continuing obligations may be required to ensure risks are managed appropriately (See **Section 7.1** for additional information).

Sites where potential risks exceed acceptable target risk levels should proceed to developing cleanup goals and evaluating response actions. Completed exposure pathway evaluations should be refined to note which completed exposure pathways do not pose a risk based on results from the site-specific risk evaluation and the CSM should be updated accordingly.

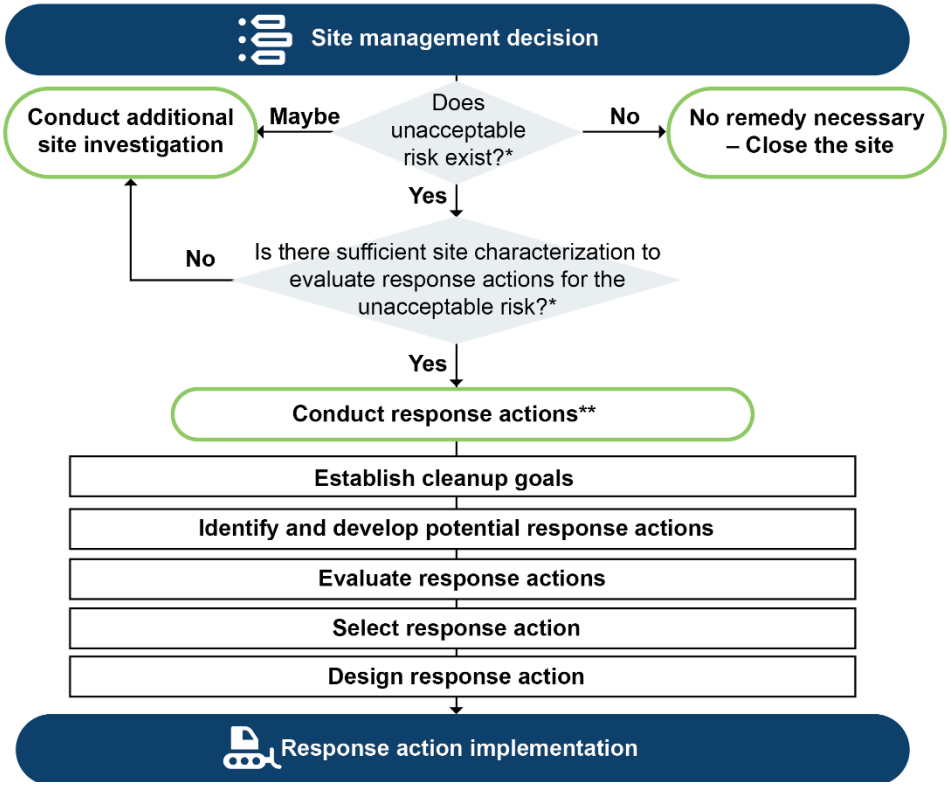
5.0 Site management decision

MERLA Remediation Phase	Site Assessment	Superfund	VIC
Site Management Decision	N/A	•Feasibility Study (FS) •Remedial/Response Action Plan (RAP) •Minnesota Decision Document (MDD) •Remedial Design •Construction Contingency Plan (CCP)	•RAP •CCP

Site management decisions follow a risk-based approach to identify the most appropriate course of action based on site-specific circumstances. A site management decision is made based on whether unacceptable risk exists at a site, which is determined through the risk assessment portion of a site investigation. Site management decisions may include **conducting additional investigation, closing a site**, or **conducting response actions**.

The objective of a site management decision is to protect human health and the environment, while considering the current and planned land use to facilitate the safe use or reuse of properties. Guidance on identifying land use, conducting investigations, and determining response actions for future risk management are provided in MPCA's Property Use Guidance (c-rem3-08). If urgent risks or emergency conditions are identified at any time, refer to **Section 2.1.1** for the required steps to determine if immediate or emergency response action is necessary.

Figure 7 – Site management decision



** Emergency and interim response actions are considered cross cutting areas and should be implemented to address imminent threat, or risk, respectively, to human health or the environment and/or when expedited response action can minimize risks in advance of final remedy selection. Emergency and interim response actions are not show on this figure for simplicity but should be performed as needed and do not need to wait for magnitude and extent to be fully characterized.*

*** Multiple unacceptable risks at a site (e.g., different media or COPCs, multiple impacted areas, etc.) might require multiple response actions which do not need to be conducted all at once. Only one response action is shown on this figure for simplicity.*

5.1 Conduct additional site investigation

If the site investigation phase reveals uncertainties, raises concerns about the extent or severity of contamination, or there is not enough data to make a well-informed site management decision, additional site investigation may be required. The decision to pursue additional investigation is often made to resolve significant data gaps, ensure that all potential risks have been thoroughly evaluated, or when the contaminated media is disturbed or land use changes.

The following questions should be considered when reviewing the findings from site investigations to determine if additional investigation is warranted:

- Is the CSM well understood?
- Are releases identified, eliminated, or controlled?
- Are source locations identified and characterized?
- Have all COPCs confirmed?
- Is the extent and magnitude of contamination adequately defined?
- Has the appropriate media been sampled?
- Have the investigation goals been met?
- Have all exposure pathways been identified and evaluated?
- Are the potential risks to human health and the environment understood?
- Is there sufficient data to select and implement response actions?

If the answer to any of these questions is "no," then additional investigation or monitoring is required before conducting response actions – circle back to the site investigation phase described in **Section 4.0**.

5.2 Close the site

The MPCA may consider a site for closure when it is determined that no unacceptable risk exists and no additional investigation, monitoring, or response actions are necessary to protect human health or the environment. If this is the case, proceed to the site closure and stewardship phase outlined in **Section 7.0**. Regular monitoring or periodic reviews may still be required as a continuing obligation to ensure those conditions remain protective over time.

5.3 Conduct response actions

If the site investigation identifies conditions where there is an unacceptable risk, then response actions are necessary to mitigate, remove, or reduce those risks to an acceptable level that will protect human health and the environment. The decision to conduct response actions involves establishing cleanup goals; identifying and developing potential remedial alternatives; evaluating remedial alternatives using threshold, balancing, and Minnesota criteria; proposing a response action that is most appropriate for the site and receiving MPCA approval of that response action; and designing a response action for the implementation phase. This process emphasizes risk-based decision-making, stakeholder collaboration, and flexibility in response options, leading to a more efficient and adaptable process.

Sites vary in terms of size, nature and extent of contamination, human health and ecological risks, physical conditions, and other pertinent factors, therefore, no two sites or remedies are the same. The MPCA allows for flexibility in the depth of evaluation, and breadth and number of remedial alternatives considered depending on site conditions (e.g., size, complexity, and uniqueness) to facilitate appropriate management of a contaminated site. Response action selection might follow a detailed response action evaluation process or a simple response action evaluation process, accordingly, as overviewed below**.**

- **Detailed response action evaluation process**: For complex sites, the MPCA may require a response action evaluation to develop, screen, and evaluate potential response actions in order to determine the most suitable strategy for a site. This process typically involves completing an FS to evaluate two or more potential remedial alternatives, or an FFS to evaluate one response action (or two versions of one response action), using threshold, balancing, and Minnesota criteria. When appropriate, the FS should be submitted to the MPCA and stakeholders for review and comment in order to address questions and resolve potential issues. Sometimes, the potential remedies presented in the FS are modified several times before a response action is chosen. Treatability or pilot studies may be required to evaluate the application of a response action. These studies may have a separate submittal after the FS or be reported within the FS. See EPA's Guidance for Conducting Treatability Studies under CERCLA webpage for additional information. Situations where a detailed response action evaluation process may apply include:
  - ✓ A large volume of contaminated material is present.
  - ✓ There are multiple property owners, RPs, and/or affected stakeholders.
  - ✓ There are multiple contaminated media types.
  - ✓ There are numerous contaminated areas.
  - ✓ The site has a complex lithology.
  - ✓ The site has complex technical issues.
  - ✓ There are land use issues or other community issues.
- **Simple response action evaluation process**: For other sites, response action evaluation may involve the proposal of a single or small set of commonly accepted response actions that meet MPCA requirements. At these sites, the RAP presents the proposed response actions and documents the response action evaluation considerations without the need for a separate FS. While proposing commonly accepted response actions may expedite the response action evaluation and MPCA review process, an appropriate level of site characterization is still required to assess whether site conditions fit criteria within the response action guidance. Situations where a simple response action evaluation process may apply include:
  - ✓ The proposed response actions are known to be effective
  - ✓ The volume of contaminated soil is low or targeted for removal for other purposes (e.g., geotechnical or construction)
  - ✓ The impacted area is small
  - ✓ There is a single or small number of RPs and primary stakeholders
  - ✓ RPs are in agreement on fully funding the response action
  - ✓ RPs own and control contaminated property where response actions will occur
  - ✓ Off-site migration is not occurring and off-site receptors are not impacted
  - ✓ The response actions are non-controversial and potential short-term impacts are not significant
  - ✓ The site does not involve significant community concerns
  - ✓ A small set of technologies are being considered and/or a treatability study is not required to determine potential feasibility
- **Federal remedy evaluation and selection process under CERCLA:** For sites following the federal remediation process under CERCLA, a more comprehensive response action (CERCLA uses the term remedy) evaluation following the traditional RI/FS process should be used. For more information, see EPA's Key Principles of Superfund Remedy Selection webpage. Situations where the federal remedy evaluation and selection process applies include:
  - ✓ State and federal Superfund sites that are listed on the NPL
  - ✓ Sites under the oversight of the EPA's Federal Superfund program or Department of Defense

- ✓ State-led or State-funded sites where the MPCA is conducting site investigations and cleanups because there is an unknown or unviable RP. In these cases, MPCA may follow the federal process more closely to maximize the opportunity for cost recovery from an RP at a future date.
- ✓ Sites where the MPCA uses its authority to issue a Determination of Inadequate Response or an RFRA.
- ✓ Sites where a party wishes to ensure their ability to pursue a cost recovery action under federal Superfund law

Regardless of the type of response action being considered, the MPCA must approve the final proposed response action prior to beginning implementation. Regular communication with MPCA project staff is required to ensure a response action is thoroughly evaluated and approved before being selected as the final response action.

5.3.1 Establish cleanup goals

Remedial/response action objectives (RAOs) and cleanup levels (collectively referred to as **cleanup goals**) are established to provide a clear and concise description of what the response actions should accomplish. Cleanup goals including the following:

- **RAOs:** These are broad objectives established to guide the remediation efforts at a site and determine when site conditions are protective of human health and the environment. Examples of RAOs include protecting the health of future residential occupants of a property from vapor intrusion risks or preventing contaminated groundwater from migrating outside the property boundary.
- **Cleanup Levels:** Cleanup levels are established to provide media- and contaminant-specific criteria that are necessary to achieve the RAOs for each exposure pathway and media. Cleanup levels should use specific, measurable, attainable, relevant, and time-bound goals to identify the media, concentrations, points of compliance, and remediation time frames. An example of a cleanup level is to reduce the concentration of lead and other COCs in soil to their respective residential SRVs within the next 12 months to allow for unrestricted use of the property or to reduce the concentration of trichloroethene and other chlorinated VOCs in soil within the source area to their respective site-specific SLVs within the next 18 months to minimize ongoing leaching to groundwater. In some cases, cleanup levels may be referred to as action levels, remedial goals, or preliminary remediation goals (PRGs).

Cleanup goals should be based on contaminants and impacted media; exposure pathways and receptors; and acceptable contaminant levels or ranges for each exposure pathway and media. Cleanup goals should be presented in the RAP or FS. Cleanup goals should be developed by considering the threshold, balancing, and Minnesota criteria, along with the current and planned property use, and the concerns of various stakeholders. The ITRC's Integrated DNAPL Site Strategy, while written for dense non-aqueous phase liquid (DNAPL) sites, provides additional guidance on establishing cleanup goals that are clear, concise, and measurable.

Ideally, the cleanup goals should result in the removal of contamination from all media as necessary for achieving unrestricted use and complete site closure. However, it is understood that achieving complete and permanent cleanup is not always feasible or practical. In these cases, the RBSE approach is used to define appropriate cleanup goals along with risk management actions that allow for residual contamination to remain in place while preventing unacceptable risks. The results from the site investigation should be considered during the response action evaluation to select the best response action for the site.

For VIC sites, the cleanup goals must address the current risk to receptors and the potential exposure pathways that will be created by the planned property use. Contaminated media that will be affected by development must also be characterized so that plans can be made for appropriately managing and disposing of these materials during site development. A VP may choose to conduct response actions over and above those required by a risk-based approach, to avoid an IC requirement or based on other business decisions.

5.3.2 Identify and develop potential remedies

The first step is to identify potential remedies based on the nature and extent of contamination and the cleanup goals for the site that correspond to the general response actions. Note, that achieving cleanup goals at a site may require more than one response action. **Table 2** provides a list of some common response actions by each environmental media.

Table 2 – Examples of common response actions by media

Soil and Soil vapor	Groundwater	Surface water	Sediment
Excavation and landfill disposal with / without treatment	Pump and treat systems	Capture and treatment from dewatering or remediation systems	Removal by hydraulic or mechanical dredging
Vapor barrier / vapor mitigation	Dual phase vacuum extraction and treatment	Capture and treatment from excavation before discharge	Biological/chemical treatment
Soil vapor extraction / soil venting	Air sparging	Surface water or groundwater flow diversion	Thin cover placement or residual cover
Engineered cap/cover/physical barrier	Engineered cap/cover	Engineered cap/cover	Engineered cap
Containment around source area	Containment (e.g., slurry wall, tight sheeting)	Containment around source area	Carbon amendments
Natural attenuation	Monitored natural attenuation	Constructed wetland	Monitored Natural Recovery
In situ chemical/biological treatment	In situ biological / chemical treatment	Erosion and sediment runoff prevention	Enhanced Monitored Natural Recovery
On-site, ex situ thermal/biological treatment	Rock fracturing and enhanced groundwater collection (with appropriate treatment)	Cut-off wall or flow barrier upgradient of source	Immobilization treatment
Soil washing	Funnel-and-gate technology	Groundwater gradient control or plume capture	
Soil flushing	In-well aeration		

Although this list is not complete, it demonstrates the wide range of response actions available for each media.

The MPCA encourages evaluation of a range of different types of remedies that can achieve cleanup goals. Sites with fewer number of contaminants or impacted media may have fewer potential response actions to consider. Additional media- and contaminant-specific response action considerations presented in **Appendix B**, and response action technology resources presented in **Appendix D**, can be used to identify potential remedies. Conduct independent research to identify current applicable technologies.

A response action must be developed based on the RAOs and the site-specific details documented in the CSM. The following factors and expectations must be considered for development of an appropriate response action:

- **Protectiveness** – Is the response action protective of human health and the environment?
- **Source removal** – Preference for removal of source material to achieve a more permanent cleanup.
- **Treatment** – Preference for treatment for detoxification or destruction of contaminants and minimizing cross-media contamination.
- **Engineering controls** – Use of engineering controls to address long-term lower-level risks.
- **Combine treatment and controls** – Use of a combination of treatment and engineering controls.
- **Restore groundwater** – Restore groundwater to beneficial uses wherever practicable.

- **Cleanup goals** – is the response action reasonably able to meet the cleanup goals within the target timeframe?
- **Innovative technologies** – Consider using innovative technologies whenever site conditions are suitable.
- **Continuing obligations** – Consider all possible ongoing obligations and future restrictions associated with a response action, including contamination notice, ICs, land use restrictions, or OM&M.

Institutional controls: An IC is a legal or administrative measure that is imposed on a property to protect cleanup work and prevent exposure to residual contamination. An IC provides information that helps guide behavior on the property and may limit how the land or its resources can be used. At a minimum, these controls may be used to provide notice to future property owners regarding the environmental conditions that exist at the site. An IC may also restrict certain activities at the site, such as disturbing contaminated soil at depth or extracting groundwater, or may require certain actions, such as maintaining clean soil buffers or ongoing operation and maintenance of a groundwater treatment or vapor mitigation system.

An IC is not intended to be the sole remedy at a site, but rather part of a larger response action to protect human health and the environment. The MPCA will continue to prefer response actions that eliminate or reduce the need for ICs, where possible.

Response action selection should consider whether an IC would be necessary for the site based on the proposed response actions and whether the property owner is willing to abide by the restrictions and affirmative obligations required by the IC. If an IC is part of a response action, due to the use of engineering controls to limit or prevent exposure, an evaluation of the potential for the control or monitoring mechanism to fail must be considered.

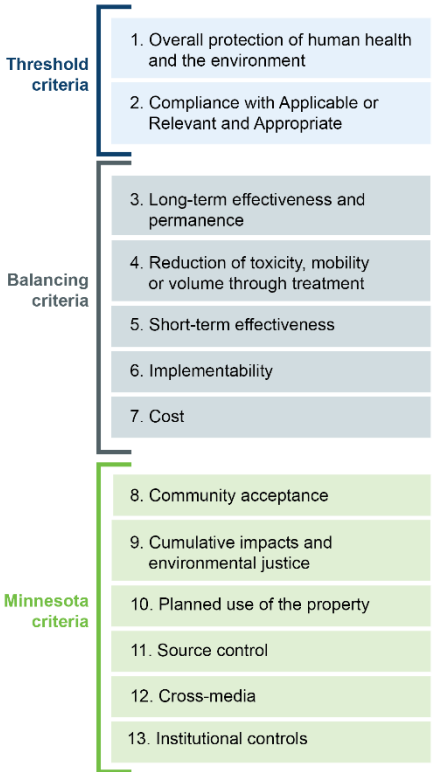
For response action evaluation and planning it is important to consider that many types of ICs and engineering controls must be approved and can only be implemented by certain types of key stakeholders such as property owners, state and federal agencies, and local government units. Stakeholders needed to approve or implement ICs must be involved early on and in all stages of response action selection and planning.

5.3.3 Response action evaluation

Response action evaluation is the screening and comparison of potential response actions to identify remedies capable of addressing unacceptable risks to human health or the environment. A “Response action” can encompass corrective actions, cleanup actions, removal actions, mitigation actions, and remedial actions. Each potential response action, or remedy, is evaluated and compared using the threshold, balancing, and Minnesota criteria to identify what remedy is best suited for the site. The response action evaluation is documented in the FS or the RAP depending on the MPCA program and the level of complexity of the site. The FS or RAP should be submitted to the MPCA to provide the justification that the proposed remedy protects human health or the environment.

Threshold, balancing, and Minnesota criteria evaluation: Specific criteria should be used to determine the most appropriate response action for a site. These criteria help decision-makers evaluate the potential remedies based on technical, economic, environmental, and social factors. The criteria are broken out into three categories:

- **Threshold Criteria**: All remedies must meet the threshold criteria.
- **Balancing Criteria**: Balancing criteria compare the potential benefits of a response action against its disadvantages. They identify the key positive and negative aspects of each potential response action with the goal of identifying the most appropriate response actions for a site. Balancing criteria are only used for an alternative if it has met the threshold criteria.
- **Minnesota Criteria**: Minnesota criteria provide additional considerations to include in conjunction with the primary balancing criteria. Several of these considerations closely relate to and expand upon CERCLA. Minnesota criteria generally align with CERCLA criteria established as part of the NCP [40CFR300.430(e)(9)], although some components are unique to Minnesota.



The thirteen criteria are further described below. Examples of comparative and analysis tools that can be used to evaluate and compare remedies to the thirteen criteria are provided in **Appendix E**.

1. Overall protection of human health and the environment:

By statute, all remedies under MERLA must provide overall protection to public health and welfare and the environment. As a threshold criterion, all remedies must meet this requirement before being selected or implemented. In Minnesota current and planned land use must be considered when evaluating overall protectiveness.

Questions to consider when evaluating a response action under this criterion include the following:

- How will any existing or potential human exposures be eliminated, reduced, or controlled?
- Will elimination, reduction, or control be achieved through removal, containment, or the implementation of engineering or IC?
- If engineering controls or ICs are implemented, what is the authority, capability, and willingness of the appropriate entity (or entities such as local government units and property owners) to implement, maintain, and monitor the control? Stakeholders needed to approve or implement an IC must be involved with the response action selection process and in agreement with proposed alternatives.
- What environmental impacts would result from implementation of the response action (e.g., greenhouse gases produced, water used, runoff and discharge of sediment, removal degradation of existing habitat)?

2. Compliance with Applicable or Relevant and Appropriate Requirements:

Response actions selected under MERLA must comply with all federal and State regulations, collectively referred to as ARARs (Applicable or Relevant and Appropriate Requirements). ARARs serve as design criteria or standards that must be considered during the selection and implementation of remedies. An environmental law or rule may be "relevant and appropriate" if it addresses circumstances sufficiently similar to those of the release, so that compliance would be a reasonable way to assure protection of human health and the environment. ARARs include federal or state environmental regulations and laws with legally enforceable requirements that must be followed. The EPA's Applicable or Relevant and Appropriate Requirements webpage may be used as a resource for evaluating, attaining, or waiving ARARs. An example of ARAR considerations is shown in the adjacent graphic.

To provide flexibility in remedy selection and site decision-making, an "ARAR waiver" may be used to waive or modify the requirements to meet certain ARARs during the selection and implementation of a remedy. ARAR waivers may be granted under specific circumstances where compliance with certain ARARs is technically impracticable, infeasible, or would cause significant delays or cost increases without providing commensurate benefits in terms of risk reduction or protection to human health or the environment. For ARARs not met, documentation of the basis must be submitted to the relevant regulatory agency for approval.

In addition, To Be Considered (TBCs) criteria should be considered along with ARARs as part of the response action evaluation and may be used in determining the necessary level of cleanup. TBCs are non-promulgated advisories or guidance issued by federal or state government that are not legally binding and do not have the status of potential ARARs; however, they can provide valuable information. Compliance with ARARs may apply to remedy selection in two ways. First, requirements may apply to the release itself, by requiring specific response actions to address that type of release or by setting cleanup goals (i.e., RAOs and cleanup levels) that must be achieved by the selected remedy for that release. For example, the Water Pollution Control Act provision requiring recovery of discharges that may cause water to become polluted. Second, requirements may apply not to the release itself, but to the operation of the response action that is selected. For example, restricting the air emissions from a soil vapor extraction system, or adhering to discharge requirements for a groundwater pump and treatment system. Legal requirements applicable to remedy operation include substantive standards, such as concentrations of air or water pollutants that may be discharged by a remediation system, and procedural requirements, such as permitting and reporting processes that must be followed as a condition for commencing or continuing the operation of a remedy.

3. Long-term effectiveness and permanence:

The purpose of considering the long-term effectiveness and permanence of a response action is to evaluate the magnitude of contamination that may remain after remedy implementation, and to assess whether the remedy will reduce, eliminate, or control long-term negative impacts on human health and the environment. Negative impacts could include chronic health effects, gradual environmental degradation, or persistent exposure to harmful substances or conditions. A well-designed and properly implemented remedy should address the significant reduction of contamination, potential impacts of treating one media for another, maintenance of engineering controls and ICs over time, and the expected design life. A critical component to consider when evaluating effectiveness is the current land use and anticipated future land use to identify realistic exposure scenarios for estimating site risks. Considering land use is required under Minn. Stat. § 115B.17, subd. 2a. This criterion is aligned with CERCLA.

Questions to consider when evaluating a remedial alternative under this criterion include the following:

- Will exposure to contaminants be eliminated or sufficiently controlled over the long term?
- Will there be a reduction of total contaminants at the site?

- What will be the magnitude, extent, and depth of residual contamination, if any?
- Is there a potential for contaminants to be transferred to another media or location?
- How does the proposed remedial solution affect the current, planned, and projected future uses of the property?
- Will any proposed institutional or engineering controls affect future plans for the property? Consider OM&M, costs, design life, and ownership.
- Level of effort and costs needed to maintain engineering controls and ICs needed for the remedy to remain protective.
- What level of confidence can be attributed to the projected future uses of the property?
- How much time is needed to achieve the desired result?

4. Reduction of toxicity, mobility or volume through treatment:

This criterion evaluates the application of treatment technologies in determining the maximum extent to which permanent solutions and treatment are practicable. Remedies that use treatment to address materials comprising the principal threats onsite is preferred. Remedies that use treatment to reduce or eliminate contaminants or their toxicity and mobility in environmental media are also preferred and should be considered when possible.

5. Short-term effectiveness:

The purpose of evaluating short-term effectiveness and risks is to consider and address the potential effects on human health and the environment during remedy implementation. Short-term risks typically refer to immediate or near-future hazards and their potential impacts over a brief period, often during a specific event. These risks are usually more immediate in nature and may include acute health effects or immediate environmental damage. Short term risks can relate to ongoing risks prior to remediation implementation or may be a temporary consequence of remediation implementation. Some examples of short-term risks include air emissions from initial soil vapor extraction remedy startup, in which potential mitigation could be utilizing vapor phase granular activated carbon (GAC) filtration systems as part of the remedy; or dust generation during excavation of impacted soils, in which mitigation could be wetting traffic areas during hauling.

Protection of the community, protection of on-site workers, and prevention of additional environmental impacts to ecological receptors must be considered when evaluating risks. Include consideration of exposure pathways, receptors, and overall time to complete a remedial action during which exposure may occur. A well-designed and properly implemented remedy can minimize short-term risks. No response action is risk-free. By identifying short- and long-term risks beforehand, effective ways to eliminate or reduce such risks can be included in the remedial design of the chosen alternative.

6. Implementability:

The purpose of evaluating implementability is to consider how technical and administrative factors affect the ability to implement each potential response action. What makes the most sense on paper does not always translate to what works best in reality. *Technical feasibility* includes assessing issues of the potential difficulties as well as uncertainties associated with construction, operation, and monitoring of the response action. *Administrative feasibility* refers to the amount of time and resources needed to effectively implement a response action. This includes the availability of services and materials and whether the necessary permits and permissions needed can be acquired. Examples are the availability of adequate off-site treatment, storage, and disposal capacity and services; availability of necessary equipment, specialists, and supplies; or availability of prospective technologies.

7. Cost-effectiveness:

A remedy can be considered cost-effective if its total costs are proportional to its overall effectiveness. To determine whether a response action is cost effective, complete a life cycle cost estimate. A life cycle cost estimate is an estimate of all project costs that will be incurred during design and implementation of a final

remedy, including costs for any ongoing interim action, complementary actions, site investigation, OM&M, and for implementing any affirmative actions required post-closure. Cost estimates should be based on the scenario of events using present-day costs. Cost estimates at this stage are intended to compare remedial alternatives at an elevated level and act more as a guiding variable rather than a formal, exact estimate. Total Project life-cycle costs should be considered rough order of magnitude costs. Typically, actual costs estimates could be 50% greater or 30% less (+50/-30) than the estimates developed. The assumptions used and the sources of cost information should be documented to support the cost estimates derived for each remedial alternative.

Present cost estimates using the following guidelines:

- Show costs for the major activities to be completed during both design and implementation phases.
- Distinguish major activity costs by factors such as consultant, subcontractors, equipment vendors, and other services such as utilities, laboratory analyses, and waste disposal fees.
- To provide a more objective cost comparison between different remedial alternatives, express total costs in current dollars. Using a "discount rate," total costs can be converted into a current-dollars amount.

It is important to consider the potential need for future remedy repair, replacement, or enhancement for each remedial alternative and the likely magnitude of the associated costs to effectively capture the long-term remedy costs. The uncertainty of future needs is best managed by evaluating the cause of the uncertainty. Identifying the causes of the uncertainty can be helpful in defining additional factors to be weighed in evaluating the relative merits and costs of the remedial alternatives. At a minimum, it is helpful to rank the alternatives on a relative basis on the issue of future costs and then consider this factor in the selection process. The exact cost estimating process is explained in detailed in EPA's Cost in the Remedy Selection Process. This process should be implemented to effectively facilitate the cost evaluation of a proposed remedy.

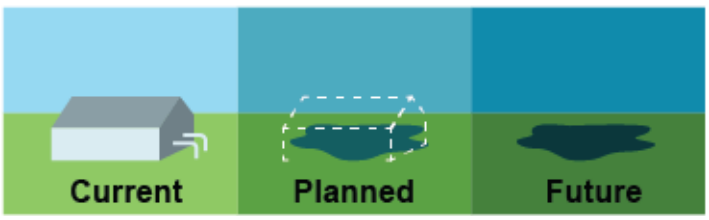
8. Community acceptance:

Community acceptance refers to the opportunity and ability for stakeholders and community members to engage in the process of selecting a particular response action and/or to be informed of the process. Before a remedy is selected, it is important for community concerns to be heard and considered, and it is often a requirement per Minn. Stat. § 115B.17, subd. 2.b. Community participation is strongly encouraged. Stakeholder and community participation should be viewed as a resource to the remediation decision-making process. It is important to understand any community goals and values concerning a site, and how they relate to land use and development issues. Expectations for community participation is further outlined in **Section 3.0**.

9. Cumulative impacts and environmental justice:

The state legislature has tasked the MCPA to identify, develop, and implement means to eliminate and reverse environmental and health inequities and disparities in areas of concern for EJ by implementing a cumulative impacts law. In evaluating cumulative impacts and EJ during remedy evaluation, consider the community's long-term exposure to various contaminants in air, soil, and water. Cumulative impacts and EJ are also described in **Section 2.1.4**. These impacts are the result of complex interactions among various social, environmental, and **public health factors.**

10. Planned use of the property:



Planned use of the property where the release is located must be considered when selecting a remedy per Minn. Stat. § 115B.17, subd. 2a. Planned use is not limited to just the land—it can also include surface and groundwater resources. Land use may change over time, thus potentially changing exposure risks and associated liability, as shown in the adjacent graphic. In cases where risk-based decisions result in contamination remaining on site, it is important to consider the potential long-term legal and financial liabilities related to the presence of the contamination and how changing land use could affect these

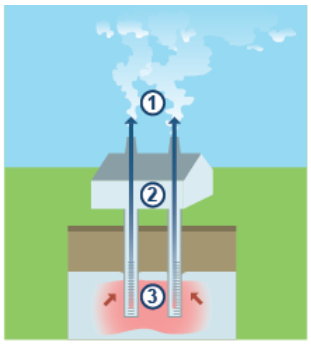
liabilities. Actions as simple as utility installation or repair can result in contact with subsurface contaminants. These liability concerns must be balanced against the risks of potential off-site liability if the contamination is removed and placed in an off-site facility. Consequently, before selecting a remedy, it is important to evaluate the potential limitations and outcomes of such a choice. This precaution is not intended to mandate a certain type of cleanup; rather, it helps to ensure that an informed decision is made when selecting a remedy. It is difficult to predict future uses of property. The MPCA does not have authority to make local property use decisions. It is important to involve local government and the affected community when assessing planned property use. In the absence of a collaborative, clear property use determination, the MPCA will select cleanup goals and response actions that allow for flexible and beneficial use of the property. For additional information, refer to MPCA's Property Use Guidance (c-rem3-08).

11. Source control:

Source control focuses on the most common sources of contamination and crucial factors to consider when evaluating source control options. Source control is defined as any action that controls, removes, destroys, or detoxifies contamination and results in site-associated risk being reduced to acceptable levels. Source control is an important part of remedy selection, especially if the identified sources are the origin of ongoing releases to soil or groundwater. Decisions regarding source control must consider site-specific factors that include community acceptance, long-term and short-term risks, the technical feasibility of removing source material, as well as cost effectiveness. Sources identified at a site can include buried waste, tanks and drums, contaminated soil, and NAPL. Source control remedies may include removal, remediation, or containment. Removing sources of contamination makes sense when they are "point sources" such as tanks or drums and removal can be straightforward. The decision to remediate a known source or suspected source requires additional considerations and must be evaluated on a site-by-site basis.

12. Cross-media contamination:

Cleanup decisions should consider the potential for cross-media transfer of contaminants. Cross-media contamination occurs when remedial technologies produce waste materials containing hazardous compounds and/or transfer contaminants from one medium to another, with or without a reduction in contaminant volume/mass. Cross-media contamination consideration is an important part of remedy evaluation. The adjacent graphic depicts an example of cross-media contamination transfer from groundwater to air.



1. Mass Transfer from GW to Air Emissions
2. Active SVE System
3. Contaminated GW

When evaluating remedies involving cross-media transfer the following considerations should be made:

- Are the natural processes in the new media more effective or expeditious in reducing toxicity, volume, or exposure?
- Will the new media meet compliance standards?
- Does the change in media allow reuse, recycling, or treatment of waste?
- Are there significant energy resources required to implement the remedy and are these reasonable?
- Does the new media have associated liability concerns, in the present or future?

Per- and polyfluoroalkyl substances (PFAS) can be used as an example of a contaminant that should be evaluated for cross-media contamination. PFAS has a strong tendency for cross-media contamination due to the recalcitrant, stable nature, and mobility of many PFAS including their ability to move between air, soil, groundwater, leachate, and surface water. One method used to treat PFAS impacted water is a GAC filtration system. GAC filtration systems use adsorption to remove PFAS from water, resulting in remediated water and spent GAC contaminated with PFAS. GAC filtration systems then require proper disposal. Although this technology works very well at some sites, the potential cross-media issues (groundwater to solids) should be evaluated. Cross-media contamination concerns may also arise from remedial technologies that require large expenditures of energy or resources for nominal environmental gain, such as an in situ thermal remediation of a

small quantity of contaminated soil or long-distance transportation of a small quantity of contaminated soil to a landfill.

13. Institutional controls:

Make sure to factor in necessary ICs and evaluate their implementability during the remedy evaluation. ICs can ensure that long-term remediation or mitigation measures (e.g., engineering controls) or monitoring requirements are implemented and maintained. When developing a remedy that includes ICs, assess the type of IC to be used, its short- and long-term effectiveness, and the authority, capability, and willingness of the appropriate entities to implement, maintain, and monitor them.

5.3.4 Response action selection

After remedies are evaluated, a remedy will be selected based on its ability to meet the site-specific objectives. The proposed remedy will be submitted to the MPCA for approval. Remedy selection will be documented in the RAP and final remedy selection will be documented by MPCA indicating approval.

The RAP should describe how the selected remedy will adequately address the identified impacts and should provide methods for ensuring that the remedy will be implemented properly. The RAP should identify cleanup goals and include references to any FS, pilot, and treatability studies conducted. The RAP should also include details on required access or consent agreements, stakeholder participation, and expectations for MPCA involvement and communication. Superfund sites listed on the PLP may have an MDD prepared by MPCA to formally document remedy decisions before beginning the remedy design process.

5.3.5 Response action design

After a remedy has been selected, a remedy design is prepared and submitted to the MPCA for review. The design document should describe the technical parameters of the remedy and the cleanup goals.

For some sites, the RAP will be the only design document necessary to obtain MPCA approval. The RAP will include construction plans necessary to implement the remedy and the OM&M Plans necessary to ensure the remedy operates as designed. Specifications are also presented, including the required components, construction methods, treatment/disposal requirements, and restoration processes.

For more complex sites or sites following the federal Superfund process, after a remedy has been selected in the FS or RAP, the Remedial Design will be used to provide the greater level of detail required for implementing the remedy. The Remedial Design will include the engineering reports, technical specifications, work plans, quality assurance and quality control measures, and other documents necessary to outline exactly how the response actions should be completed and how the cleanup goals will be met.

CSM stage #4 – Design CSM stage

The design CSM stage is used to support full-scale remedy planning and implementation. Additional investigation efforts may be needed to identify and resolve significant data gaps that affect remedy success, such as uncertainties of specific physical, geologic, or hydrogeologic data (e.g., geochemical parameters, tracer studies, radius of influence testing). Site-specific pilot studies may be performed to further test remedial action performance.

The design CSM stage should allow for final remedy selection decisions to be made. The CSM should support cost-benefit analysis, engagement and scoping with contractors or sub-contractors, assessment of the proposed risk mitigation techniques, and preparation of contingency plans for foreseeable issues that may be encountered during full-scale remedial action implementation.

Most design documents must be submitted and reviewed by the MPCA before the actual construction, installation, or removal of contaminated substances can begin. The MPCA may not provide approval of engineering designs since MPCA cannot be the signing Professional Engineer, however the MPCA must review

and concur with design documents. Failure to obtain MPCA approval prior to implementation runs the risk of jeopardizing eligibility for final assurance letters if a response action deemed necessary was omitted or failed to achieve acceptable cleanup goals. Discuss design document review requirements with your MPCA project manager.

5.3.6 Contingency planning

Contingency planning is incorporated into remedy selection to prepare for potential deviations that may arise during remedy implementation or site redevelopment due to uncertainties associated with the site or the selected remedy. These contingency plans, often submitted as a CCP document or as a section within the RAP, are used to anticipate and proactively address challenges such as encountering additional hazardous substances or unforeseen challenges. Contingency plans describe strategies to effectively respond and address these challenges, which may include modifying remedial action approaches, incorporating additional mitigative actions, adjusting health and safety protocols, or implementing alternative remediation technologies. A CCP can help streamline reactions, minimize downtime, and stay within project timelines if a release is encountered during RAP implementation or redevelopment.

Contingency plans should be well-documented and set out an organized, planned, and coordinated set of response actions to be taken in case unexpected issues are identified during remedy implementation. They should include detailed information on specific risks, contingency options, and actions to be taken. They should clearly define roles and responsibilities for communication during unexpected events, address compliance with environmental regulations, and consider budgetary constraints to ensure financial resources are available for contingency measures.

By proactively developing contingency plans, remediation projects can enhance their resilience to unexpected challenges and ensure the successful achievement of environmental protection and restoration goals.

6.0 Response action implementation

MERLA Remediation Phase	Site Assessment	Superfund	VIC
Remedy Implementation	N/A	•RAP Implementation Report •Operation, Maintenance, & Monitoring (OM&M) Plan •OM&M Report	• RAP Implementation Report • OM&M Plan • OM&M Report

Following MPCA review and approval of the response action plan (and response action design, if required), response actions appropriate to address the contamination are implemented. This phase includes conducting the bulk of the response actions and cleanup construction activities at a site. For example, this may entail:

- Installing a soil vapor extraction system.
- Installing a groundwater extraction and treatment facility for contaminated groundwater.
- Excavating contaminated soil for treatment or disposal.
- Installing a multi-layered capping system.
- Consolidating contaminated soil and installing physical barriers such as an engineered cap.

Completion at this stage indicates that all construction and implementation steps required for the response actions have been accomplished for a portion of a site or the entire site, even though final cleanup goals may not have been attained yet. In some cases, the remedy implementation may be followed by a number of years of OM&M. For example, a groundwater treatment system may need to operate for several years in order for groundwater to meet cleanup goals, and operation and maintenance will be required to maintain integrity of the system while long-term monitoring of the system will be required to verify the system is meeting performance goals. Additionally, a monitored natural attenuation remedy may only require long-term monitoring, but not operation and maintenance to verify the remedy is functioning as planned.

CSM stage #5 – Remediation/Mitigation CSM stage

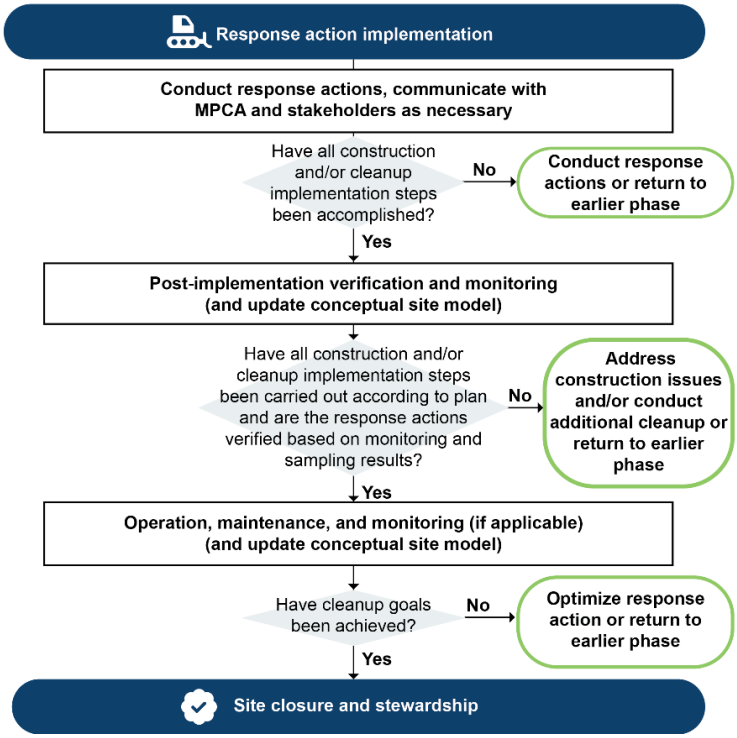
The remediation/mitigation CSM stage involves the actual implementation of the remedial strategy to address environmental contamination and risks to human health and the environment. This stage of the CSM should be initiated as the remedy implementation begins and should be continued through remedy performance evaluation or optimization activities, as needed. The remediation/mitigation CSM stage is used to adapt to issues encountered during cleanup implementation, manage the budget and timeframe for remedy performance, and document site completion activities as cleanup goals are achieved.

- **Primary data sources**: Design plans developed during prior CSM stages; monitoring, verification, and confirmation data collection during cleanup implementation.
- **Typical level of complexity**: Medium to high.
- **Use in decision-making:** Document remedy implementation and effectiveness; adapt to remedy

MPCA involvement: During remedy implementation, MPCA expects regular updates, discussions, and ongoing collaboration to ensure milestones are successfully met. Any deviations from the remedy design or issues with the function of a remedy, such as equipment substitutions, modifications to milestones, cost adjustments, or required follow-up actions, should be documented. Expectations should be clarified with the MPCA project manager before and during implementation, through regular meetings, calls, or weekly reports.

Community involvement: Communication during and after remedy implementation will ensure milestones are met and maintain positive community engagement. Specifically, communicate timelines and any maintenance requirements following implementation. Communicate to all relevant stakeholders if an interim response action is being replaced with a long-term solution, and any maintenance requirements associated with the solution.

Figure 8 – Response action implementation



6.1 Post-implementation verification and monitoring

Following implementation of the remedy, verify that the response actions have been conducted successfully and have either met cleanup goals or are likely to meet cleanup goals in the future. Post-implementation verification and monitoring is necessary to ensure the success and sustainability of the remedy by providing an assessment of the initial remedy protectiveness and assuring stakeholders that risks have been effectively addressed. Verification and monitoring activities are composed of site inspections, construction verification testing, and pre- and post-implementation sampling of environmental media to confirm the remediation efforts are operational and functional.

Examples of post-implementation verification and monitoring activities include:

- Construction inspections to verify that engineered systems have been installed according to the design specifications.
- Soil confirmation sampling to demonstrate that contaminants have been successfully excavated.
- Long-term groundwater monitoring to verify that groundwater treatment systems are achieving extraction goals and have the appropriate radius of influence to prevent off-site contaminant migration.
- Post-mitigation diagnostic testing of sub-slab depressurization systems to confirm that the system is creating adequate pressure field extension across the building floor slab.

Following successful implementation of the remedy, a RAP Implementation Report must be prepared and submitted to the MPCA for review and approval. The RAP Implementation Report is used to document the implementation activities, including any deviations from the original plan; provide results of any verification, monitoring, or additional investigation tasks completed; demonstrate the efficacy of the implemented remedy; and enable MPCA staff to evaluate whether remedy implementation has been successful. The RAP Implementation Report should clearly describe the plan and schedule for all tasks necessary for ongoing remedy effectiveness, along with decision-making criteria to determine when and for how long additional activities should be completed.

6.2 Operation, maintenance, and monitoring

After remedies are implemented and demonstrated to be effective, they must be maintained and monitored for as long as necessary to ensure they continue to operate as designed and remain protective of human health and the environment. An OM&M consists of all the activities required to maintain the effectiveness and integrity of a remedy. This may include remedy OM&M, long-term monitoring of impacted media, or monitoring of implemented ICs. An OM&M activities help identify contamination trends, evaluate the ongoing performance of response actions, and determine when cleanup goals are met or when a remedy should be optimized. These activities provide important data to compare the actual remedy performance with design expectations and should be used to recommend changes to improve protectiveness, reduce cost, or shorten the time necessary to reach site closure. The EPA's Cleanup Optimization at Superfund Sites webpage offers resources on remedy optimization, covering topics from remediation system evaluations to long term monitoring optimization, with many resources aimed at optimizing pump and treat systems.

Examples of OM&M activities include:

- Long-term groundwater monitoring to assess plume stability.
- Regular site inspections to ensure protective caps or covers are in place and continue to be effective.
- Assessing and documenting the operation of remediation systems.
- Repairing protective caps, covers, or remediation system components .
- Verifying compliance with property use restrictions .
- Long-term operation of vapor mitigation system to prevent vapor intrusion.

A commitment to submit an OM&M Plan should be included in the RAP, if necessary. The OM&M Plan is typically a standalone document submitted with the RAP Implementation Report. When necessary, these plans should provide an overview of the tasks and their schedules, a reporting schedule, and sufficient supporting information to ensure that the remedy continues to perform as intended and remains protective of human health and the environment. The OM&M Plan should be kept up to date and reflect any relevant changes throughout the project, such as changes in surrounding land use or the presence of new receptors.

An OM&M activities may be considered part of the remedy implementation phase, as is typical for active remediation systems, or may be considered a continuing obligation after site closure, as is typical for mitigation systems such as protective soil caps.

If further response actions or remedy optimization is deemed necessary or beneficial in order to achieve site closure in a timely manner, be prepared to revisit the prior remediation phases to ensure that response actions remain compliant with regulations, consistent with site conditions, and aligned with advancements in technology.

CSM stage #6 – Post-remedy CSM stage

A post-remedy CSM stage involves the summarization of information collected during the remedy implementation and stewardship phases of the remediation process. The post-remedy CSM can be used to document the achievement of cleanup goals, assess adequacy of treatment, facilitate long-term management strategies, and plan for site succession during reuse or redevelopment. The post-remedy CSM should provide information regarding important remedy features, contamination remaining in place after remedy implementation, and document the effectiveness of risk mitigation.

- **Primary data sources**: Long-term OM&M data; post-remedy effectiveness reports.
- **Typical level of complexity**: Medium to high.
- **Use in decision-making**: Evaluate remedy performance; document ongoing ICs, contamination in-place, or other remedy features; prepare site closure documents; plan for site reuse.

6.3 Implementation of institutional controls

After response actions are implemented, any required IC must be drafted and submitted to the MPCA for review. After MPCA approval, the IC must be recorded with the property records in the appropriate county office. IC documents are typically recorded at either the county recorder's or registrar of titles office after cleanup is completed or the bonds have been spent. Templates and instructions for the covenant and affidavit are located on MPCA's Cleanup guidance and assistance webpage, including:

- Instructions for preparing an institutional control.
- Environmental Covenant and Easement.
- Affidavit concerning real property contaminated with hazardous substances.

7.0 Site closure and stewardship

MELA Remediation Phase	Site Assessment	Superfund	VIC
Site Closure and Stewardship	•Site Assessment Risk-Based Closure Form	•No Action (NA) / No Further Action (NFA) Letter •*Delisting from the PLP**	•Various assurance letters for closure

** Item is not considered a document, but rather an event.*

Closure occurs when the MPCA has determined that no additional work is necessary to protect human health and the environment based on the current information known and the current or proposed property use. Site closure also means that MPCA's regulatory oversight ends. Sites are eligible for closure when the MPCA has concluded the following conditions are met, as applicable to the site and program:

- The observed conditions do not indicate that an unacceptable risk is present.
- The extent and magnitude of the contamination has been defined sufficiently to meet program requirements and any remaining contamination poses a minimal risk to human health and the environment.
- All necessary response actions required for meeting cleanup goals have been completed.
- In cases with an unknown or unviable RP, no additional MERLA funding is needed to conduct response actions.
- Any required ICs are fully implemented and documented to MPCA.
- All required documentation and reports have been submitted, approved by the MPCA, and a determination has been made that the site does not pose a threat to human health and the environment from the release or a threatened release of a hazardous substance, or pollutant or contaminant.

If the MPCA determines that a site meets all cleanup goals and requirements, then closure is accomplished in a number of different ways depending on the appropriate program:

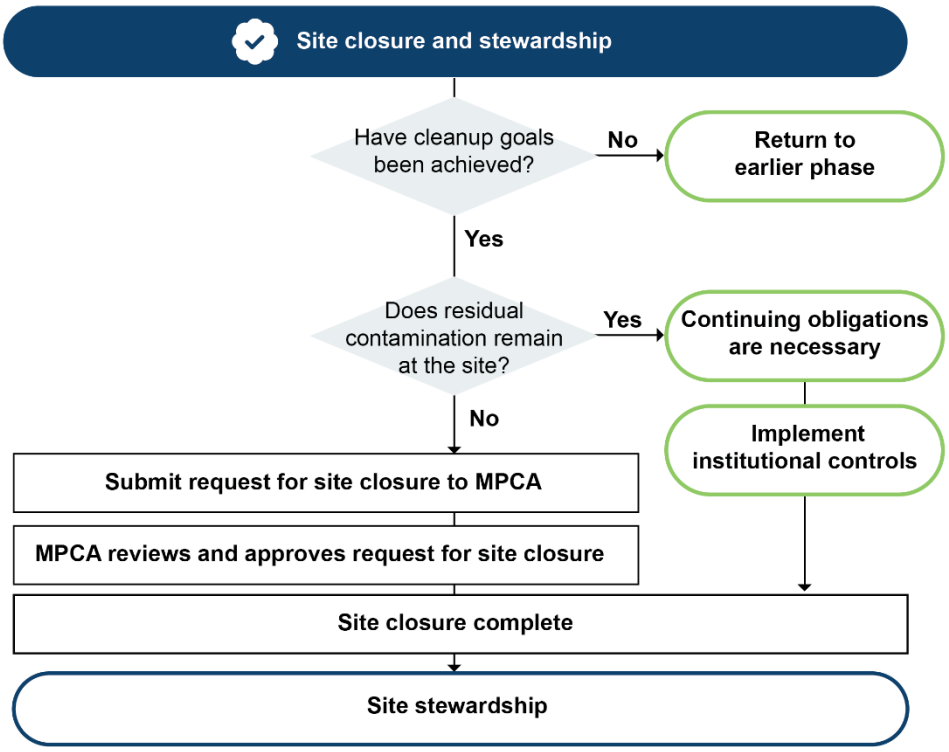
- **Site Assessment:** A site is closed when site conditions indicate no risk is present or any risk that is present has been adequately addressed; the site is referred to another Remediation program; or a viable RP has been identified and invited to enroll in Superfund.
- **Superfund:** CRPs are issued NFA/NA letters based on the MPCA's discretionary enforcement authority and reflect the agency's administrative decision regarding a certain identified release of contaminants. Sites may also be delisted from the PLP if RPs/CRPs have completed all necessary response actions. Conditions at some sites may require continuing obligations after the delisting process to ensure long-term risks are managed and remain effective. A map showing the location of all currently active and closed Superfund Sites is provided on MPCA's Sites listed on the Minnesota PLP webpage.
- **VIC:** A VIC site is closed when on-site risk has been managed or when the applicant withdraws from the VIC Program. Refer to MPCA's Brownfield Program Services (c-brwnfld4-01) for information on the

technical assistance and assurance letters available. If unresolved potential risk remains at the time of VIC closure, the site is referred to the Site Assessment Program for evaluation.

- **RCRA Remediation Program:** Sites are issued a RCRA Corrective Action Completion Determination, which indicates the successful completion of corrective actions and that the remediation goals have been achieved to hazardous waste generator sites.
- **CLP:** In most cases, closed landfill sites that enter the CLP have already been closed and have entered into the postclosure care period to monitor and manage any residual contamination and maintain the landfill's pollution control equipment (e.g., leachate and landfill gas collection and disposal). Once the notice of compliance is issued to the owner/operator of the landfill and a binding agreement is executed, the CLP is responsible for managing the site in perpetuity. For more information see Postclosure care exit evaluation guidance (w-sw5-65).
    - Any site can be reopened if new information is presented indicating site conditions may no longer be protective. Future changes in property use, human health-based risk guidance, and legal requirements are among several factors that can result in the need for reopening of a site.

A complete and permanent cleanup of all releases at a site is the ideal cleanup goal to achieve site closure. With a complete and permanent cleanup, there is no need for ongoing risk management, land use restrictions, ongoing OM&M, or MPCA oversight. However, the MPCA allows for residual contamination to remain at a site if the extent and magnitude of the contamination across all media has been defined and any remaining contamination does not pose an unacceptable risk to human health and the environment under the risk-based approach.

Figure 9 – Site closure and stewardship



7.1 Continuing obligations

Owning or conducting activities at a contaminated site will always require awareness of the contamination and any associated restrictions, requirements, and responsibilities. Even after response actions have been implemented or when the release concentrations are below current risk-based values, an owner of a property with an environmental release has ongoing risk management obligations after a site has been issued closure. Continuing obligations may be documented in an IC or OM&M Plan, such as maintenance of clean soil buffers or engineered covers, ongoing operation of a remedial system, and routine monitoring, inspections, and reporting to the MPCA. Even in the absence of an IC, prior to changing the site use or conducting earthwork, a property owner should review the environmental conditions of a site to determine if measures are needed to manage potential risk related to those planned actions.

Continuing obligations also include notifying the MPCA if new releases occur or upon discovery of a significant change in the condition of the site; providing access and cooperation to state or federal agencies and their environmental contactors for future site activities; and providing notice to future property owners about residual contamination at the site, in accordance with IC or real estate disclosure requirements or other legal requirements.

Note that CERCLA may have additional site-specific requirements, such as a Five-Year Review, for federal Superfund sites.

By adhering to the continuing obligations, property owners can ensure that the site conditions remain protective over the long term.

8.0 References and resources

Many useful resources and guidance documents have been prepared by the MPCA, other state and federal agencies, and other groups that focus on relevant topics in the remediation process (e.g., CSMs, risk assessment, and site decision-making processes). Some of these resources have been incorporated into this guidance document. The list below is intended to provide general reference material on a wide variety of resources. Users should note that this list is not exhaustive.

Federal Laws/Rules §

- CERCLA: 42 U.S.C. 9601 et it. seq.
- National Contingency Plan: 40 C.F.R. pt. 300
- RCRA: 42 U.S.C. § 6901 et seq

Minnesota State Laws and Statutes

- Environmental Response and Liability: Minn. Stat. § 115B
- Petroleum Tank Release Cleanup: Minn. Stat. § 115C
- Pollution Control Agency: Minn. Stat. § 116
- MERLA: Minn. Stat. § 115B.01 through Minn. Stat. § 115B.20
- Landfill Cleanup Program: Minn. Stat. § 115B.39 through Minn. Stat. § 115B.445
- The Land Recycling Act: Minn. Stat. § 115B.175
- Harmful Substance Compensation: Minn. Stat. § 115B.25 through Minn. Stat. § 115B.37
- Dry Cleaner Environmental Response and Reimbursement Law: Minn. Stat. § 115B.47 through Minn. Stat. § 115B.53

EPA Guidance

- CERCLA and Federal Facilities webpage
- Clarification of the Consultation Process for Evaluating the Technical Impracticability of Groundwater Restoration at CERCLA Sites document
- Environmental Cleanup BMPs: Effective Use of the Project Life Cycle Conceptual Site Model fact sheet
- Framework for Cumulative Risk Assessment document
- Guidance for Quality Assurance Project Plans, EPA QA/G-5 webpage
- Guidance on Systematic Planning Using the Data Quality Objectives Process webpage
- Key Principles of Superfund Remedy Selection webpage
- Key Optimization Components: Conceptual Site Model webpage
- Optimizing Site Cleanups webpage
- Risk Assessment Guidance webpage directory
- Superfund Cleanup Process webpage
- Superfund Site Assessment Guidance & Training webpage
- Superfund Remedial Investigation/Feasibility Study (Site Characterization) webpage
- Summary of the RCRA webpage
- Smart Scoping for Environmental Investigations Technical Guide

Interstate Technology Regulatory Council (ITRC) Guidance

- Integrated DNAPL Site Strategy webpage
- Integrated DNAPL Site Characterization and Tools Selection webpage
- LNAPL Site Management: LCSM Evolution, Decision Process, and Remedial Technologies webpage
- Site Characterization Considerations and Media-Specific Occurrence for PFAS document
- Decision Making at Contaminated Sites: Issues and Options in Human Health Risk Assessment webpage
- Exit Strategy – Seeing the Forest Beyond the Trees webpage
- Long-Term Contaminant Management Using Institutional Controls webpage
- Remediation Management of Complex Sites webpage
- Soil Background and Risk Assessment webpage
- Green and Sustainable Remediation: State of the Science and Practice document
- Technical and Regulatory Guidance: Green and Sustainable Remediation: A Practical Framework document
- Decision Making at Contaminated Sites document

MPCA Guidance Documents

- Assessment of Sensitive Groundwater Conditions (c-prp4-18)
- Brownfield Program Services (c-brwnfld4-01)
- Brownfield Program Response Action Plans (c-rem4-43)
- Data Quality Objectives (p-eao2-14)
- Emergency Management Program Spill Cleanup Policy (c-er4-13)
- Environmental Justice Framework (p-gen5-05)
- Green and Sustainable Remediation (c-prp-10)
- Instructions for preparing an Institutional Control (c-rem4-47)
- Intrusion Screening Values (c-rem3-12)
- Laboratory Quality Control and Data Policy (p-eao2-09a)
- Phase I ESA Report for Brownfield Program enrollment (c-brwnfld4-03)
- Postclosure care exit evaluation guidance (w-sw5-65)
- Property Use Guidance (c-rem3-08)
- Quality Assurance Project Plan Guidance (p-eao2-13)
- Quality Management Plan (p-eao2-15)
- Risk evaluation and site management decision at petroleum release sites (c-prp4-02)
- Soil Reference Value Technical Support Document (c-r1-05)
- Remediation General Policy (c-rem2-03)
- Typical contaminants based on site use and processes (c-rem3-35)
- Surface Water and Sediment Evaluation at Remediation Sites (c-rem3-31)

- Remediation Division Methane Guidance (c-rem3-32)

Other Guidance

- United States Army Corps of Engineers Conceptual Site Models engineer manual
- Agency for Toxic Substances and Disease Registry Overview of the Exposure Pathway Evaluation webpage
- ASTM E1689-20 Standard Guide for Developing Conceptual Site Models for Contaminated Sites webpage
- Eni Rewind Remediation Technologies Handbook document

Acronyms

ARAR	Applicable or Relevant and Appropriate Requirement
AERA	Air Emissions Risk Analysis
BF#	Brownfields site ID #
CCP	Construction Contingency Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Closed Landfill Program
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
COPC	Contaminant of potential concern
CRP	Cooperative Responsible Party
CSM	Conceptual Site Model
DNAPL	Dense non-aqueous phase liquid
DQO	Data quality objective
EAO	Environmental Analysis and Outcomes Division
EISV	Expedited Intrusion Screening Value
EJ	Environmental justice
EPA	Environmental Protection Agency
ERP	Emergency Response Program
ESA	Environmental Site Assessment
FRTR	Federal Remediation Technologies Roundtable
FS	Feasibility Study
GAC	Granular activated carbon
GSR	Green and sustainable remediation
HASP	Health and Safety Plan
HBV	Health-Based Value
HI	hazard index
HRL	Health Risk Limit
HQ	Hazard quotient
IC	Institutional control
ISV	Intrusion Screening Value
ITRC	Interstate Technology Regulatory Council
LNAPL	Light non-aqueous phase liquid
LUC	Land use control
MCL	Maximum Contaminant Level

MDD	Minnesota Decision Document
MDH	Minnesota Department of Health
MERLA	Minnesota Environmental Response and Liability Act
MPCA	Minnesota Pollution Control Agency
NA	No Action
NAPL	Non-aqueous phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFA	No Further Action
NPL	National Priorities List
OM&M	Operation, maintenance, and monitoring
PCB	Polychlorinated biphenyl
PFAS	Per- and polyfluorinated substances
PLP	Permanent List of Priorities
QAPP	Quality Assurance Project Plan
RAA	Risk Assessment Advice
RAO	remedial/response action objective
RAP	Remedial/Response Action Plan
RBSE	Risk-Based Site Evaluation
RBV	risk-based value
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RFRA	Request for Response Action
RI	Remedial Investigation
RP	Responsible Party
SA#	Site Assessment ID #
SAP	Sampling and Analysis Plan
SLV	Soil Leaching Value
SQT	Sediment Quality Target
SRV	Soil Reference Value
SR#	Superfund Remediation ID #
TBCs	to-be-considered materials
VIC	Voluntary Investigation and Cleanup Program
VP	Voluntary Party
WQC	Water Quality Criteria
WQS	Water Quality Standards

Appendix A. Typical Reporting Documents per Remediation Phase

Federal Remediation Process	Federal Superfund Program (CERCLA)	RCRA Remediation Program
Site Assessment	•Preliminary Assessment/Site Inspection •*NPL Site Listing** •*No Further Remedial Actions Planned (NFRAP)**	•RCRA Facility Assessment (RFA)
Site Characterization	•Remedial Investigation/ Feasibility Study	•RCRA Facility Investigation (RFI) •Corrective Measures Study (CMS)
Remedy Decisions	•Proposed Plan •Record of Decision	•Statement of Basis •Final Decision and Response to Comments
Remedial Design/Remedial Action	•Design documents and work plans •Remedial Action Implementation Report •Construction Completion Report •Monitoring and Verification Reports	•Corrective Measures Implementation (CMI) Report
Post-Construction Completion	•Closure Memorandum •Deletion *from NPL**	•RCRA Corrective Action Completion Determination

MERLA Remediation Phase	Site Assessment	Superfund	VIC
Pre-Investigation	•Site Summary Report •Investigation Summary Report •*Listing on PLP*** •*Enrollment in Superfund***	•Phase I Environmental Site Assessment (ESA) •*Listing on PLP*** •*Enrollment in Superfund**	•Phase I ESA
Site Investigation		•Phase II ESA •Remedial Investigation (RI)	•Phase II ESA
Site Management Decision		•Feasibility Study (FS) •Remedial/Response Action Plan (RAP) •Minnesota Decision Document (MDD) •Remedial Design •Construction Contingency Plan (CCP)	•RAP/CCP
Response Action Implementation	N/A	•RAP Implementation Report •Operation, Maintenance, & Monitoring (OM&M) Plan •OM&M Report	•RAP Implementation Report •OM&M Plan •OM&M Report
Site Closure and Stewardship	•Site Assessment Risk-Based Closure Form	•No Action (NA) / No Further Action (NFA) Letter •*Delisting from PLP**	•Various assurance letters for closure

** Item is not considered a document, but rather an event.*

***Item is an event that may occur during any remediation phase.*

Figure does not include all potential planning documents that may be required.

Discuss reporting requirements with your MPCA project manager to clarify what is required for a particular site.

Appendix B. Media and contaminant-specific considerations

Media-specific and contaminant-specific guidance for **site characterization**, **risk assessment**, and **response action selection** provide a structured approach in the MERLA remediation process. When available, this guidance offers specific methodologies, screening values, comparison criteria, and other considerations tailored to the unique characteristics of each media or type of contaminant and should be considered alongside the unique combination of hydrogeologic conditions, environmental contamination, and potential exposure pathways at each site.

When response actions are deemed necessary, this guidance can expedite the response action evaluation and MPCA review processes by helping parties quickly identify the remedial technologies likely to be most effective at a site. Under the MPCA's flexible approach to response action selection, parties selecting remedies for sites that have specific, commonly encountered contaminant groups (e.g., wood-treating chemicals, PFAS) or media (e.g., vapor intrusion and sediment) may use common response action that have established guidance and implementation procedures. It should be noted that certain site conditions (e.g., a larger suite of COPCs or many potential exposure pathways) may require a more formal and detailed process, which often requires assessing several potential response actions for the site and all impacted media together to determine the necessary response action or remedies. Guidance for specific media and contaminants are discussed below. Links to additional information and guidance established by the MPCA and other state and federal agencies are provided throughout each section.

Soil

Contaminated soil can pose a risk to human or ecological health via the direct contact exposure route, vapor migration into buildings, or by contaminant leaching into groundwater. The decision to remediate or contain contaminated soil that is known or suspected to pose an unacceptable risk, based upon risk-based criteria, should be evaluated on a site-by-site basis. The primary goal is to eliminate exposure to contaminated shallow soil. This typically involves excavation of the contaminated soil and backfilling with clean soil to the original surface grade. Other actions may be considered, such as capping, if shown to be cost-effective and sufficiently protective of human health and the environment

In general, source control should be a priority if there is a completed pathway resulting in actual exposure to receptors. In situations where it can be demonstrated that a stable groundwater plume exists and receptors are not going to be impacted, source removal may not be necessary. However, associated ICs will be necessary when source material is left in place.

Source containment remedies, such as capping or near-source groundwater extraction, may be acceptable without source removal provided the likelihood of exposure is small, should the containment controls fail. In addition, soil-leaching-driven source removal must be evaluated in the context of the overall risk reduction and cost-effectiveness. In instances where NAPLs are present in an aquifer, it is possible that source removal in the unsaturated zone will not result in significant reduction of groundwater contaminant concentrations, and, therefore, that it will not significantly reduce groundwater associated risk. Refer to the NAPL discussion below.

Groundwater

Groundwater investigations focus on understanding hydrogeological conditions, groundwater flow patterns, and contaminant distribution and migration pathways. Due to the potential for high mobility and/or volatility of VOCs or PFAS, these compounds have the potential to travel large distances from the initial source of contamination or result in cross-media transfer to surface water or soil vapor. At sites where the COPCs include these classes of compounds, the potential exposure pathways associated with transport and media transfer should be considered.

The typical groundwater exposure pathway is ingestion of contaminated drinking water through private drinking water wells; however, other exposure pathways are possible, including ingestion of groundwater through

municipal water systems, direct contact to groundwater during construction activities, or potential cross-media transfer pathways between groundwater, surface water, and/or soil vapor. Risk-based screening values for groundwater contaminants should use the lowest applicable water guidance value established by the MDH, EPA, or MPCA, including the following: HRLs, HBVs, RAAs, MCLs, or WQS. The newest value should always be used even if it is higher than previous HBV. See the MDH's Dual Guidance for Drinking Water webpage for procedures to updating drinking water HBVs.

Vapor Intrusion

Vapor intrusion should be addressed through the existing MPCA Vapor Investigation and mitigation decision best management practices. A vapor intrusion system installed in a building is considered a risk mitigation system, rather than a remedial system. Note that at some sites, a mitigation system such as a sub-slab depressurization system is one part of a larger remedial effort that includes operation of a remedial system(s) to address the source of the contamination. The corrective action goal is to eliminate actual or potential explosive vapor concentrations. This may be accomplished by remediating the source of vapors to the point where unsafe levels will not occur. In the case of a leaky storm sewer, the goal may be accomplished by replacement or in situ repair of the sewer line.

Methane

The MPCA has developed the Remediation Division Methane Guidance (c-rem3-32) document to address methane sources from landfills and dumps, sewers, enhanced bioremediation byproducts, petroleum hydrocarbon releases, feedlots, and natural sources such as wetlands. Methane is produced from degradation of organic matter under anaerobic subsurface conditions, and production can be delayed for days to years depending on the source and subsurface conditions.

Tanks and drums

Removing sources of contamination should be the presumed response action when they are "point sources," such as tanks or drums, and removal is easily achievable. Removal of containers is an effective method of source removal when compared to contaminated soil or groundwater cleanups, because the mass of contaminated media is much smaller and more contained. In all instances where containers are known to exist and are suspected of causing environmental degradation, removal should be fully evaluated.

Surface water and sediment

The MPCAs Surface Water and Sediment Evaluation at Remediation Sites (c-rem3-31) guidance document explains the application of existing surface water quality rules and standards, and outlines the assessment process to evaluate the risks posed to receptors in surface waters and aquatic sediments discharges at remediation sites. Additionally, it is recommended to reference the ITRCs Contaminated Sediments Remediation: Remedy Selection for Contaminated Sediments interactive guidance. Remediation of contaminated sediments commonly targets the complimentary goals of protecting human health and the environment and restoring impaired environmental resources to beneficial use. Although the selection and implementation of sediment remedies can be straightforward for simple sites, many contaminated sediment sites are challenging from a technical and risk-management perspective. The ITRC guidance provides a response action selection framework to evaluate remedial technologies and develop remedial alternatives (often composed of multiple technologies) based on site-specific data.

Non-aqueous phase liquids

LNAPLs and DNAPLs, when present in soil and/or groundwater, represent a serious source of contamination and warrant specific discussion in the context of investigation, risks, and removal/cleanup.

The corrective action goal for mobile LNAPL is to recover it to the maximum extent practicable or remediate to the point where migration is no longer occurring under existing conditions as described in Light Non-aqueous Phase Liquid Management Strategy.

Removal of NAPL-impacted soil often reduces overall levels of contamination, and, therefore, risk. However, defining NAPL extent and implementing effective removal technologies can prove problematic. This is especially true of DNAPLs, which can be located deep in an aquifer or spread vertically or horizontally over large areas. If there is indication that NAPL exists at a site, investigation and removal is strongly encouraged when technically feasible and cost-effective. However, balancing criteria must be considered, and removal must be evaluated in terms of the likelihood of success and the resultant overall reduction in risk.

If another high-risk condition requires remediation, the mobile LNAPL corrective goal may be superseded or encompassed by another corrective action goal. In many cases involving NAPL, site conditions will warrant following the "complex remedy pathway" alongside the existing guidance.

Polychlorinated biphenyls

In instances where wood-treating chemicals or polychlorinated biphenyls (PCBs) are the contaminant of concern, investigating parties should utilize the EPA's guidance for PCB Site Revitalization Guidance Under Toxic Substances Control Act. The EPA developed this guidance to assist in evaluating appropriate remedial technologies for specific contaminant types. The guidance provides documentation of the effectiveness of selected remedial technologies under the particular conditions described in the documents.

Per- and polyfluoroalkyl substances

The MPCA has developed PFAS remediation guidance addressing PFAS releases at sites enrolled in a MPCA Remediation program. The guidance uses an adapted life cycle approach and provides consistent and predictable instructions for addressing PFAS contamination from investigation to clean up. It operationalizes the strategies identified in the PFAS Blueprint and expands upon the criteria established in the PFAS Monitoring Plan as the regulatory framework for PFAS sites.

Appendix C. Exposure pathway evaluations

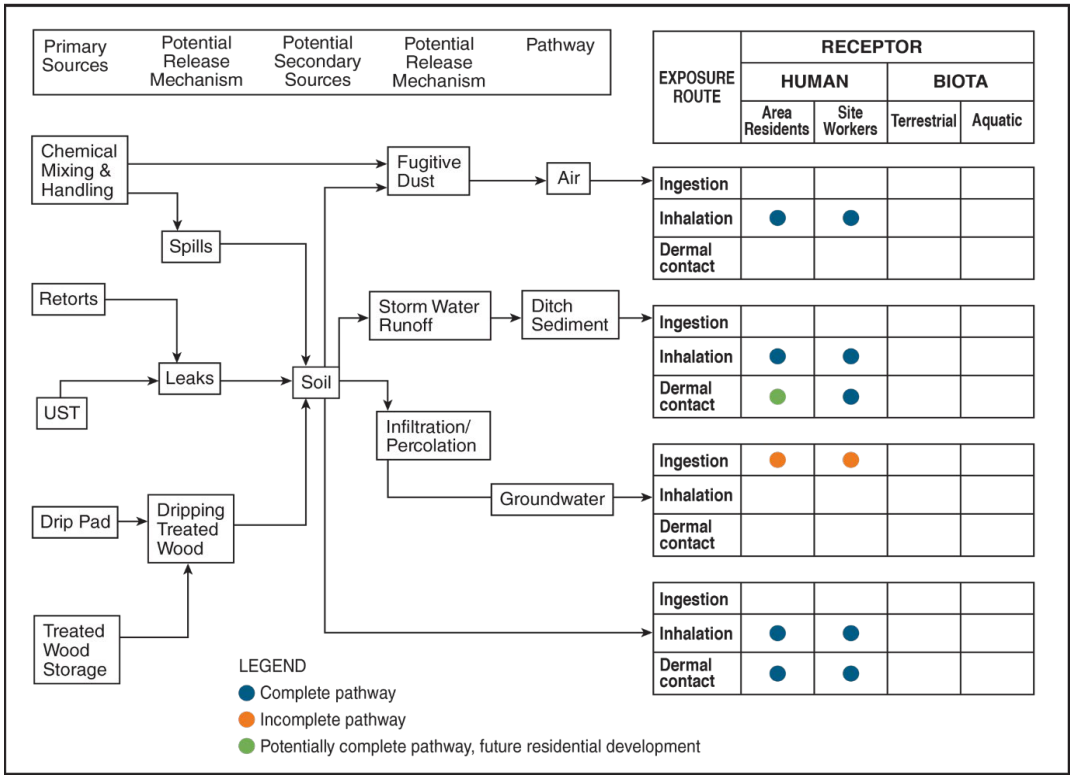
A CSMs provide a holistic view of site conditions, incorporating factors such as contaminants, environmental media, and receptor populations. By using the CSM framework to identify and evaluate exposure pathways, investigating parties are able to prioritize the investigation efforts and ensure all risks are accurately assessed. Below are two examples of how exposure pathways can be visually represented to aid in the evaluation process.

High-level pathway exposure example

Media	Exposure Route	Receptor				
		Human			Biota	
		Area Residents	Area Recreators	Site Workers	Terrestrial	Aquatic
Groundwater	Ingestion	●	●	●		
	Direct Contact	●	●	●		
Surface Water	Ingestion	●	●	●	●	●
	Direct Contact	●	●	●	●	●
Soil	Ingestion	●	●	●	●	●
	Direct Contact	●	●	●	●	●
Sediment	Ingestion				●	●
	Direct Contact	●	●	●	●	●
Vapor	Inhalation	●	●	●	●	●

Legend	
Complete pathway	●
Incomplete pathway	●
Potentially complete pathway	●
Not Applicable	

Example for pathway-exposure conceptual site model



Source: ITRC, Decision Making at Contaminated Sites, 2015

Appendix D. Remedy technology resources

There are many useful resources that focus on remedial technologies. The list below provides general reference material on a wide variety of remedial approaches. Users should note that in many situations more than one response action/remedy or remedial technology may be needed, concurrently or sequentially, to achieve cost-effective remediation throughout the life cycle of a given site. Commonly used, well-documented remedial technologies may require fewer supporting data than newer, more experimental technologies; however, an appropriate level of site characterization is still required to assess whether the remedy is suitable for the site.

- **EPA CLU-IN Database:** This database contains useful information on emerging remedies and references to a wide variety of other information sources on specific remedies.
- **Interstate Technology Regulatory Council Guidance & Documents:** This database provides guidance documents pertaining to specific remedial technologies as well as contaminants of concern.
- **Envirowiki:** This webpage provides overviews on the science and application of common remedial technologies.
- **EPA Superfund Data and Reports Database:** This database contains over 30,000 documents containing information from active and archived contaminated sites evaluated by Superfund.
- **Federal Remediation Technologies Roundtable (FRTR) Technology Screening Matrix:** This matrix allows users to screen up to 49 in situ and ex situ remedial technologies for soil and groundwater remediation. The FRTR database provides information for each of the technologies, including applicability, cost, and implementability considerations.
- **EPA Community Guides to Cleanup Technologies:** This webpage provides community guides for 26 different remedial technologies. These guides seek to answer basic questions about specific remedial technologies such as “what is it?” “how does it work?” and “is it safe?”
- **EPA Brownfields Road Map to Understanding Options for Site Investigation and Cleanup:** This document provides a general outline for the steps needed to investigate and clean up Brownfields sites, as well as example processes for technology selection.
- **Eni Rewind’s Remediation Technologies Handbook:** This handbook provides guidance for contaminant characteristics, preliminary assessments, and innovative remedial technologies.

Technology screening tables

The soil and groundwater technology screening matrices provided below are versions of the screening matrices developed by *Eni Rewind’s Remediation Technologies Handbook* with supplemental information from the *FRTR Technology Screening Matrix*. These matrices identify the suitability of remediation technologies based on the type of contaminant and are grouped into three categories:

- Applicable – The technology has demonstrated the capability of removing the contaminant at a high efficiency.
- Limited Efficiency – The technology has demonstrated it is capable of addressing the contaminant but is often limited by site conditions, lithology, or other factors.
- N/A – The technology is generally incapable of removing the contaminant at an acceptable efficiency.

These matrices are not meant to be exhaustive lists of remedial technologies, but instead serve as starting points for identifying potential remedial technologies based on the type of media and contaminant. A list of additional useful resources is provided, below, which are organized by treatment technology.

Soil technology screening matrix

Soil Technology Screening Matrix		Contaminants						
		Inorganic Compounds	Organic Compounds					
Technology	Remediation Times	Metals	Non-halogenated VOCs	Halogenated VOCs	Non-halogenated SVOCs	Halogenated SVOCs	Hydrocarbons/ Fuels	Other/Emerging Contaminants
In Situ Biological Treatments								
Natural Attenuation	Lengthy	Applicable	Applicable	Applicable	Applicable	Applicable	N/A	
Bioremediation	Lengthy	Limited Efficiency	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable for 1,4-dioxane
Bioventilation	Short/ Medium	N/A	Applicable	Limited Efficiency	Applicable	Limited Efficiency	Applicable	
Phytoremediation	Lengthy	Limited Efficiency	Limited Efficiency	Applicable	Limited Efficiency	Applicable	Applicable	
Ex Situ Biological Treatments								
Biopile	Short/ Medium	N/A	Applicable	Limited Efficiency	Applicable	Limited Efficiency	Applicable	
Landfarming	Medium	N/A	Applicable	Limited Efficiency	Applicable	Limited Efficiency	Applicable	
In Situ Physical/Chemical Treatments								
Air Sparging and/or Soil Vapor Extraction	Short/ Medium	N/A	Applicable	Applicable	Limited Efficiency	Limited Efficiency	Limited Efficiency	Applicable for mercury and radon; Limited effectiveness for 1,4-dioxane and PFAS
Capping	Short	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable	
Chemical Oxidation	Short	N/A	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable for 1,4-dioxane
Soil Flushing	Short/ Medium	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable for perchlorate and PFAS
Solidification/Stabilization	Medium	Applicable	N/A	N/A	Limited Efficiency	Limited Efficiency	Limited Efficiency	Limited effectiveness for 1,4-dioxane and PFAS, further study needed
Thermal	Short	N/A	Applicable	Applicable	Applicable	Applicable	Applicable	
Ex Situ Physical/Chemical Treatments								
Desorption and Incineration	Short	N/A	Applicable	Applicable	Applicable	Applicable	Applicable	Potentially applicable for PFAS
Excavation and Disposal	Short	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable	
Soil Washing	Short	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable for PFAS

Note: The Soil Technology Screening Matrix provides a list of common, well-documented technologies for consideration. Primary sources: Eni Rewind's Remediation Technology Handbook and Federal Remediation Technologies Roundtable.

Groundwater technology screening matrix3

Groundwater Technology Screening Matrix		Contaminant						
		Inorganic Compounds	Organic Compounds					
Technology	Remediation Times	Metals	Non-halogenated VOCs	Halogenated VOCs	Non-halogenated SVOCs	Halogenated SVOCs	Hydrocarbons/ Fuels	Other/Emerging Contaminants
In Situ Biological Treatments								
Natural Attenuation	Lengthy	Applicable	Applicable	Applicable	Applicable	Applicable	N/A	
Bioreactors	Lengthy	Limited Efficiency	Limited Efficiency	Applicable	Limited Efficiency	Applicable	N/A	
Cometabolic Bioremediation	Lengthy	N/A	Applicable	Applicable	Applicable	Applicable	Limited Efficiency	Applicable for 1,4-dioxane
Enhanced Aerobic Bioremediation	Lengthy	Limited Efficiency	Applicable	Applicable	Limited Efficiency	N/A	Limited Efficiency	Applicable for 1,4-dioxane
Enhanced Anaerobic Bioremediation	Lengthy	N/A	N/A	Applicable	N/A	Applicable	N/A	
Phytoremediation	Lengthy	Limited Efficiency	Limited Efficiency	Applicable	Limited Efficiency	Applicable	Applicable	
In Situ Physical/Chemical Treatments								
Activated Carbon Adsorption	Lengthy	N/A	Applicable	Applicable	N/A	N/A	Applicable	
Air Sparging	Medium	N/A	Applicable	Applicable	Limited Efficiency	Limited Efficiency	Limited Efficiency	
Chemical Oxidation	Short/ Medium	N/A	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable for 1,4-dioxane; Current testing being performed for PFAS
Chemical Reduction	Lengthy	Applicable	N/A	Applicable	N/A	Limited Efficiency	N/A	
Electrokinetic-Enhanced	Medium/ Lengthy	Limited Efficiency	N/A	Applicable	N/A	Applicable	N/A	Current testing being performed for LNAPL
Multi Phase Extraction	Medium	N/A	Applicable	Applicable	Limited Efficiency	N/A	Applicable	
Permeable Reactive Barriers	Lengthy	Limited Efficiency	Applicable	Applicable	Applicable	Applicable	Limited Efficiency	
Thermal	Short	N/A	Applicable	Applicable	Applicable	Applicable	Applicable	
Ex Situ Physical/Chemical Treatments								
Adsorption	Lengthy	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable for PFAS
Air Stripping	Lengthy	N/A	Applicable	Applicable	Limited Efficiency	Limited Efficiency	Limited Efficiency	
Chemical Precipitation	Lengthy	Applicable	N/A	N/A	N/A	N/A	N/A	
Filtration	Lengthy	Applicable	N/A	N/A	N/A	N/A	N/A	
Pump and Treat	Lengthy	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable	
Reverse Osmosis	Lengthy	Applicable	Applicable	Applicable	Applicable	Applicable	N/A	

Note: The Groundwater Technology Screening Matrix provides a list of common, well-documented technologies for consideration. Primary sources: Eni Rewind's Remediation Technology Handbook and Federal Remediation Technologies Roundtable.

Additional remediation technology resources

Remediation technologies	Media	Resources
Air Sparging	Soil, groundwater	FRTR, CLU-IN/EPA, CLU-IN/NAVFAC ScienceDirect
Bioreactors	Soil, groundwater, surface water, sediment	FRTR, Envirowiki, EPA CLU-IN/U.S. Air Force
Biopile	Soil, sediment	FRTR, CLU-IN/EPA
Bioremediation	Soil, groundwater, surface water, sediment	FRTR, EnviroWiki, CLU-IN/EPA, EPA
Bioventilation	Soil, groundwater	FRTR
In Situ Chemical Oxidation	Soil, groundwater, sediment	FRTR, CLU-IN/EPA, EnviroWiki, EnviroWiki, EPA,
In Situ Chemical Reduction	Soil, groundwater, sediment	FRTR, CLU-IN/EPA, Envirowiki, EPA
Electrokinetics	Soil, groundwater	FRTR, CLU-IN/EPA, NAVFAC
Excavation and Disposal	Soil, sediment	FRTR, EPA
Granular Activated Carbon (Adsorption)	Soil, groundwater, sediment	FRTR
Landfarming	Soil, groundwater, sediment	FRTR
Multi-Phase Extraction	Soil, groundwater	FRTR, CLU-IN/EPA
Natural Attenuation	Soil, groundwater, surface water, sediment	FRTR, CLU-IN/EPA
Phytoremediation	Soil, groundwater, surface water, sediment	FRTR, CLU-IN/EPA
Permeable Reactive Barriers	Soil, groundwater, sediment	FRTR, CLU-IN/EPA, EPA
Sediment Capping	Sediment	FRTR, FRTR, ITRC, EPA
In Situ Flushing	Soil, groundwater	FRTR, CLU-IN/EPA
Soil Vapor Extraction	Soil	FRTR, CLU-IN/EPA, EnviroWiki
Solidification/Stabilization	Soil, groundwater, sediment	FRTR, CLU-IN/EPA
Soil washing	Soil	CLU-IN/EPA
Pump and Treat	Soil, groundwater, surface water, sediment	FRTR, ITRC
Thermal Treatments	Soil, groundwater, sediment	FRTR, FRTR, FRTR, CLU-IN/EPA, CLU-IN/EPA
Water Treatment Technologies	Groundwater, surface water	FRTR

Appendix E. Comparative and analysis tools

Comparative analysis tools can be used to assess and compare potential response actions using the threshold, balancing, and Minnesota criteria. Below are two examples of comparative analysis tools using quantitative and qualitative comparison methods that may assist in the response action evaluation. The criteria comparison method is site-specific and will vary for each site.

Quantitative comparative analysis tool

Evaluation criteria	Choice 1	Choice 2	Choice 3
Overall protection of human health and the environment (8)	3	2	1
Compliance with ARARs (8)	3	1	2
Long-term effectiveness and permanence (6)	3	3	1
Reduction of toxicity, mobility or volume through treatment (5)	3	1	1
Short- and long-term risks-term effectiveness (6)	3	2	1
Implementability (4)	3	2	1
Cost-effectiveness (1)	3	2	2
Community acceptance (2)	3	3	1
Cumulative impacts and environmental justice (3)	3	1	2
Planned use of the property (6)	3	1	1
Source control (7)	3	2	1
Cross-media contamination (6)	3	1	2
Institutional controls (8)	3	1	1
Total	**210**	**112**	**88**

Rank remedial solutions against each other in each category, with the best option getting a 3 and the worst a 1. Use weighted values (in parenthesis) to define importance of criteria as needed in order to calculate a total score for each choice.

Qualitative comparative analysis tool