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Canada

Federal Contaminated Sites Action Plan (FCSAP)

Executive Summary of the FCSAP

Long-Term Monitoring Planning Guidance

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Purpose of the FCSAP LTM Planning Guidance

The overall goals of this document are to:

- provide a framework for the development and implementation of scientifically defensible LTM plans;
- facilitate consistency, as is practicable, across federal departments, regions and regulatory jurisdictions for content and implementation of LTM plans; and
- establish procedures for identifying decision criteria prior to LTM data collection.

Specific objectives are to:

- focus custodians' (i.e., federal departments, agencies and consolidated Crown corporations responsible for contaminated sites) attention on the potential long-term monitoring requirements of a particular remedial option before it is selected and developed into a Remedial Action Plan (RAP) or Risk Management Plan (RMP);
- facilitate development of a baseline scope, schedule, and cost for LTM; and
- provide a mechanism to ensure that the risk management/remediation performance and goals of a particular site continue to be achieved.

The guidance document is organized as follows:

1. **Section I:** *Introduction*.
2. **Section II:** *Understanding Long-Term Monitoring in the Context of the Federal Approach to Contaminated Sites (FACS)*. This section defines LTM, provides examples of LTM activities, discusses where LTM fits within the FACS 10-step process, and provides guidance on when LTM is required for a FCSAP project.
3. **Section III:** *Steps for Developing an LTM Plan – The United States Environmental Protection Agency Six-Step Process*. This section describes a scientific approach for developing a monitoring plan that is capable of achieving site closure where possible. Guidance is provided on the development of

monitoring objectives and decision rules for interpretation of monitoring program results.

4. **Section IV:** *Project Management and Policy Considerations*. This section discusses issues related to project management, such as FCSAP cost eligibility, roles and responsibilities, stakeholder involvement, adaptive management, and LTM project scope considerations.
5. **Section V:** *References*.
6. **Appendix A:** *Main Findings of Custodian and Expert Support Consultation on FCSAP LTM*. This appendix provides further details on the consultation outcomes.
7. **Appendix B:** *Terrestrial Contaminated Sites: Guide to Additional References for LTM Program Design and Management*. This appendix includes examples of best practices for LTM at terrestrial contaminated sites and a guide to further resources for LTM project management.
8. **Appendix C:** *Aquatic Contaminated Sites: Scientific and Technical Guidance for Developing LTM Programs and a Case Study Review*. This appendix provides further technical guidance for LTM of aquatic contaminated sites, including a case study review.
9. **Appendix D:** *Long-Term Monitoring Plan Template*. This appendix provides a template for LTM plan content that may be used to develop a scope of work for LTM plans.
10. **Appendix E:** *Long-Term Monitoring Plan Review Checklist*. This appendix provides a checklist that may be used to review the content of LTM plans.

Disclaimer on the Scope of the FCSAP LTM Planning Guidance and Intended Users

The guidance document focuses on the contaminated site LTM process and its appropriate documentation in the Canadian federal context only for sites that will remain under federal control. It is not intended to provide regulatory or technical guidance on LTM of contaminated sites subject to provincial or territorial jurisdictions.

Furthermore, the document is not intended to prescribe the scale, complexity, protocols, data quality objectives or investigation methods for meeting the needs of site-specific monitoring. Rather, it presents a framework that can be used to develop and implement scientifically defensible and appropriate LTM plans that promote national consistency and transparency in the contaminated site management decision-making process.

The guidance is intended for use by federal contaminated site remediation/risk management project managers, managers of contaminated site programs (groupings of projects) and project sponsors (organizations that have management responsibility for contaminated properties). The guide has been developed primarily for use by custodian department project managers, expert support departments and other FCSAP practitioners.

Understanding Long-Term Monitoring in the Context of the Federal Approach to Contaminated Sites (FACS)

Contaminated site management encompasses activities that are designed to define the human health and environmental risks posed by the site, and then to take action to reduce or mitigate those risks. In the federal context, the FACS (CSMWG, 1999) describes a 10-step process that generally encompasses the activities that might be included in the management of a contaminated site. A flowchart illustrating the FACS process is shown in Figure 1:

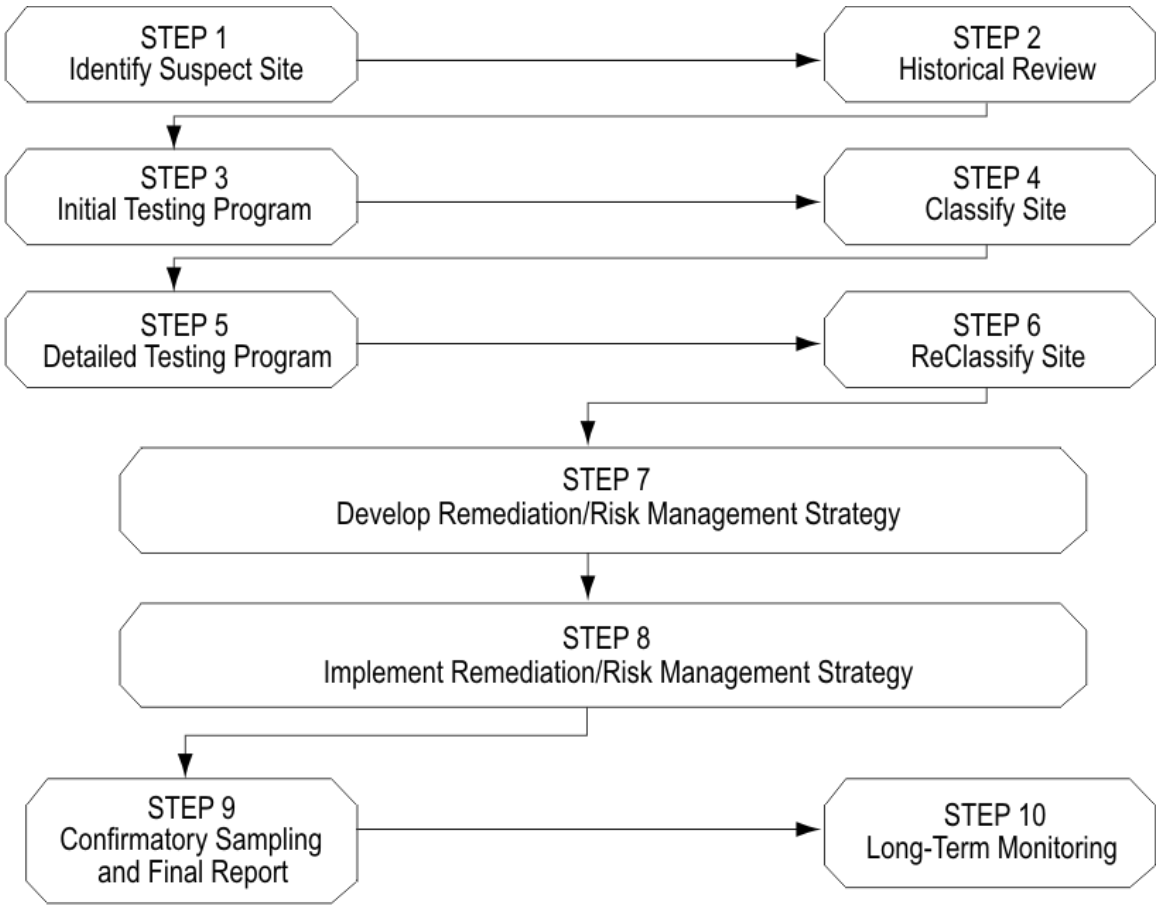

Figure 1: The 10 steps for addressing a contaminated site under the Federal Contaminated Sites Action Plan (FCSAP).

LTM takes place in Step 10 of the FACS process and begins after the remediation/risk management (R/RM) goals have been achieved. The main driver for developing LTM plans is the need to ensure that R/RM controls remain protective of human health and the environment. LTM is typically required at sites where the R/RM approach relied on the elimination of contamination transport pathways to receptors rather than the removal or treatment of contaminants exceeding remediation objectives.

These include sites where:

- Engineered controls, such as containment strategies, stabilization or encapsulation, were used to manage contaminants and/or physical hazards on site;
- Institutional controls, such as restriction of site access or land uses, are implemented to reduce receptor exposure; or
- Contaminants were left in place based on the results of a risk assessment (RA), but site conditions are dynamic and require confirmation that the site model on which the RA is based remains valid over time.

Other factors, such as regulatory requirements or the need to address stakeholder concerns, may also influence whether LTM is necessary for a particular site.

There is currently no federal guidance available for planning and implementing LTM. Some custodian departments have developed their own process for planning and implementing LTM; this guidance is not intended to replace these established processes, but such processes should be aligned with the intent contained herein.

LTM plans are typically designed to meet one or more of the following goals: (1) to audit the R/RM action and evaluate its overall effectiveness and efficiency over time; (2) to provide early warning that additional R/RM action may soon be necessary; and (3) to audit contaminant concentration levels at a compliance location. This assumes that the R/RM goals have already been met, as confirmed by the confirmatory sampling conducted in Step 9, but that for one reason or another there is residual risk necessitating LTM, which occurs at Step 10. LTM is most applicable to cases where contaminant concentrations are not reduced but, rather, exposure pathways are mitigated — for example, through construction of landfill caps or containment walls.

There are a number of types of environmental monitoring related to contaminated site management. Many of these monitoring methods are associated with the implementation of the remedial/risk management plan (Step 8 of the FACS) and are

therefore NOT considered to be part of LTM. A pipeline indicating where each of the monitoring activities fits within the FACS 10-step process is provided in Figure 2.

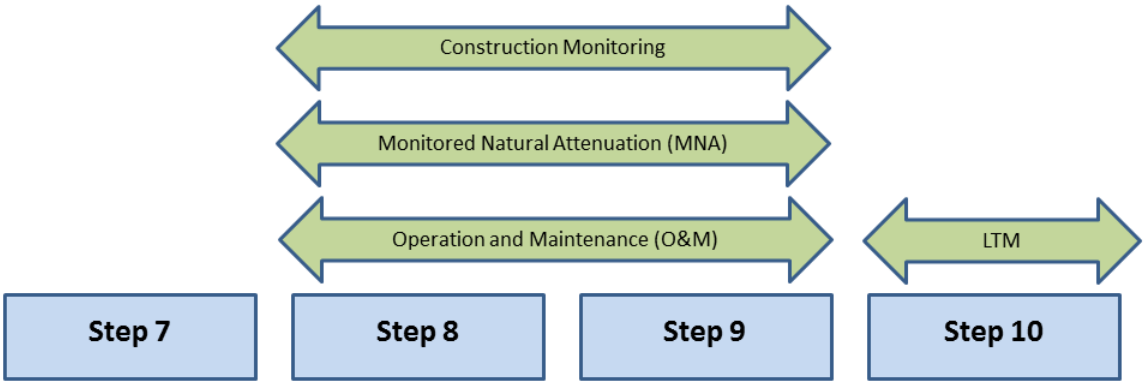

Figure 2: Pipeline indicating where environmental monitoring activities fit within the FACS 10-step process.

Site closure is attained when the contaminated site no longer poses unacceptable human and ecological risks and these conditions are anticipated to continue for the foreseeable future so that no further management action is required. It is critical to plan for site closure as early as possible in the FACS process. The scientific approach for developing LTM plans presented in the FCSAP LTM Planning Guidance is intended to facilitate the achievement of site closure and is summarized in the following section.

When is LTM Required, and When is it Not Required?

According to the available FCSAP guidance materials, long-term monitoring may or may not be required depending on the nature and extent of remedial activities at a particular site. LTM is NOT typically required at sites that:

- have undergone remediation wherein all contaminated materials and media have been removed from the site and confirmatory sampling has been completed and confirms this;
- have had contaminated material or media treated such that no contaminants of concern have been left in place at concentrations above the remediation criteria

established for the site and confirmatory sampling has been completed and confirms this;

- do not constitute a risk to human health or the environment and require no further remedial action based on the findings of a risk assessment; or
- have been investigated and demonstrated to not exceed applicable guidelines, standards or criteria, whether generic or risk-based.

Each site must also be evaluated for potential risk for migration of contaminants off the site and for ongoing impacts to the surrounding environment.

R/RM at many federal contaminated sites, especially those that are remote, often involves leaving some contaminants on site. Risk management approaches that rely on containment, fixation or other sequestration methods to eliminate contaminant transport pathways to receptors generally require some level of ongoing monitoring. In the case of U.S. federal contaminated sites (Superfund sites) that rely on such methods, ongoing monitoring is required at five-year intervals in perpetuity.

The following are examples of remedial actions, infrastructure and situations that typically require LTM (US EPA, 2001):

- on-site waste encapsulation, stabilization or fixation;
- landfill caps or covers and slurry walls;
- site access controls such as roads, signage and fencing;
- sediment capping;
- sites at which R/RM has been implemented but where residual contaminants in soil, sediment or groundwater (usually at depth) are still present at levels above generic or site-specific criteria and represent a continuing threat to the receptors and potential users of the site; or
- sites where contaminants were left in place based on the results of a risk assessment (RA), but site conditions are dynamic and require confirmation that the site model on which the RA is based remains valid over time (e.g.,

submerged tailings or contaminated sediment or seasonal variation of water table).

A flowchart outlining the main remedial actions and criteria determining when LTM is required is provided in Figure 3.

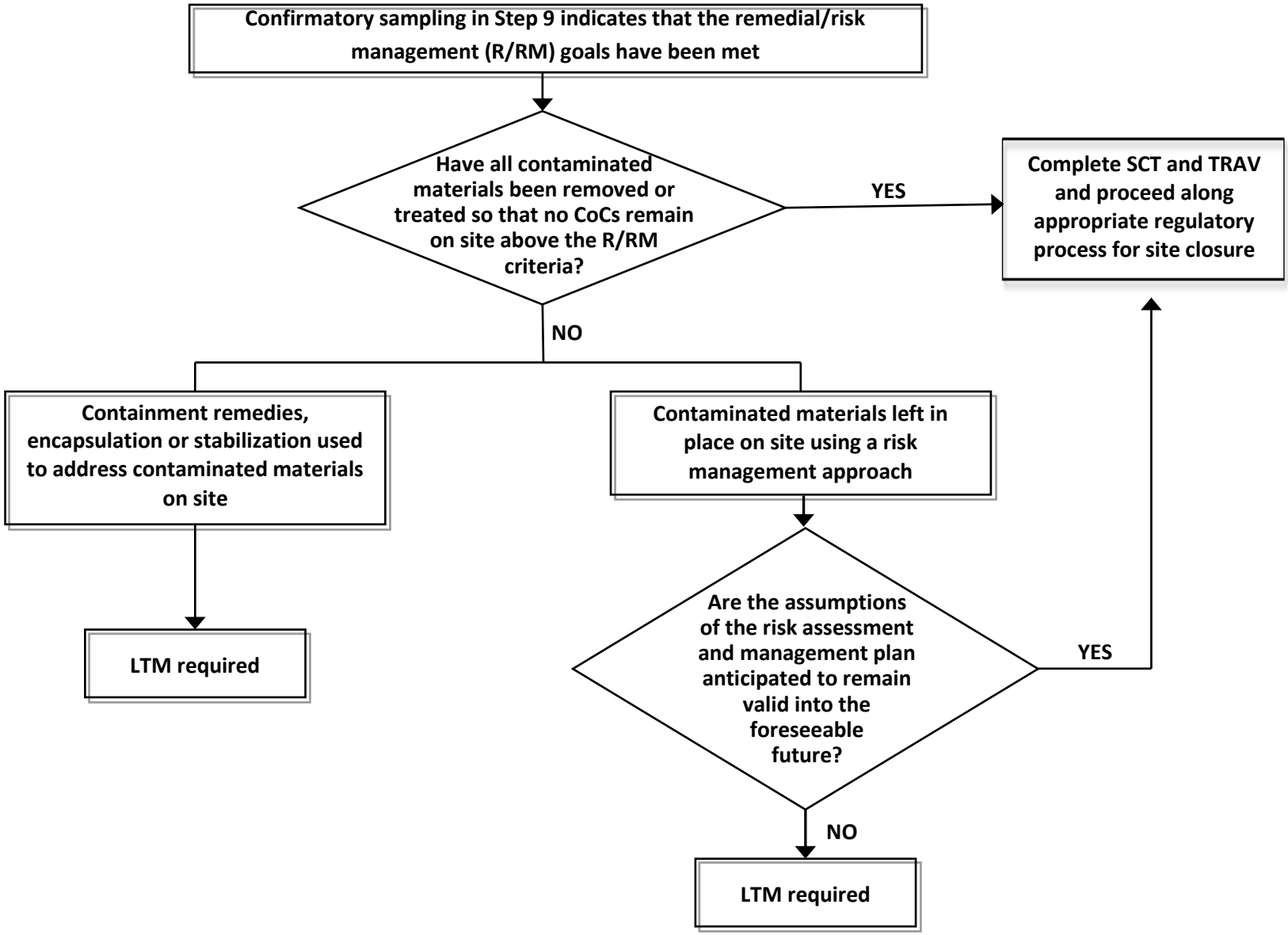

Figure 3: Flowchart indicating when LTM may be required for a FCSAP site. CoCs = Contaminants of Concern; SCT = Site Closure Tool; TRAV = Tool for Risk Assessment Validation.

Consultation with custodian department representatives has indicated that other factors may be drivers for developing an LTM plan for a particular site. For instance, an LTM plan is a requirement for acquiring a water use licence from regulators in northern Canada such as the Nunavut Water Board. Such regulatory requirements are typical for many federal contaminated sites in northern Canada, especially mine and military sites. Legal/regulatory requirements for LTM are not usually very prescriptive and are generally performance-based — for example, to prevent impacts to wildlife or fish habitat (Pike, 2011). Whether or not LTM is necessary for a particular RM strategy is a decision that must be made by the professional or group of professionals responsible for the site management.

Examples of LTM Activities

There are many LTM activities that apply to federal contaminated sites. Some examples of these are listed below.

1. Inspection of on-site containment and treatment facilities

On-site containment of contaminated material is a common approach to managing the risk to human health and the environment that these materials may represent. Containment is considered a risk management approach because the contaminants of concern (CoCs) are not removed from the site; rather, the potential transport pathways are removed through the use of engineered controls. Sediment caps, on-site engineered containment facilities for contaminated sediments, landfills and caps, and surface water drainage controls are examples of typical containment strategies. Appendix B provides additional detail and recommended best practices for monitoring constructed facilities.

2. Evaluation of risk assessment and/or risk management assumptions

Risk management plans are often based on the results of a human health and ecological risk assessment (HHERA), which may include various lines of evidence to determine risk levels and to set site-specific criteria and/or protection goals. This category of monitoring consists of collecting data to ensure that exposure pathways, CoCs, and

receptors have not changed and that the site continues to meet the project risk assessment criteria.

This type of monitoring is commonly used at aquatic sites and may involve the collection of sediments and biological samples (e.g., fish) to ensure that contaminant concentrations in the aquatic food web are decreasing.

3. Inspection of stabilized structures

Stabilized structures are engineered measures that are used to control migration of contaminants from a site, limit erosion or mitigate potential physical hazards. Long-term monitoring activities include visual inspection of stabilized structures to ensure continued stability, measurements of permafrost degradation and/or aggradation in northern regions, chemical analysis of groundwater, surface water and soil quality, and evaluation of revegetation success. Best practices and guidance for LTM of such stabilized structures are available from a variety of sources; several resources are summarized in Appendix B.

4. Institutional and administrative controls

At some risk-managed contaminated sites, restricting site access is one form of institutional or administrative control with the goal of preventing exposure to residual contamination to ensure continued protection of human and environmental health. If restriction of site access is a component of a risk management plan for a site, confirmation of the continued integrity of these measures should be included in the LTM plan for the site. Some typical site access measures that would require monitoring and maintenance over time include fencing, blockage of underground mine surface openings, site access road barriers, and warning signage.

Planning for Site Closure

The current Treasury Board definition of a “closed” site is one for which no future action is required and no further liability exists. Site closure is not listed as a discrete step in the FACS framework, but it corresponds to the final decision point on the achievement

of remedial goals — that is, the point at which the contaminated site no longer poses human and ecological risks and these conditions are anticipated to continue for the foreseeable future so no further management action is required. Achieving site closure for sites under FCSAP is important as this makes it possible to demonstrate program and site-level achievements as well as to document the successful completion of the remedial and/or risk management objectives.

Clear definition of remedial objectives is necessary to determine and measure the success of a selected remediation approach; similarly, the ongoing success of a remediation project requires clear definition of the LTM objectives. Selection of the remedial option and development of the RAP or the RMP should be done in conjunction with the evaluation of the LTM requirements (if any) associated with the proposed remedial option. This facilitates the achievement of site closure by defining the final project acceptance criteria early in the planning process, and also allows for potential monitoring costs to be taken into account during the remedial options analysis (Pike, 2011).

The Tool for Risk Assessment Validation (TRAV) was developed to confirm the quality and documentation of risk assessments that are undertaken to support a risk management approach to contaminated site remediation. The TRAV was subsequently integrated into a more comprehensive Site Closure Tool (SCT). The SCT includes recommended minimum requirements for risk management and LTM, and provides a template so that RM and LTM measures for the project are clearly documented. The process of closing federal contaminated sites has many inter-related steps. Upon completion of Step 5 of the FACS (Detailed Testing Program), project and program managers may begin to use the FSCAP SCT to document the process and to guide future site planning to ultimately achieve site closure.

Site closure is intimately tied to the design of the monitoring program: the monitoring objectives, measurement endpoints and associated monitoring exit criteria decided at the start of the program are used to determine when the LTM goals have been

achieved. To document progress toward site closure, quantifiable measurement endpoints and action levels that indicate when the monitoring objective has been achieved must be defined as part of the monitoring program design.

In practice, since federal projects often incorporate risk management (where contaminants are left in place or are treated in some way and left on site), many sites require some level of ongoing LTM. However, the scope of monitoring can be reduced greatly over time as knowledge of the R/RM strategy performance increases and as monitoring indicates that R/RM remedial goals continue to be met.

Steps for Developing an LTM plan: The US EPA Six-Step Process

The FCSAP LTM Planning Guidance is based on the United States Environmental Protection Agency (US EPA) six-step framework for developing LTM plans that will support management decisions and site closure (US EPA, 2004). Within this framework, Steps 1 through 3 document the logic and rationale of the monitoring program by developing monitoring objectives that are related directly to the objectives of the site remediation or risk management activity and by developing decision rules that will support site management decisions. Steps 4 through 6 ensure that this logic is maintained by focusing data needs and data collection and analysis methods to provide direct support to the monitoring objectives, decision rules, and subsequent management decisions. The framework is iterative and allows for evaluation of the monitoring data as they are generated, thus supporting adaptive management of the site activity and the monitoring program.

The following is a summary of the US EPA six-step framework for developing LTM plans and the key points to consider at each step:

1. Identify monitoring plan objectives

Monitoring plan objectives are specific statements that clarify the scope and intent of the monitoring program. Identifying a clear set of quantifiable monitoring objectives is

critical for developing an LTM plan that is capable of achieving site closure where possible.

Monitoring objectives are identified by examining the site activities (e.g., engineered and institutional controls) that are used as part of the R/RM strategy. This examination should focus on the anticipated outcomes of the site activities, the mode of action, the exposure pathways for the human and ecological receptors determined to be at risk at the site, and the contaminants of concern and associated remediation objectives. Key assumptions of the R/RM strategy that need confirmation or require on-going monitoring to ensure continued protectiveness should also be identified during this review. Stakeholder involvement in defining monitoring objectives is important to ensure that the monitoring plan considers stakeholder issues and concerns and to facilitate final acceptance of the completed R/RM and LTM activities.

2. Develop monitoring plan hypotheses

Monitoring plan hypotheses are statements and questions about the relationship between an R/RM activity and one or more expected outcomes for that activity. The development of monitoring objectives, monitoring hypotheses, and a monitoring conceptual model serves to focus the monitoring program on achieving a desired outcome (e.g., site closure) rather than facilitating the continuous collection of data for an undefined purpose.

Identification of monitoring hypotheses is assisted by the development of a comprehensive post-remediation/risk management conceptual site model (CSM). The CSM summarizes all available site-specific information related to contaminant sources and release mechanisms, affected media, contaminant transport and environmental fate, and receptor exposure, and it should be updated to reflect post-R/RM conditions.

Key questions to consider when developing monitoring hypotheses based on the CSM are as follows:

- Where was contamination left on site?

- What are the residual vulnerabilities/risks to human health and the environment?
- Are there areas with incomplete understanding regarding R/RM assumptions and residual risk?
- Are there sentinel species, specific environmental media or measurement points on which LTM should focus?
- Have the locations and frequency of monitoring activities been identified on the basis of vulnerability and current scientific and traditional knowledge?

3. Formulate monitoring decision rules

Monitoring decision rules are quantitative pass/fail statements that are used to evaluate monitoring data and decide on a course of action. Decision rules include an action level (also called a trigger or a target) against which the monitoring results are compared, as well as management actions to be considered when the action level has or has not been exceeded. The development of scientifically defensible decision criteria is essential for effective project management and decision-making.

The following questions are useful in developing monitoring decision rules:

- Why are we going to monitor this specific component?
- What is the vulnerability or risk that LTM is mitigating?
- How would we know that there was a problem?
- What would constitute a trigger for action?

Action levels for decision rules should be consistent with remedial objectives for the site and the outcomes of the site-specific risk assessment. The LTM plan should also detail alternative actions to be considered for implementation when an action level has not been met, including a contingency plan and emergency response procedures if required.

To assess progress toward site closure, it is critical to establish quantitative exit criteria that represent the successful completion of each monitoring objective where possible. When the exit criteria are met, monitoring for that objective may be concluded.

4. Design the monitoring plan

In this step, the data needs, data collection and analysis methods, quality assurance/quality control (QA/QC) requirements and final decision rules are developed. The method for developing monitoring plans relies heavily on the use of the US EPA data quality objective (DQO) process (US EPA, 2000). It consists of the following four stages:

i. *Identify the data needs*: This stage identifies which data are necessary to test the monitoring hypotheses, to answer the monitoring questions, to test the validity of key assumptions for the conceptual site model, and ultimately to support a management decision. The QA/QC requirements should also be identified and documented as part of the monitoring quality assurance project plan (QAPP).

ii. *Determine the monitoring boundaries*: These boundaries represent the "what, where, and when" aspects of the monitoring plan. Spatial boundaries delineate the entire geographical area of the site subject to LTM and define monitoring sample locations, including reference sites if appropriate. Temporal boundaries include identifying the index period for monitoring activities, the monitoring frequency, and the anticipated timeframe required before monitoring activities can be terminated.

iii. *Identify the data collection methods*: The available approaches for collecting the required data are reviewed in this stage and screened to select the approach that will best meet the data needs within required time and cost constraints. A list of screening criteria to aid in selection of monitoring tools is presented in Box 3 of the FCSAP LTM Planning Guidance.

iv. *Identify the data analysis methods*: The statistical design and approach for analyzing the monitoring data are determined in this stage, including DQOs such as the level of significance and statistical power. A robust statistical design is critical to ensure that the study design and data analysis methods are able to distinguish between natural variability in the data and actual response in the parameter being evaluated.

Following integration of these steps, the monitoring plan is reviewed and optimized to select the most cost-effective approach for data collection and analytical measurement that will meet the monitoring objectives. The final choice of monitoring program design, as well as the main assumptions and rationale for its selection, should be documented at this stage. An LTM report template and associated reviewer checklist are provided in Appendices D and E, respectively, of the FCSAP LTM Planning Guidance.

5. Conduct monitoring analyses and characterize results

As the monitoring data are collected, the first stage in data review is to determine whether the data meet the DQOs for the monitoring plan design outlined in the monitoring QAPP. If the data do not meet the DQOs, the underlying reasons for the deviations should be assessed. Once the cause of the deviations is identified, either the remedial strategy or the monitoring plan may be revised. Any changes should be documented as revisions to the LTM plan and/or monitoring QAPP.

6. Establish the management decision

If the data do meet the DQOs, the data are evaluated in this step to identify recommended actions for each monitoring objective using the decision rules established in the LTM plan. Where appropriate, trend analysis should be carried out to compare monitoring data with results from previous monitoring events. If the monitoring results are not trending towards meeting the decision rule, causative factor and uncertainty analyses should be conducted and recommendations should be made for revising the R/RM strategy and/or LTM plan if needed. The monitoring data should also be used to evaluate assumptions and uncertainties within the post-remediation conceptual site model and to refine the model where necessary.

In addition to evaluating the data in relation to the monitoring decision rules, project managers should assess the continued effectiveness of the R/RM strategy for protecting human health and the environment. Three key questions are used to evaluate remedy protectiveness as follows (after US EPA, 2001):

- Is the remedy functioning as intended by the R/RM plan?
- Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?
- Has any other information that could call into question the protectiveness of the remedy been identified?

Finally, recommendations for changes to the scope of the monitoring program should be identified and an evaluation of progress towards site closure should be made. As exit criteria are achieved for each monitoring objective, related monitoring activities can be concluded. Site closure is achieved when the exit criteria have been met for all of the monitoring objectives. At this point, the remedial strategy and the monitoring program for the site may be concluded. The monitoring program outcomes and the scientific rationale used to determine that the site no longer poses unacceptable human health and ecological risks should be documented in accordance with the site closure tool and reporting framework developed by Public Works and Government Services Canada (PWGSC).

Final site closure may not be attainable for those sites at which contaminants remain in place (e.g., capped sites and those with engineered containment facilities) and ongoing maintenance and performance monitoring are required. However, as confidence in the conceptual site model assumptions and remedy performance increases, the scope and frequency of associated monitoring activities may be greatly reduced. As new technologies (e.g., remote sensing) become more broadly available, alternative methods for data collection that could meet the monitoring objectives in a more cost-effective manner should be explored as part of an adaptive site management approach.

Project Management and Policy Considerations

Section IV of the FCSAP LTM Planning Guidance outlines important issues for effective project management of LTM programs. These considerations have been provided in the

guidance document to highlight the need to develop the LTM plan concurrently with development of the R/RM strategy for both funding and scientific reasons.

Current practice for developing LTM plans includes implementing recommendations of a qualified firm, as well as assembling a team including the client (custodian), consultant, expert support departments (Fisheries and Oceans Canada (DFO), Environment Canada (EC), Health Canada (HC), and PWGSC), provincial or territorial governments, and other stakeholders to answer key questions, including:

- Is the plan sound?
- Is the plan efficient?
- What media should be monitored at what locations?
- What species and what parameters should be monitored?

The questions listed above are difficult ones that must integrate best practice, professional experience, practicality of implementation, and stakeholder support. Answers to the questions may serve as a starting point for the project manager to determine reasonable, practical, defensible, and efficient monitoring rules and triggers. A large volume of expertise is accessible both within the federal government and through the network of industry consultants, researchers, and contractors affiliated with the FCSAP program. Project managers should not hesitate to seek input from an expert support department and any other members of the LTM planning team to ensure that the decision rules they wish to implement have a strong scientific basis and are also based on a well-informed overview of site-specific conditions.

FCSAP does not currently define requirements for governance of management decisions for LTM. In the absence of program-wide direction related to LTM management decision-making, it will ultimately be the custodian's responsibility to make decisions. It is recommended that, at a minimum, the LTM plan defines the governance structure for making these decisions (i.e., the LTM plan will document who gets to make these decisions). The "who" may be different depending on the scope and particularities of the remediation project.

A large amount of expertise on developing LTM programs is available and should be consulted when assembling an effective LTM planning team. Stakeholder involvement is also critical to ensure that stakeholder concerns are addressed at the early planning stages and to facilitate acceptance of management decisions. Considerations on scaling the level of effort for LTM programs and adaptive management are discussed in the FCSAP LTM Planning Guidance.

For Further Reading

To obtain a full copy of the FCSAP LTM Planning Guidance, please contact the FCSAP Secretariat at FCSAP.PASCF@ec.gc.ca.

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