Ministry of Environment and Parks

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TECHNICAL GUIDANCE ON CONTAMINATED SITES

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Monitored Natural Attenuation and Enhanced Attenuation for Groundwater Remediation

This document provides guidance for using monitored natural attenuation (MNA) and enhanced attenuation (EA) to remediate contaminated groundwater. These remediation alternatives can be used to manage residual contamination following active remediation, when active remediation is impractical or cost-prohibitive, or when natural processes are already effectively managing risk. MNA and EA are long term risk management strategies best conducted under independent remediation or with an approved remediation plan.

Natural attenuation

Natural attenuation refers to a variety of physical, chemical, or biological processes that, under favourable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil, sediment or groundwater over time. The effectiveness of natural attenuation is determined by evaluating how well natural processes reduce contaminant concentrations and whether these reductions are sufficient to meet remediation goals.

Monitored natural attenuation

MNA is a passive remediation alternative that involves monitoring natural attenuation processes and plume stability until the concentrations of contaminants in environmental media are reduced at the point of compliance: the applicable Contaminated Sites Regulation (CSR) remediation standards.

MNA is most successful for organic compounds such as petroleum hydrocarbons and some chlorinated organic compounds. Other contaminants, like certain metals, may also be considered for MNA if enough lines of evidence support its use.

When MNA will not be effective within a reasonable time frame, typically defined as one generation, EA may be a viable remediation alternative to accelerate contaminant reduction.

Enhanced attenuation
Enhanced attenuation refers to interventions that increase the rate of contamination removal occurring by natural attenuation processes. EA can be used as a bridge between active remediation actions and MNA.

For organic contaminants, EA can promote and accelerate biodegradation through chemical and biological enhancement techniques:

- Chemical enhancement supplements the hydrogeological system to improve biological degradation processes by increasing availability of electron acceptors or donors
- Biological enhancement supplements the natural biological capacity and longevity within the source-plume system by adding nutrients and/or species of microorganisms

When to use MNA and/or EA
MNA and EA are most effective when used following source removal and/or together with other active remediation measures such as hydraulic control, groundwater extraction, or reactive barriers to manage contamination. Reliance on MNA without source removal and control is unlikely to meet remediation goals in a reasonable timeframe.

MNA and EA offer several advantages:

- Minimizes disturbance and risk of exposure to the environment and receptors
- Lower implementation costs
- Sustainable remediation alternative that uses less energy and produces less waste and emissions
- Enables remediation in areas where access is limited

MNA and/or EA may be an acceptable remediation alternative when substances in groundwater at your site or at downgradient affected parcels must meet remediation standards within a reasonable timeframe. For example:

- When a vulnerability assessment indicates an effect from future climate hazards, like drought, that necessitates the restoration of the groundwater aquifer to meet drinking water standards for future generations
- To remediate groundwater contamination where the contaminant source has been controlled or removed but residual groundwater contamination has migrated to neighbouring properties
- To reduce future liability for risk managed contamination
- Where the implementation of active remedial alternatives might cause unacceptable environmental damage to vulnerable habitats
- To remediate contamination in areas that are remote or difficult to access, such as under buildings

The decision to use MNA and/or EA should be supported by detailed site characterization data and a conceptual site model showing the nature and distribution of all contamination, the

contaminant source zones and the groundwater plume, as well as the potential behaviour of contaminants in the affected media and potential exposure pathways. A decision diagram to implement MNA or EA is provided in Appendix 1.

Basic conditions for MNA and EA

MNA and EA can be carried out if all the following conditions are met:

a) Contaminant source has been removed, reduced or controlled
b) Contaminant plumes are stable or shrinking
c) Risks to human health and the environment are managed (e.g. exposure pathways have been eliminated using institutional controls)
d) Long term monitoring can be implemented to ensure effectiveness of remediation
e) MNA or EA will result in the remediation goals being met within a reasonable timeframe based on historic trends, predictive modelling, geochemical arguments, and other lines of evidence

Additional considerations for EA

In addition to the basic conditions above, the application of EA should:

- Increase the rate of natural attenuation
- Be sustainable, to ensure remediation goals will be met without the need for ongoing or repeated application of the enhancement(s) beyond a reasonable time frame

Performance Monitoring

Both MNA and EA require careful design, documentation, and monitoring to ensure effectiveness.

The progress of groundwater remediation under MNA and EA should be closely monitored to ensure the above conditions are met and:

- Attenuation mechanism(s) remain effective over time and capable of supporting continued acceptable attenuation rates
- Attenuation is occurring at an acceptable rate to meet the applicable remediation goals
- The contaminant plume is shrinking

Progress should be evaluated by measuring contaminant concentrations over time and comparing them to the remediation goals for the site. Regular monitoring detects changes in site conditions that might reduce the efficiency of natural attenuation processes and identifies degradation products that may cause a risk to human health and/or the environment. A contingency plan should be developed in case MNA and/or EA fails to perform as anticipated.

It is expected that advances in the science and practice surrounding MNA and EA are considered and incorporated into all MNA and EA based remediation programs, to the degree practicable.

Reporting
Regular reporting is necessary to demonstrate progress. Monitoring reports should include:

- Sample results showing contaminant trends over time
- Analysis of plume stability
- Conclusions about the effectiveness of MNA and/or EA and whether conditions warrant a change in remediation strategy to manage risk or to meet remediation goals
- Information such as degradation products, geochemical parameters and other lines of evidence that support conclusions

Notifications of Independent Remediation
When conducting MNA or EA using independent remediation, a Notification of Independent Remediation must be submitted according to section 54 of the *Environmental Management Act*. The director may impose requirements for progress monitoring and reporting.

Obtaining certification
To use MNA or EA under an approval in principle, reporting requirements may be imposed such as:

- Performance verification plans; and
- Contingency plans

A covenant under section 219 of the *Land Title Act* may be requested by the ministry to restrict the use of the groundwater until the remediation goal is met.

Once the remediation goal is met, an application for a Certificate of Compliance either to the risk-based or numerical remediation standards can be made, as applicable.

For more information, see Remediate a contaminated site or direct enquiries to remediationFAQs@gov.bc.ca.

Revision history

Approved Date	Effective Date	Document Version	Notes
Draft	Draft	1.0	Draft guidance posted November 2014
March 20, 2026	April 1, 2026	2.0	New guidance replaced draft guidance

Appendix 1

MNA/EA Decision Diagram for Groundwater Remediation