

## **Appendix 50**

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# **Meadowbank and Whale Tail Aquatic Effects Management Program Version 4**

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# Aquatic Effects Management Program (AEMP) Meadowbank Mine



Prepared for:

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# Aquatic Effects Management Program (AEMP)

## Meadowbank And Whale Tail Projects

**Version 4**

Prepared for:



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3	2015-11	4	54, 55, 56	Updated Tables 4-1, 4-2, 4-3 and language in text related to those tables to match current CREMP
4	2020-03	2	22	Added Pore Water Quality Monitoring Program and integrated the Whale Tail Project Note – the next revision will fully integrate the Whale Tail Project into the AEMP

# TABLE OF CONTENTS

DOCUMENT CONTROL .....	II
TABLE OF CONTENTS.....	III
LIST OF FIGURES .....	V
LIST OF TABLES.....	VI
ACROYNMS .....	VII
1 INTRODUCTION.....	1
2 AEMP-RELATED MONITORING PROGRAMS.....	3
2.1 Core Receiving Environment Monitoring Program .....	3
2.1.1 Overview .....	3
2.1.2 Sampling Areas.....	3
2.1.3 Monitoring Components.....	5
2.1.1 Sampling Effort.....	5
2.2 Receiving Environment Effects Assessment Studies.....	6
2.2.1 TSS and Dike Construction (2008 and 2009).....	7
2.2.2 TPE Sediment Bioavailability (2015 to 2019) .....	8
2.3 Dike Construction Monitoring.....	9
2.4 Fisheries Authorizations.....	10
2.4.1 Fish-Out Programs.....	10
2.4.2 Habitat Compensation Monitoring .....	12
2.5 Groundwater Monitoring.....	14
2.6 Dewatering Monitoring.....	16
2.7 Water Quality and Flow Monitoring .....	18
2.8 MDMER and NWB Type A Water Licence Requirement I-1(a).....	19
2.9 AWAR/WHTR and Quarry Water Quality .....	20
2.10 Other Related Monitoring Activities .....	21
2.10.1 Blasting.....	21
2.10.2 Air Quality Monitoring .....	21
2.10.3 Pore Water Quality Monitoring .....	22
3 CROSS-LINKAGES AMONG AEMP-RELATED PROGRAMS.....	31
3.1 Introduction.....	31
3.2 Cross-Linkages Among Monitoring Programs .....	32
4 MANAGEMENT RESPONSE PLAN .....	40

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4.1	Introduction and Objective .....	40
4.2	The MRP at the Program-Specific Level .....	41
4.2.1	Risk-Based Selection of Key Monitoring Variables.....	41
4.2.2	Experimental Design and Statistical Framework.....	46
4.2.3	Sampling and Analysis Plans .....	47
4.2.4	Thresholds and Triggers .....	48
4.2.5	Data Summary Framework .....	51
4.3	The MRP at AEMP Level .....	51
4.3.1	Integrated Data Evaluation .....	51
4.3.2	Management Actions .....	52
5	STRUCTURE AND CONTENT OF THE ANNUAL AEMP REPORTS .....	64
6	REFERENCES.....	66

## LIST OF FIGURES

Figure 3-1. Simple pathway-style conceptual site model showing transport, fate and potential effects relationships for construction-related sedimentation.....	37
Figure 3-2. Primary transport pathways, exposure media, and receptors of concern for the Aquatic Effects Management Program. ....	38
Figure 3-3. Example of stressor-specific (zinc in effluent) conceptual site model showing cross-linkages among AEMP-related monitoring programs.....	39
Figure 4-1. Generic management response process for the AEMP. ....	59
Figure 4-2. Management response plan for the AEMP programs. ....	60
Figure 4-3. Derivation of thresholds and potential triggers for exposure variables.....	61
Figure 4-4. Derivation of thresholds and potential triggers for effects variables.....	62
Figure 4-5. Example of an issue-specific conceptual site model for the 2008 sedimentation event during East Dike construction. ....	63
Figure 5-1. AEMP annual reporting process.....	65

## LIST OF TABLES

Table 2-1.	AEMP-related monitoring plans.....	24
Table 2-2.	Concordance between AEMP-related monitoring programs and the Nunavut Water Board A Licence conditions applying to general and aquatic effects monitoring. Adapted from Schedule I, Table 2: Monitoring Programs in 2AM MEA1526 License A and 2AMWTP-1826. ....	26
Table 3-1.	Major mine-related activities and potential effects identified in the <i>Aquatic Ecosystem/Fish Habitat Impact Assessment</i> (AEIA, 2005) for the construction phase of the Meadowbank Gold Project. ....	34
Table 3-2.	Major mine-related activities and potential effects identified in the <i>Aquatic Ecosystem/Fish Habitat Impact Assessment</i> (AEIA, 2005) for the operations phase of the Meadowbank Gold Project. ....	35
Table 3-3.	Major mine-related activities and potential effects identified in the <i>Aquatic Ecosystem/Fish Habitat Impact Assessment</i> (AEIA, 2005) for the closure/post-closure phase of the Meadowbank Gold Project. ....	36
Table 4-1.	Example template for summarizing results of monitoring under each program. ....	54
Table 4-2.	Example / template summary of exceedances of triggers and thresholds for key AEMP monitoring variables.....	55
Table 4-3.	Example template for integrated evaluation of monitoring results across all programs for a monitoring variable or group of variables <sup>1</sup> . ....	56
Table 4-4.	Toolbox of some potential receiving environment assessment methods.....	57
Table 4-5.	Toolbox of some potential mitigation options. ....	58



## ACROYNMS

AEMP	Aquatic Effects Monitoring Program
AN	Ammonium nitrate
AWAR	All-weather access road (Baker Lake to Meadowbank)
BACI	Before-after-control-impact statistical comparison
CCME	Canadian Council of Ministers of the Environment
CI	Control-impact statistical comparison
CIRNAC	Crown Indigenous Relations and Northern Affairs Canada (formerly INAC)
CPUE	Catch-per-unit-effort
CREMP	Core Receiving Environment Monitoring Program
CSM	Conceptual site model
DFO	Department of Fisheries and Oceans
EA	Environmental Assessment
EAS	Effects Assessment Studies
ECCC	Environment and Climate Change Canada
EEM	Environmental Effects Monitoring
FF	Far-field area
HADD	Harmful alteration, disruption or destruction
HCF	Habitat compensation feature
ISQG	Interim sediment quality guideline (from CCME)
MDMER	Metal and Diamond Mining Effluent Regulations
MF	Mid-field area
MRP	Management response plan
NIRB	Nunavut Impact Review Board
NF	Near-field area
NWB	Nunavut Water Board
QA/QC	Quality assurance and quality control
ROC	Receptor of concern
SOPC	Stressors of potential concern

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SPL	Second Portage Lake
TDS	Total dissolved solids
TPL	Third Portage Lake
TSS	Total suspended solids
VEC	Valued ecosystem component
WL	Water Licence
WOE	Weight-of-evidence
WTHR	Whale Tail Haul Road (Meadowbank to Amaruq)

# 1 INTRODUCTION

The Aquatic Effects Management Program (AEMP) for Agnico-Eagle Mines' (Agnico Eagle) Meadowbank Gold Mine was included as part of the Environmental Assessment (EA) for the project in 2005 (AEMP 2005), and has been formally implemented since 2006. The initial Type A Water License (2AM-MEA0815) issued in 2008 for the project by the Nunavut Water Board (NWB) required a revised AEMP, and specified some of the requirements for that revision. Most importantly, while the 2005 AEMP was focused on core receiving environment studies at the level of basins and lakes, the revised AEMP needs to be broader in scope to comply with the following licence requirements (stipulated in Part I-1):

- *Comprehensive receiving environment monitoring to identify changes to the aquatic receiving environment associated with mine activities<sup>1</sup>;*
- *Linkage between monitoring results and adaptive management response<sup>2</sup>;*
- *Monitoring of lake productivity<sup>3</sup>;*
- *Sampling and analysis plans<sup>4</sup>; and*
- *Monitoring under Fisheries Authorizations, NWB Licence Compliance Monitoring, Metal and Diamond Mining Effluent Regulations (MDMER) Environmental Effects Monitoring (EEM), and Groundwater Monitoring*

The last requirement diverges from traditional AEMPs (INAC, 2009) and required Agnico to propose a new approach, which was presented in draft to the NWB (March 2-3, 2010 in Yellowknife) and necessitated the restructuring of the AEMP. As a result, the AEMP was restructured to serve as an overarching 'umbrella' that conceptually provides an opportunity to integrate results of individual, but related, monitoring programs in accordance with the Type A water license requirements. The scope of the 2005 AEMP, which was essentially the core receiving environment monitoring, is now one of the monitoring programs that is integrated

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<sup>1</sup> This component is included in quarterly environmental effects monitoring (EEM) receiving environment monitoring under the Metal and Diamond Mines Effluent Regulation (MDMER).

<sup>2</sup> This applies to most monitoring programs. Some programs, such as the Effects Assessment Studies (EAS) are conducted only when needed.

<sup>3</sup> This is conducted as part of the Core Receiving Environment Monitoring Program (CREMP).

<sup>4</sup> This is part of the CREMP and other programs.

under the restructured AEMP and has been renamed the Core Receiving Environment Monitoring Program (CREMP) to minimize confusion.

The restructured AEMP is organized into the follow five sections:

- **Section 2** reviews each of the underlying monitoring programs, including the CREMP, the cornerstone broad-level monitoring program.
- **Section 3** reviews the inter-linkages among the component programs.
- **Section 4** develops the Management Response Plan for the AEMP that is to be implemented following the integration of results for each component program.
- **Section 5** outlines the expected structure and content for the annual AEMP report beginning for the year 2013 (i.e., monitoring in 2012, reported in 2013).

The Water Licence was renewed in 2015 (2AM-MEA1525) for continued operations and subsequently amended in 2019 (2AM-MEA1526) to authorize in-pit tailings disposal.

In 2016, Agnico Eagle proposed to develop the Whale Tail Pit Project to continue mine operations and milling at the Meadowbank Mine and extend the Meadowbank Mine to include development of resources from Whale Tail Pit. The initial Type A Water License (2AM-WTP1826) for the Whale Tail Pit project was issued in May 2018 and must comply with the AEMP.

## 2 AEMP-RELATED MONITORING PROGRAMS

The following subsections summarize the major monitoring programs related to the AEMP. **Table 2-1** lists the programs and provides citations of relevant monitoring plans. **Table 2-2** shows the concordance between the AEMP-related monitoring programs and the NWB A Licence conditions related to general and aquatic effects monitoring.

### 2.1 Core Receiving Environment Monitoring Program

#### 2.1.1 Overview

As discussed in **Section 1**, the CREMP was originally the Aquatic Effects Management Program (AEMP, 2005), which was developed to address issues identified during the environmental assessment (EA) process that could potentially impact the aquatic receiving environments surrounding the development. Building from earlier baseline monitoring (BAER, 2005), the 2005 AEMP described the general monitoring strategy designed to detect impacts to the aquatic environment.

The program was designed to take an integrated, ecosystem-based approach that links mitigation and monitoring of physical/chemical effects on key ecological receptors in the receiving environment. At its core, the report addresses key issues identified in the Meadowbank and Whale Tail EA (i.e., mining-related activities with the potential to affect water quality, fish habitat and fish populations). Monitoring results are intended to inform the *adaptive management*<sup>5</sup> process, supporting the early identification of potential problems and development of mitigation options to address them.

#### 2.1.2 Sampling Areas

The CREMP is intended to detect changes at a basin or lake scale to help define the extent (both spatially and temporally) of any changes in water quality, sediment chemistry, or biological communities (phytoplankton and benthos). A common element for the Meadowbank and Whale Tail Pit study designs is the use of near-field (NF), mid-field (MF), and far-field (FF) areas to provide spatial context when interpreting potential changes year-over-year. Near-field areas provide the first line of early-warning for introductions of stressors into the receiving environment. These areas are situated closest to the development near dikes, dewatering

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<sup>5</sup> This terminology is refined in **Section 4.1**.

discharge points, and proposed effluent sources. MF and FF areas are located farther downstream from the NF monitoring areas and provide insights into the spatial extent of any observed changes in chemistry or biological communities closer to the source. A detailed description of the Meadowbank and Baker Lake study areas is included in the *CREMP: 2015 Plan Update* (Azimuth, 2015); the Whale Tail Pit study areas are described in the *Whale Tail Pit Addendum* to the CREMP: 2015 Plan Update (Azimuth, 2018). A brief description of the sampling areas is provided below.

#### 2.1.2.1 Meadowbank Sampling Areas

There are 9 sampling areas included in the Meadowbank CREMP. Third Portage Lake East Basin and North Basin (TPE and TPN), Second Portage Lake (SP), and Wally Lake (WAL) are the NF areas monitored annually for changes related to operations at the Meadowbank mine and mill. Tehek (TE) the South Basin of Third Portage Lake (TPS) and Tehek far-field (TEFF) are monitored only if changes are detected upstream at the NF locations consistent with the strategy outline in **Section 2.1.1**.

Two reference areas are shared for the Meadowbank and Whale Tail Pit programs: Inuggugayualik Lake (INUG) and Tasirjuaraajuk Lake (aka Pipedream Lake [PDL]). INUG has been the core reference area since formal monitoring began in 2006. PDL was added to the Meadowbank CREMP in 2009; while the absence of data at this area from 2006 to 2008 make it of limited utility in the BACI statistical analyses, it provides insights into the strength of regional patterns (i.e., how well it matches INUG).

#### 2.1.2.2 Whale Tail Sampling Areas

There are 6 lakes currently included in the Whale Tail Pit CREMP study design. Whale Tail Lake South Basin (WTS) and Mammoth Lake (MAM) are NF areas designed to detect changes related to dike construction in Whale Tail Lake and Mammoth Lake and eventual discharge of treated water during operations. Nemo Lake (NEM) is also considered a NF area because of its proximity to the site, even though it is situated in a different watershed. MF areas are Lake A20 (upstream from WTS, but joined to WTS after flooding) and Lake A76 (downstream from MAM). Lake A76 is situated at the junction of the two flow paths leading to Lake DS1. Given its morphology and location, it represents an ideal MF exposure area for both flow paths. Lake DS1 is the FF location to provide additional context for characterizing spatial extent of effects.

#### 2.1.2.3 Baker Lake Sampling Areas

There are two NF areas for the Baker Lake CREMP, one targeting the hamlet's barge landing area (Baker Barge Dock [BBD]) and the other Agnico Eagle's fuel storage facility (Baker Proposed

Jetty<sup>6</sup> [BPJ]). The primary reference area for Baker Lake is located approximately 10 kilometers to the east of the hamlet along the north shore of the lake (Baker Akilahaarjuk Point [BAP]). A second reference area on the East Shore of Baker Lake (BES) between BAP and BPJ was added in 2011 to provide additional context for interpretation of sediment chemistry and benthic invertebrate data.

### 2.1.3 Monitoring Components

Water quality, sediment quality, phytoplankton community, and benthic invertebrate community are monitored annually as part of the routine CREMP. Sampling is completed as per SOPs included in the *CREMP: 2015 Plan Update* (Azimuth, 2015). Locations for water, limnology, and phytoplankton were selected randomly for the Meadowbank and Baker lakes areas from within their respective lake basins. The Whale Tail Pit study area lakes are smaller and more variable in depth compared to the Meadowbank project lakes. To avoid selecting locations in less than 5 m of water, a number of fixed water quality monitoring locations were established in each lake. No water sampling occurs in June or October when ice conditions are unsafe.

Sediment for chemistry and benthic invertebrate community analyses were collected from the established areas (i.e., depositional zones between 6.5 m and 9 m) in each basin/lake.

#### 2.1.1 Sampling Effort

A results-driven sampling strategy for the Meadowbank study lakes was developed as part of the *CREMP: 2015 Plan Update* (Azimuth, 2015). The objective of this strategy is to increase the overall efficiency of the CREMP by maintaining monitoring intensity in the areas most likely to be affected by mining-related activities (i.e., NF areas), while potentially reducing monitoring intensity at MF and FF areas depending on the water quality results observed at up-gradient areas. The annual decision-making framework presented in the *CREMP: 2015 Plan Update* applies to MF and FF areas at Meadowbank (i.e., MF area TE (which is paired with upstream NF areas TPE, SP, and WAL), MF area TPS (which is paired with NF area TPN), and to FF area TEFF (paired with upstream MF area TE). The same strategy may eventually be implemented at Whale Tail as more years of 'after' data become available. For the time being, monitoring at Whale Tail MF and FF areas will continue at the same frequency as the NF areas (i.e., there were five water chemistry/phytoplankton sampling events each year).

As per the normal Meadowbank CREMP data analysis process, NF results are evaluated on an annual basis (i.e., with CREMP reporting due at the end of March following each monitoring

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<sup>6</sup> Note that while a jetty was initially considered, the idea was abandoned in favour of continued use of the existing barge landing.

year), with the NF results (i.e., for *Year*) dictating the monitoring requirements for the MF area in the subsequent year (i.e., *Year +1*). The Year +1 NF and MF results are used as the basis to determine the MF and FF monitoring requirements for Year +2, and so on. While the full CREMP program will be conducted at each NF area each year, the specific monitoring requirements for the MF and FF areas vary based on the NF and MF results, respectively. Below are the various outcomes of the CREMP data analysis and associated program requirements for MF and FF areas in the following year (see Azimuth, 2015 for more details, including a worked example of the strategy):

- No changes identified – no statistical changes above any trigger values. No further sampling required.
- Minor changes identified – statistically significant changes exceeding the early warning trigger values for parameters without effects-based threshold values (i.e., trigger values are based on the 95<sup>th</sup> percentile of the baseline distribution). Spot sampling through-ice is required to determine if changes extend to MF area (or to FF if such changes are seen at an MF area), but no further sampling is needed that year at the MF or FF areas unless moderate changes (see below) are identified at those areas.
- Moderate changes identified – statistically significant changes exceeding the early warning trigger values for parameters with effects-based thresholds (e.g., CCME water quality guidelines for water chemistry parameters). Full CREMP water sampling (all events) is required to determine if changes extend to MF area (or to FF if such changes are seen at an MF area).
- Major changes identified – statistically significant changes exceeding the effects-based threshold values. Full CREMP program (i.e., including sediment and biological components) is required to determine if changes extend to MF area (or to FF if such changes are seen at an MF area).

## 2.2 Receiving Environment Effects Assessment Studies

In addition to the core receiving environment monitoring ([Section 2.1](#)), the 2005 AEMP included complementary *targeted studies* to address activities or issues that required more intensive spatial and/or temporal monitoring and possibly more specialized techniques. An overview of the targeted effects assessment studies completed as part of the Meadowbank CREMP are described below:



### 2.2.1 TSS and Dike Construction (2008 and 2009)

Agnico Eagle commissioned targeted *effects assessment studies* (EAS) in 2008 and 2009 to address concerns regarding the potential impacts of elevated TSS concentrations on the local receiving environment from dike construction.

The East Dike TSS EAS was initiated in 2008 and targets the effects of TSS from East Dike construction, primarily on Second Portage Lake, but also extending into Tehek Lake. This study continued in 2009 to implement some planned components as well as to address some new uncertainties raised by the 2008 results.

The Bay-Goose TSS EAS was initiated in 2009 and targets the effects of TSS from Bay-Goose construction, primarily on the east basin of Third Portage Lake, but also downstream into Second Portage Lake and Tehek Lake. Due to the phased nature of construction of the Bay-Goose Dike (i.e., Phase 1 in 2009; Phase 2 in 2010), the timing of study components is variable, with some conducted in 2009 and others slated for either 2010 and/or 2011.

Given that suspended sediments can directly or indirectly affect the entire range of organisms in the aquatic environment, the strategy developed for the EAS studies addressed a broad array of concerns. The general components included in the TSS EAS are:

- **Water Quality and Limnology** – The most obvious effect of sediment inputs into clear lakes is a noticeable reduction in water clarity and reduced light penetration. There are other possible effects, however, which can be equally significant. These include introduction of metals and nutrients, or other changes to normal conditions (e.g., oxygen reductions or increased temperature).
- **Field Effects Measurements** – Directly measuring key aspects of target aquatic receptors in the field is the best approach to determining the ecological significance of elevated TSS. Water-clarity related changes in productivity could affect primary and secondary productivity of the water column. Potential effects to fish will be most likely manifested through changes to high-value habitat (e.g., sedimentation of spawning areas).
- **Laboratory Effects Measurements** – Taking site water into the laboratory provides a unique opportunity to conduct a suite of tests on sensitive life history stages under controlled conditions. These tests provide insights into how turbid water and/or settled sediment affect zooplankton and fish survival, feeding and growth.

## 2.2.2 TPE Sediment Bioavailability (2015 to 2019)

Chromium concentrations in sediment at TPE have been followed closely since 2012 when the first evidence of an increasing trend was observed in the basin (Azimuth, 2013). In 2014, a targeted coring study confirmed chromium was increasing in concentration over time (Azimuth, 2015b). Subsequently, two targeted studies were completed in 2015 and 2018 using laboratory sediment toxicity tests with *Chironomus dilutus* and *Hyalella azteca* to determine if the increase in sediment chromium was adversely affecting growth and survival for these two species. The 2015 study also included sequential extraction analyses of the sediment to quantify the fraction of chromium in the sediment matrix available for uptake (and toxicity) to benthic invertebrates. Below is a summary of the conclusions from the 2015 and 2018 targeted studies at TPE:

- **Chironomid Tests** – Survival in the 10-d tests has typically been high (generally above 90% in most replicates from TPE), with only slight reductions in growth relative to the field control groups. In 2018, the apparent minor reduction in chironomids from the TPE treatment was considered to have *low* ecological significance to the community composition<sup>7</sup>
- **Amphipod Tests** – Significant lower survival and growth were observed in 2015 and 2018. As a taxonomic group, *Hyalella* (or amphipods), are not represented in the assemblage of benthic invertebrates in the Meadowbank project lake study areas. Furthermore, this species is among the more sensitive invertebrate taxa to the effects of metals.
- **Sequential Extraction Test Results** – As a complement to the sediment toxicity testing in 2015, sequential extraction analysis was conducted on sediment from exposure and reference areas used in the toxicity tests. Result from this geochemical analysis showed that most of the chromium at TPE is found in the ‘residual’ fraction, which is less mobile and bioavailable than chromium associated with carbonates, iron and manganese hydroxides, and organic material. Importantly, the total concentration of chromium in the more bioavailable fractions was well below the CCME interim sediment quality guideline (ISQG). This line of evidence demonstrated that concentrations of chromium in the sediment were unlikely to adversely affect the structure or function of the benthic community at TPE.
- **Weight-of-Evidence Conclusions (2018)** – Toxicity test results were integrated with the benthic invertebrate taxonomy and sediment chemistry results in weight of evidence

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<sup>7</sup> Low level effect size = 10 to 20% reduction in mean growth compared to the field control group (PDL and INUG in 2018).

(WOE) framework to determine the health of the benthic invertebrate community at TPE. The WOE assessment in 2018 confirmed the low bioavailability of sediment chromium (i.e., low risk to the benthic invertebrate community), but recommended follow-up studies in 2019 to determine the underlying cause of the effect to *Hyalella* survival and growth observed in the 2018 toxicity tests.

## 2.3 Dike Construction Monitoring

In addition to the core receiving environment monitoring (**Section 2.1**), the 2005 AEMP included complementary *targeted studies* to address activities or issues that required more intensive spatial and/or temporal monitoring and possibly more specialized techniques. For Meadowbank, targeted dike construction monitoring was conducted for the East Dike in 2008 and the first phase of the Bay-Goose Dike in 2009; monitoring is continuing in 2010 for the second phase of the Bay-Goose Dike. Monitoring is being conducted according to the *Water Quality Monitoring and Management Plan for Dike Construction and Dewatering at the Meadowbank Mine* (Agnico Eagle 2009a). For Whale Tail, targeted dike construction monitoring was conducted for the Whale Tail Dike in 2018-2019 and Mammoth Dike in 2019. Monitoring is being conducted according to the *Water Quality Monitoring and Management Plan for Dike Construction and Dewatering (the Plan; January, 2017)* (Agnico Eagle 2017a).

Dike construction monitoring focuses primarily on total suspended solids (TSS) as an indicator of environment status; water quality is a secondary focus. In the field, turbidity (easily measured using handheld equipment) profiles over depth are conducted at each monitoring station (see below). An empirical relationship between TSS and turbidity is then used to obtain real-time estimates of TSS concentrations for each profile. Routine monitoring is conducted at least daily (weather dependent) at a network of “routine” (i.e., close to the work area and good indicators of sampling stations (Routine Stations), as well as at stations situated near high-value habitat (HVH Stations). TSS trigger values, developed in the monitoring plan (Agnico Eagle, 2009a, 2017) are as follows:

- Routine Stations - 50 mg/L for 24-hr average and 15 mg/L for 30-day average.
- High-Value Habitat Stations – same as the routine stations, except after September 1, when 25 mg/L for 24-hr average and 6 mg/L 30-day average are in effect.

Monitoring results are evaluated as follows:

- As routine monitoring continues, a moving 24-hour average TSS concentration is calculated at each monitoring station. If the 24-hour average exceeds the Short-Term Maximum, Agnico Eagle provides a recommended course of action to regulators.

- If the 7-day moving average TSS concentration exceeds the maximum monthly mean, this triggers a series of actions. First, it is determined if the average has been heavily influenced by one or more events that have been addressed. Second, mitigative options are considered, such as re-deployment of silt curtains, deployment of additional silt curtains, and possible adjustments to construction practices.
- If the 30-day moving average Maximum Monthly Mean is exceeded, Agnico Eagle provides a recommended course of action to regulators.

In addition to monitoring turbidity at routine and high-value habitat stations in the near vicinity of dike construction, broad surveys are conducted. Broad surveys extend further afield to areas downstream and upstream of the dike construction area and are conducted every couple of weeks. Focused turbidity surveys are also conducted in the event of the formation of a TSS plume and to test turbidity curtain effectiveness. In conjunction with TSS sampling, water quality sampling is also conducted at key stations approximately weekly to monitor other parameters (e.g., nutrients, total and dissolved metals).

## 2.4 Fisheries Authorizations

### 2.4.1 Fish-Out Programs

Agnico Eagle officially began construction of the Meadowbank Gold Project in July 2008 under Fisheries and Oceans Canada (DFO) *Authorization for Works or Undertakings Affecting Fish Habitat* NU-03-0191 (hereafter referred to as the “Authorization”). The East Dike was the first dike constructed in the project during the open water season of 2008 and divided Second Portage Lake more or less in half, separating the northwest arm of Second Portage Lake (SP) from the rest of the lake. Prior to draining the northwest arm as part of mine development, and as stipulated by the Authorization, fish were removed from the entire area during the summer of 2008. A similar program was implemented in 2010 for the portion of Third Portage Lake impounded by the Bay-Goose Dike.

The fish-out program, which was founded on DFO’s draft *General Fish-Out Protocol for Lakes to be Lost due to Mining Developments*, was specifically designed (Azimuth, 2008a) and implemented (Azimuth, 2009; North-South Consultants, 2011) to obtain a broad range of scientific information to improve our overall understanding of the ecology of northern lakes.

The Meadowbank fish-out programs generally consist of the following technical elements:

- **General Limnology** – basic data limnological (oxygen and temperature profiles, secchi depth, water samples for nutrients) and biological (zooplankton biomass) data are collected within each basin of the impounded area once per month during the open

water season. In addition, benthic invertebrate community productivity and taxonomy were collected once.

- **Mark/Recapture Phase** – The mark-recapture phase involving tagging and releasing fish to obtain population estimates. The phase continues until the 2-day moving average recapture rate of marked and released fish is 10%, or to a maximum duration of 14 days.
- **Catch-Per-Unit-Effort (CPUE) Phase** – Starting at least three days after the mark-recapture phase, the CPUE phase involves collecting detailed catch information in order to derive fish population estimates using both the Leslie and DeLury methods. All captured fish are identified to species, weighed and measured for fork length (total length in the case of burbot, sculpin and stickleback). Each fish is physically “milked” to identify reproducing males or females. Detailed biological information is collected on a subset of fish. The CPUE phase ends when: (a) there has been a consistent, statistically significant (e.g.,  $p < 0.10$ ) decline over a 10-day or greater period (for at least one of the two CPUE methods) for gill nets and for trap nets; and (b) overnight sets are catching very few fish regardless of the location of deployment.
- **Final Removal** – Intensive effort is expended to removal all fish. The removal phase is continued until either:
  - No fish are caught for 48 hours, and then after a 24 hour break, no fish are caught for an additional 48 hours; or
  - Catch has declined to near zero and the total catch has reached at least 95% of the estimated initial abundance from the CPUE data.
- **Habitat Mapping** – After dewatering is sufficient enough to expose the habitat, and after snowmelt has occurred, low level aerial photographs are taken to document the habitat. Ground surveys are also conducted to verify the habitat interpretations based on the photos. This provides the opportunity to compare and contrast mapping efforts based on through-water aerial photos, through-air aerial photos and ground surveys.

For Whale Tail, in preparation of for fishout activities, a Conceptual Whale Tail Lake (North Basin) Fishout Workplan (February 2017) has been developed in consultation with the Fisheries and Oceans Canada. This work plan was based on DFO guidance document *General Fish-Out Protocol for Lakes and Impoundments in the Northwest Territories and Nunavut* (Tyson et al, 2011), experience from previous fishout, and input from local community. The fishout was conducted by North-South Consultants.

The Whale Tail fish-out programs generally consists of the following technical elements:

- **Trial Phase** – Prior to commencing the catch-per-unit-effort (CPUE) Phase, a 2-day trial period in 2018 was conducted in order to allow fishout personnel to determine the number of crews and the number of nets that could be managed per crew for the duration of the CPUE Phase
- **Catch-per-unit-effort (CPUE) Phase** – The CPUE phase consisted of daytime gillnet set with the objective of calculating initial fish populations and maximizing successful transfer of fish to Whale Tail Lake (South Basin). The objective was to collect fish community data for the entire fish population of Whale Tail Lake (North Basin). This normally involves collecting fish using standard unit of effort for the duration of the phase. However, with DFO approval, extra effort was employed for part of the CPUE phase.
- **Final Removal** – In September 2018, the CPUE phase was terminated in consultation with DFO, since the calculated CPUE exceeded 98% of initial estimated for two consecutive days, according to the DeLury method
- **Fish Population Data Collection** – Length and weight for all captures fish were recorded. Gender and reproductive status were also recorded for a subset of fish that did not survive capture or transfer. A further subset of incidental mortalities was also examined in more details for stomach fullness and tissue weights. For these fish, muscle tissues samples and aging structures (otoliths) were also removed.

## 2.4.2 Habitat Compensation Monitoring

### 2.4.2.1 Meadowbank Mine Site and Western Channel Dike

Agnico Eagle began construction of the East Dike in July 2008 under Fisheries and Oceans Canada (DFO) *Authorization for Works or Undertakings Affecting Fish Habitat* NU-03-0191. Agnico Eagle has worked closely with DFO on aspects related to the harmful alteration, disruption or destruction (HADD) of fish habitat. The Authorization was based on the No-Net-Loss Plan (Azimuth, 2006), which was prepared to quantify project-related HADDs and present a habitat compensation strategy for the mine site to comply with DFO's No-Net-Loss of Habitat policy. Habitat compensation features (HCFs) have been designed to serve as productive fish habitat (e.g., Azimuth, 2006; Golder, 2008 for the mine site) for the purpose of compensating for HADD related habitat loss. To determine the HCFs capability to support fish, a long-term tiered monitoring strategy has been undertaken to document water quality, colonization by algae (i.e., the base of the food chain) and ultimately, utilization by fish.

In addition to meeting physical design specifications for fish, acceptable water quality is essential if HCFs (e.g., dike faces) are to function as intended, by providing spawning, nursery and foraging habitat for lake trout, Arctic char and round whitefish. Spawning requirements of each of these species in the project lakes is similar and occurs in relatively shallow water, between 2 and 6 m depth, below the ice scour depth and above the depth where there is a transition to very fine grain sediment (Azimuth, 2006).

A tiered monitoring strategy (Azimuth, has been employed that involves a combination of qualitative and quantitative measures to assess the capability of the HCFs to function as intended. Tiering provides a scientifically-defensible, yet cost-effective means of assessing potential limitations to HCF productivity.

Qualitative tools include visual/functional components including fishing, visual surveys, minnow trapping and measuring periphyton growth. Quantitative measures start with simple tools such as interstitial water quality/chemistry, and can lead to more specialized tools such as toxicity testing and/or in situ studies (Tier 3), should Tier 1 or Tier 2 studies fail, respectively. The results of both quantitative and qualitative tools are evaluated using a weight-of-evidence approach to determine whether HCFs are functioning as intended.

While the Western Channel crossing was within the mine site development footprint for the NNLP (Azimuth, 2006), the culverted crossing was constructed in spring 2008 under a different DFO Authorization (NU-08-0013). Monitoring requirements for the associated HCFs are essentially the same as those described for the mine site.

#### 2.4.2.2 Meadowbank All-Weather Access Road

The construction of the 105-km All-Weather Access Road (AWAR) between the Hamlet of Baker Lake and Meadowbank Mine Camp was completed in the spring of 2008 under DFO Authorization (NU-03-0190-2). Prior to AWAR construction, baseline fisheries assessments found Arctic grayling (*Thymallus arcticus*) to be the predominant fish species. Other fish species opportunistically using the AWP streams included Lake trout, Arctic char, Round whitefish, slimy sculpin and ninespine stickleback. Many small ephemeral streams were defined as non-fish bearing; 6 of the proposed crossings were considered fish bearing and required follow-up monitoring. Follow-up monitoring in 2006 confirmed the predominance of Arctic grayling in crossings R02, R06, R09, R15 and R19. The decision to construct clear span bridges at these crossings was made to reduce the footprint on these streams and accommodate fish passage.

The three main objectives of the AWAR fisheries monitoring program, that is designed to meet the Department of Fisheries and Oceans Authorization (NU-03-0190), are to complete:

- An assessment of the fish passage at R02, R06, R09 and R15 (HADD crossings) from the year the road construction began until 2010, inclusive; and every two years after starting in 2012 until 1 year following AWAR decommissioning. The monitoring is focused on capturing Arctic grayling moving upstream and downstream (upstream of the bridge crossings) using non-invasive hoopnets. By capturing, identifying, enumerating, and collecting biological data of the Arctic grayling, an assessment and evaluation by comparing to baseline data can be made of the Arctic grayling population at each crossing. Furthermore, velocity measurements are collected both upstream and downstream of the crossing to provide a physical measurement and gauge for the ability of fish to move beyond the bridge structures.
- R02 habitat compensation evaluation from the year the road construction began until 2011, inclusive; and every two years after starting in 2013 until 1 year following AWAR decommissioning. Similar to 2007 and 2008 baseline data collection, larval drift traps that successfully collect Arctic grayling eggs and fry serve as an important tool to evaluate the success of the R02 Habitat Compensation Features. These traps are set in reference areas upstream of the R02 compensation structures and at representative locations downstream and data is compared to historical data. In combination, strategically located hoopnets collect previous and current year recaptured fish (using Floy tagging) provide data to determine the tendencies, patterns and movements of Arctic grayling near the R02 habitat compensation area. Additionally, electro-fishing techniques later in the summer (late July and August) may be used to evaluate Arctic grayling foraging and population recruitment (i.e., year 0-1). Based on the number of fish collected moving upstream near the R02 compensation area, the larval drift data and the recapture *observational* data a weight of evidence approach provides information on whether or not Arctic grayling are successfully using the R02 compensation area as spawning habitat and/or foraging and that young-of-the-year are nursing in its vicinity.
- Creel Surveys are to be conducted on an annual basis. These surveys obtain information on the fishing habits in the vicinity of the AWAR and general fishing patterns of Baker Lake residents.

## 2.5 Groundwater Monitoring

Agnico Eagle is responsible for completing annual groundwater monitoring as a condition of the Nunavut Impact Review Board (NIRB) Project Certificate (No. 004 and No. 008) and the NWB Water License. For Meadowbank, under these conditions groundwater at wells in the groundwater flow path of the tailings storage facility must be monitored for the following



parameters: pH, turbidity, alkalinity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphides, total dissolved solids (TDS), total and free cyanide, and a suite of dissolved metals. The Goose Island and Portage pits will be developed within a through talik (unfrozen ground that extends to the base of the permafrost) which is below Third Portage Lake. The tailings storage facility located in the basin of the north arm of Second Portage Lake is also situated over a through talik (Golder, 2004). Groundwater monitoring wells have been installed to provide information on baseline groundwater quality in the taliks and provide information on the movement of unfrozen groundwater. The objective of the groundwater sampling program, initiated in 2003, was two-fold: to measure the salinity of the deep groundwater to calibrate the pit groundwater inflow component of the site water quality model; and to benchmark pre-mining groundwater quality against which to measure effects of mining on groundwater quality, if any.

Groundwater flow and quality data has been collected from the Portage area since 2003 and have been used as input into the water quality model for the site. Groundwater in the Vault area is not monitored because the talik present under Vault Lake is not anticipated to extend through the permafrost. Four monitoring wells were installed at the site in 2003, three of which subsequently developed internal damage and could no longer be operated. In 2006, the three defective monitoring wells were replaced, but the replacement wells also became inoperable after the first round of sampling in 2006.

To comply with the NIRB project certificate and Water license more robust monitoring well design through permafrost was developed (which included 200-m deep wells, with stainless steel riser pipe heated with trace cables) and 2 of the inoperable wells were replaced in 2008. The installation of the third monitoring well occurred in 2010 and in 2012 only one well was operable. Presently, the installation of groundwater wells, location and monitoring are under review.

For Whale Tail, the objective of the program is:

- Obtained groundwater sample from the multi-level Westbay well system, pit wall and sump;
- Complete thermal analyses;
- Updated groundwater inflow and total dissolved solids (TDS) quality predictions based on supplemental data collection since the FEIS in support of the annual update to the water quality and water balance models.
- Groundwater monitoring plan for horizontal and vertical groundwater flow; and,
- Threshold and adaptive management plan related to the groundwater management.

No groundwater wells were currently installed the Whale Tail Project. All of the groundwater results were obtained from the Westbay well system. Groundwater modelling is regularly update and monitoring required will be adjusted in the annual update of the Groundwater Monitoring Plan

Overall, the objectives of the groundwater sampling program remain in line with historical sampling which is to:

- Ensure monitoring well instrumentation is operating effectively,
- Evaluate groundwater quality and flow in second portage and third portage taliks, and
- Ensure the sampling meets QA/QC requirements.

## 2.6 Dewatering Monitoring

During dewatering of the northwest arm of Second Portage Lake and the Whale Tail Lake North Basin, there is potential for sediments to become suspended as exposed substrates slump. Suspended sediments could then enter the dewatering pipe(s) and be discharged to the receiving environment. In addition, the discharge itself could disturb the bottom sediments in the lakes and lead to increased levels of suspended sediments. The goal of the dewatering and monitoring plan is to mitigate against possible problems with suspended sediments and other key parameters (i.e., pH and aluminum) during dewatering.

To prevent increased re-suspension of sediments, the Intake pipe(s) are located at a sufficient distance from shore and, to the extent possible, in areas with highest water depth. As dewatering progresses, intakes can only be located in deep basins. As well, the discharge points are located in areas of Third Portage Lake where there is deep, low-value habitat discharge area and the Whale Tail Lake South Basin.

Dewatering monitoring is primarily focused at the water intake pumps or at the outlets of the water treatment plant, but will also include the receiving environment. Unlike monitoring during dike construction, where turbidity was used solely as a real-time surrogate for estimating TSS (see [Section 4](#)), turbidity measurements will be used two-fold: as a surrogate for TSS (using an established site-specific relationship) and directly as an indicator of water clarity as per the license limits. There are two Water Treatment Plants (WTP) installed to treat discharge water from the Meadowbank Dewatering. The water is monitored and then discharged to Third Portage Lake at proper set-back and depth. If the intake water meets the water quality license criteria the WTP is bypassed and water is discharged directly to Third Portage and Second Portage Lakes. At Whale Tail, water that didn't need WTP was discharge to Whale Tail Lake (South basin) and once treatment is needed was is discharged to Mammoth Lake. Standard

operating procedures are followed to ensure that routine monitoring is consistent, conducted by a qualified environmental technician and meets the QA/ QC requirements.

The following describes the mitigative approach to be taken if the respective exceedances occur:

- If parameter levels in a single sample from the WTP outlet or intake pump exceed the STM, this will trigger a series of actions. First, visual inspections will try to identify any obvious source of slumping on the lake edges to determine if the source of sediment is likely to be short-term or more continuous. Second, mitigative measures will be considered, such as movement of the intake pipe(s) and/or putting the WTP in recirculation mode.
- If the moving 24-hour average turbidity value exceeds the STM, then dewatering will shut down or the WTP will be put in recirculation mode while (a) mitigative measures are considered, (b) monitoring continues, (c) weather shifts (if weather is a factor), and (d) Agnico Eagle provides an appropriate course of action to regulators. Dewatering will resume once the conditions that led to the elevated turbidity levels have been addressed.
- If the 7-day moving average TSS or turbidity concentration at the WTP outlet or intake pump exceeds the MMM, this will trigger a series of actions. First, visual inspections will try to identify any obvious source of slumping on the lake edges to determine if the source of sediment is likely to be short-term or more continuous. Second, mitigative measures will be considered, such as movement of the intake pipe(s) and/or putting the WTP in recirculation mode.
- If the 30-day moving average Maximum Monthly Mean is exceeded, then dewatering will shut down or the WTP will be put in recirculation mode while (a) mitigative measures are considered, (b) monitoring continues, and (c) Agnico Eagle provides an appropriate course of action to regulators. Dewatering will resume once the conditions that led to the elevated TSS levels have been addressed.

In addition to the monitoring and management of suspended sediments, a hydraulic monitoring plan has been developed to monitor the water levels in Third Portage Lake, Second Portage Lake, Whale Tail Lake South Basin and Mammoth Lake on a regular basis while dewatering activities are occurring; and outlet erosion inspections to monitor outlet stability, including potential erosion and/or ice damming within the outlets. Third Portage Lake and Second Potage Lake water levels will be surveyed at a location of sufficient distance from the outlets to limit potential lake level drawdown effects. Lake water levels will be monitored weekly during the freshet and ice-free period, and weekly during the ice-up period, dependent of the ice conditions and worker safety. The outlet will be visually inspected to confirm that no significant

erosion of the channel bed or channel banks, or ice damming has occurred. Significant ice damming observed within the outlets will be removed as soon as possible in order to minimize potential reductions in channel capacity. The regular inspection program will occur during the freshet and ice-free period at a minimum of once every two weeks.

The objectives of the dewatering monitoring program are to:

- Collect turbidity/ TSS monitoring data on a daily basis,
- At least daily, carry out visual inspections of the intake, WTP and discharge areas,
- Collect water samples for analysis at an accredited laboratory (TSS and turbidity samples),
- Collect water samples in Third Portage Lake, Whale Tail Lake South Basin and Mammoth Lake receiving environment,
- Ensure the sampling program meets the QA/QC requirements,
- Conduct hydraulic monitoring of the water levels in Third Portage Lake, Second Portage Lake, Whale Tail Lake South Basin and Mammoth Lake on a regular basis during dewatering activities, and
- Complete outlet erosion inspections to monitor outlet stability, including potential erosion and/or ice damming within the outlets.

## 2.7 Water Quality and Flow Monitoring

The Water Quality and Flow Monitoring Plan has been prepared in accordance with the requirements of the Nunavut Water Board Type A Water License 2AM-MEA1526 and 2AM-WTP1826.

The Plan summarizes the monitoring locations, sampling frequency, monitored parameters, compliance discharge criteria and an adaptive management plan for water quality at the Meadowbank and Whale Tail Project.

The purpose of this Water Quality and Flow Monitoring Plan (the Plan) is to monitor the performance of the waste and water management systems at the Meadowbank and Whale Tail Projects. The program includes:

- Verifying and validating the predicted water quality values with empirical measurements of the mine site water quality and flows;
- A comparison of measured water quality data to compliance requirements stipulated in the Nunavut Water Board Type A Water License 2AM-MEA1526 and 2AM-WTP1826; and

- A framework for adaptive management that allows the identification and rectification, where necessary, of unexpected trends or non-compliance in water quality and flows.

The Plan provides information on the locations of the monitoring stations at the various stages of mining. These monitoring locations are to be used to evaluate the performance of the mine waste and water management system.

The objectives of the monitoring program are:

1. to track the chemistry of the contact and non-contact water prior to and for discharge;
2. to identify if water treatment is required prior to discharge; and
3. to minimize the potential impact of mining activities on the surrounding environment.

## 2.8 MDMER and NWB Type A Water Licence Requirement I-1(a)

In January 2010, Agnico Eagle's Meadowbank Gold Project and in July 2018 Whale Tail Project became subject to the Metal Mines Effluent Regulations (MMER; changed to Metal and Diamond Mining Effluent Regulations [MDMER] in 2018). MDMER monitoring requirements include, but are not limited to, the following:

- Weekly collections of effluent water quality samples from the final discharge point. Parameters for analysis include: pH, arsenic, copper, cyanide, lead, nickel, zinc, TSS and Radium 226.
- Estimation of monthly discharge volume
- Monthly acute lethality testing with rainbow trout and *Daphnia magna*.
- Quarterly effluent characterization sampling for analysis of aluminum, cadmium, iron, mercury, molybdenum, ammonia and nitrate, at the final effluent discharge point.
- Bi-annual sublethal toxicity testing at the final dewatering discharge point with fish, invertebrate, plant and algae species as endpoints.
- Quarterly water quality monitoring is completed in the receiving environment. Water quality is analyzed for: temperature, dissolved oxygen, pH, hardness, alkalinity, aluminum, cadmium, iron, mercury, molybdenum, ammonia, nitrate, arsenic, copper, cyanide, lead, nickel, zinc, TSS and Radium 226, at the effluent discharge area and at a reference station.
- Biological monitoring studies conducted on a three-year cycle targeting fish and benthic invertebrate communities. Monitoring cycles for Meadowbank were conducted in 2011 (Azimuth 2012), 2014 (Portt & Associates 2015), and 2017 (Portt & Associates 2018); the next cycle is scheduled for 2020 (Meadowbank for Cycle 4 and Whale Tail for Cycle 1).

In addition to MDMER, the NWB A Licence (Part I-1a) stipulates that monitoring is required to show that CCME guidelines are met 30 m from any outfall. This requirement is integrated into the MDMER program.

## 2.9 AWAR/WTHR and Quarry Water Quality

Agnico Eagle is responsible to manage erosion, water quality, and the introduction of sediment along the 110-km AWAR that connects the Hamlet of Baker Lake to the Meadowbank mine site and the 64 km Whale Tail Haul Road (WTHR) that connect Meadowbank mine site to Whale Tail Project. As part of the water quality management, Agnico Eagle personnel complete routine and event inspections both pre- and post-freshet for potential or present erosional issues at all stream crossings, complete routine water quality monitoring at all major crossings during the open water season, and collect water samples at representative watercourses and quarries as required.

As per the water quality management plan, a tiered approach is taken during the open water season to evaluate and monitor erosion and turbidity along the AWAR and WTHR. To prioritize monitoring at crossings, all crossings were visually inspected for erosion and turbidity on a regular basis, especially during freshet and immediately after freshet. If visual turbidity is observed at a specific location during routine inspections or event inspections (i.e. following freshet or after a rain event), the characteristics of the plume are monitored. Unless turbidity issues are observed, surface water quality sampling is not deemed necessary at non-HADD crossings or contact pools.

Water samples are collected upstream (reference) of the crossings and immediately downstream of the crossings to evaluate the water quality of the AWAR bridge and abutment construction. Water samples are collected at quarries that contain accumulated water.

The objectives of the annual AWAR, WTHR and quarry water quality monitoring program are to:

- Conduct turbidity and erosion monitoring,
- Assess water quality at watercourse crossings,
- Assess quarry water quality, and
- Ensure sampling meets QA/QC requirements.

## 2.10 Other Related Monitoring Activities

### 2.10.1 Blasting

Agnico Eagle has developed a Blasting Monitoring Program for the control of blasting vibrations at Meadowbank and Whale Tail (Agnico Eagle 2020b). The monitoring program complies with the Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters: which is to provide a monitoring and a mitigation plan that is currently in consultation with the DFO, restrict blasting when caribou or sensitive local wildlife may be affected, and minimize the use of ammonium nitrate to reduce effects on water quality. The program also adheres to the guidance provided in the *Monitoring Explosive-Based Winter Seismic Exploration in Waterbodies, NWT 2000-2002* (Cott and Hanna, 2005)

To ensure that the blast does not impact nearby fish and fish habitat, a blast pressure and vibration threshold has been established. The blast setback distance from fish habitat to the center of detonation of a confined explosion, should not produce an instantaneous pressure change greater than 50 kPa (which affects fish swim bladders) (Wright and Hopky, 1998). Through monitoring and mitigation these levels have been established and are followed at Meadowbank and Whale Tail. These setbacks account for the type of substrate (i.e., rock, frozen soil, ice, saturated soil or unsaturated soil) and the weight of explosive charge.

All blasts are monitored to ensure that vibrations generated are less than 13mm/sec and the overpressure is under 50 kPa using an Instantel Minimate Blaster portable unit. The monitoring unit is installed as per the supplier's specifications at Meadowbank at four stations: one near the north end of Portage Pit along the shore of Second Portage Lake (north of the East Dike), one near the south end of Portage Pit on the shore of Second Portage Lake (south of the East Dike), one situated on the Bay Goose Dike near the Third Portage Lake East Basin and one Vault dike near Wally Lake.

The blasts of Whale Tail Pit were monitored from Mammoth Station until June 25<sup>th</sup>, 2019. A new monitoring station, named Mammoth Station 2, was implemented closer to the Mammoth Lake and from June 26<sup>th</sup>, 2019 monitoring is done from that station. The locations were chosen to have the optimal distance between the blasts and the water (fish habitat). The data is collected, analyzed and if there are exceedances, changes are made to the blast methodology to ensure compliance. These data are reported annually.

### 2.10.2 Air Quality Monitoring

The Air Quality Monitoring Plan at Meadowbank and Whale Tail addresses the concentration of suspended particulate matter and the deposition rate of particles due to mine operation

activities. The main components of the air quality monitoring plan include the monitoring of suspended particulate matter (i.e., dust due to wind erosion, vehicles, airstrip activity and incineration), dust fall monitoring, passive NO<sub>x</sub> monitoring, QA/QC and reporting.

Sampling stations will be adapted to reflect the operations of the site. The best available technology will be used to conduct the passive sampling and the dynamic sampling programs. Particulate sampling is to be carried out year-round provided safety and weather conditions permit. The sampling program collects information on total dust fall (everything that falls into the collection vessel) and fixed dust fall (non-combustible). These data can be quantified to ascertain dust fall rates and trends. One station to monitor Nitrogen dioxide will also be established.

### 2.10.3 Pore Water Quality Monitoring

Type A Water Licence 2AM-MEA1526 was amended to authorize water uses and tailings deposition in the mined pits. One of the requirements of the authorization (Section IV, Part B: General Conditions) was the development of a Tailings Pore Water Quality Monitoring Program for Board review and approval. The elements of this program (Agnico Eagle 2020d) are described in this section.

In-pit tailings disposal will involve the sub-aqueous (3-m minimum water cover) deposition of slurry tailings into the pits. Deposition will start with the Goose Pit for approximately one year, then move to Portage Pits A and E.

The purpose of the Pore Water Quality Monitoring Program is to characterize chemical composition of the tailings pore water to verify predictions for mine closure (i.e., update and calibrate the hydrogeological and contaminant transport models developed for the tailings in-pit deposition). Pore water quality is expected to be influenced by the mill effluent process water and reclaim water (a mix of process water and any other direct inputs to the pit [e.g., precipitation and surface runoff]). Geochemical reactions within the tailings solids are not expected to influence pore water chemistry.

Due to the harsh Arctic conditions present at Meadowbank, direct monitoring of the movement and quality of the tailings pore water, which normally involves installation of piezometers or monitoring wells, will not be pursued. Rather, the quality of the process water and reclaim water, which are expected to bound the actual pore water quality, will be monitored. In addition, plant effluent solids will be monitored to evaluate potential impacts on mill water chemistry. Water quality results for tailings effluent pore water and reclaim water will be compared to Portage Effluent Limits; results exceeding the discharge limits will be flagged as a



potential risk for closure and post-closure. Agnico Eagle proposes to collect pore water samples directly from the in-pit tailings, once it is safe to do, so after the pits reach full capacity.

**Table 2-1. AEMP-related monitoring plans.**

Plan Title	Plan Citation	Regulator	Authorization / Regulation
Core Receiving Environment Monitoring Program (CREMP) formerly the Aquatic Effects Management Program (AEMP)	Azimuth. 2016. Core Receiving Environment Monitoring Program (CREMP) 2015, Meadowbank Mine. Report prepared by Azimuth Consulting Group, Vancouver, BC for Agnico Eagle Mines Ltd., Baker Lake, NU. March, 2016.  Azimuth. 2018. Core Receiving Environment Monitoring Program (CREMP) 2015- Whale Tail Addendum, Meadowbank Mine. Report prepared by Azimuth Consulting Group, Vancouver, BC for Agnico Eagle Mines Ltd., Baker Lake, NU. May, 2018.  Azimuth. 2020. Aquatic Effects Management Program (AEMP), Meadowbank Mine. Report prepared by Azimuth Consulting Group, Vancouver, BC for Agnico Eagle Mines Ltd., Baker Lake, NU. March 2020.	NWB DFO ECCC CIRNAC	2AM--MEA1526 and 2AM-WTP1826 Part I, Item 1 (AEMP) Item 2 (CREMP)
MDMER Plan	Azimuth. 2020. Aquatic Effects Management Program (AEMP), Meadowbank Mine. Report prepared by Azimuth Consulting Group, Vancouver, BC for Agnico Eagle Mines Ltd., Baker Lake, NU. March 2020.	ECCC	Sec 36 of Fisheries Act
Habitat Compensation Monitoring Plan - Mine Site	Azimuth. 2008. Meadowbank Gold Project Aquatic Effects Management Program Targeted Monitoring - Habitat Compensation Monitoring Plan. Report prepared by Azimuth Consulting Group Inc., Vancouver, BC, for Agnico-Eagle Mines Ltd., Vancouver, BC. May 2008.	DFO	HADD NU-03-0191
Habitat Compensation Monitoring Plan Western Channel	Azimuth. 2008. Meadowbank Gold Project Western Channel Crossing - Habitat Compensation Monitoring Plan. Report prepared by Azimuth Consulting Group Inc., Vancouver, BC, for Agnico-Eagle Mines Ltd., Vancouver, BC. May 2008.	DFO	HADD NU-08-0013
Tier 2 & 3 Habitat Compensation Monitoring Plan	Azimuth. 2009. Detailed Plans for Tier 2 and Tier 3 Habitat Features Compensation Monitoring for the Meadowbank Gold Project. Technical memorandum from Azimuth Consulting Group Inc., Vancouver, BC, to Fisheries and Oceans Canada, Iqaluit, NU. March 2009.	DFO	HADD NU-03-0191
Monitoring Plan for AWAR HADD Crossings	Azimuth. 2007. Monitoring Plan for Meadowbank Project All-Weather Private Access Road (AWPAR) HADD Crossings for Condition 5 of Authorization NU-03-0190 (2). Technical memorandum from Azimuth Consulting Group Inc., Vancouver, BC, to Fisheries and Oceans Canada, Iqaluit, NU. June 2007.	DFO	HADD NU-03-0190
Water Quality and Flow Monitoring Plan	Agnico Eagle. 2016. Meadowbank Gold Project Water Quality and Flow Monitoring Plan In Accordance with Water License 2AM-MEA1526 Version 5 March 2019  Agnico Eagle. 2019b. Whale Tail Water Quality and Flow Monitoring Plan In Accordance with Water License 2AM-WTP1826 Version 6 March 2019	NWB	2AM-MEA1526 Part I, Item 3  2AM-WTP1826 Part I, Item 4
Groundwater Monitoring Plan	SNC. 2020. Groundwater Monitoring Plan Meadowbank Gold Project. Version 11, March 2020  Golder. 2020. Groundwater Monitoring Plan Whale Tail Project. Version 3, March 2020	NWB	2AM-MEA1526 Part I, Item 6  2AM-WTP1826 Part I, Item 8
Water Quality Monitoring Plan for Dike Construction and Dewatering	Agnico Eagle. 2009. Meadowbank Gold Project Water Quality and Management Plan for Dike Construction and Dewatering In Accordance with Water License 2AM-MEA0815 Version 4 March 2010  Agnico Eagle. 2017a. Whale Tail Project Water Quality and Management Plan for Dike Construction and Dewatering In Accordance with Water License 2AM-WTP1826 Version 1 January 2017	NWB	2AM- MEA1526 Part D, Item 11  2AM- MEA1526 Part D, Item 5
QAQC Plan	Agnico Eagle. 2020a. Quality Assurance/ Quality Control Plan: Meadowbank and Whale Tail Project, March 2020. Prepared by Agnico-Eagle Mines Limited- Meadowbank Division.	NWB CIRNAC NIRB	2AM- MEA1526 and 2AM-WTP1826Part I, Item 19 Project Certificate 004 Conditions 6 + 23 Approved by INAC analyst
Fish-Out Program	Azimuth. 2008. Fish-Out Program for the Meadowbank Gold Project. Technical memorandum from Azimuth Consulting Group Inc., Vancouver, BC, to Fisheries and Oceans Canada, Iqaluit, NU. May 2008.  Agnico Eagle. 2017b. Conceptual Whale Tail Lake (North Basin) Fishout Work Plan. February 2017.	DFO	NU-08-0052  16-HCAA-00370
Operational ARD-ML Testing Plan	Agnico Eagle 2013. Meadowbank Gold Project Operational ARD/ML Sampling Plan in Accordance with Water License 2AM-MEA1526 Version 2, November 2013  Agnico Eagle 2019a. Meadowbank Gold Project Operational ARD/ML Sampling Plan – Whale Tail Pit Addendum in Accordance with Water License 2AM-WT1826 Version 4, March 2019	NWB	2AM- MEA1526 Part I, Item 4  2AM- MEA1526 Part B, Item 13

Plan Title	Plan Citation	Regulator	Authorization / Regulation
Blast Monitoring & Blasting Design Addendum	Agnico Eagle. 2020b. Meadowbank and Whale Tail Blast Monitoring Program. Version 4 March 2020	NIRB DFO GN	Project Certificate 004 Condition 85 Project Certificate 008 Condition 22
Air Quality Monitoring Plan	Agnico Eagle. 2020c. Meadowbank and Whale Tail Projects Air Quality and Dustfall Monitoring Plan. Version 5 March 2020	ECCC NIRB	Project Certificate 004 Condition 71 Project Certificate 008 Condition 1
Pore Water Quality Monitoring Program	Agnico Eagle. 2020d. Pore Water Quality Monitoring Program. Version 2 March 2020	NWB	No. 2AM-MEA1526 Amendment NO. 3 Pit Part B General Condition

**Table 2-2. Concordance between AEMP-related monitoring programs and the Nunavut Water Board A Licence conditions applying to general and aquatic effects monitoring. Adapted from Schedule I, Table 2: Monitoring Programs in 2AM MEA1526 License A and 2AMWTP-1826.**

**Meadowbank**

Station	Description	Phase	Monitoring Parameters	Frequency
<b>Meadowbank Mine Site Monitoring Plan</b>				
ST-DC-1 to TBD	Monitoring stations during Dike Construction as defined in Final Water Quality Monitoring and Management Plan for Dike Construction and Dewatering referred to in Part D Item 5	Construction	As defined in Final Water Quality Monitoring and Management Plan for Dike Construction and Dewatering referred to in Part D Item 5	As defined in Final Water Quality Monitoring and Management Plan for Dike Construction and Dewatering referred to in Part D Item 5
ST-DD-1 to TBD	Monitoring stations during Dike Dewatering as defined in Water Quality Monitoring and Management Plan for Dike Construction and Dewatering referred to in Part D Item 5	Construction	As defined in Final Water Quality Monitoring and Management Plan for Dike Construction and Dewatering referred to in Part D Item 5	As defined in Final Water Quality Monitoring and Management Plan for Dike Construction and Dewatering referred to in Part D Item 5
ST-1	Water Intake for camp, mill and reflooding	Late operation, closure	Volume (m3)	Monthly
ST-1 W	Water Intake for reflooding	Late operation, closure	Volume (m3)	Monthly
ST-3	Water Intake for Emulsion Plant	Late operation, closure	Volume (m3)	Monthly
ST-4	Water reclaimed from Tailings Storage Facility	Late operation, closure	Volume (m3)	Monthly
ST-5	Portage Area (east) diversion ditch	Late operation, closure	Group 3	Monthly during open water
ST-6	Portage Area (west) diversion ditch	Late operation, closure	Group 3	Monthly during open water
ST-8	East Dike Seepage Discharge	Late operation, closure	Group 3	Monthly
ST-9	Portage Attenuation Pond prior to discharge through Third Portage Lake Outfall Diffuser	Early operation	Full Suite	Prior to discharge and Weekly during discharge
			Volume (m3)	Daily during periods of discharge
			Acute Lethality	Once prior to discharge and Monthly thereafter
ST-10	Vault Attenuation Pond prior to discharge through Wally Lake Outfall Diffuser	Late operation	Full Suite	Prior to discharge and Weekly during discharge
			Volume (m3)	Daily during periods of discharge
			Acute Lethality	Once prior to discharge and Monthly thereafter

Station	Description	Phase	Monitoring Parameters	Frequency
ST-11	Tailings Storage Facility	Post closure	Group 1	Annually during open water
ST-12	Portage/ Goose Pit Lake	Post closure	Full Suite	Annually during open water season
ST-13	Vault Pit Lake	Post closure	Full Suite	Annually during open water
ST-14	Discharge to the TSF from Landfarm sump at mine site	Late operation, closure	Group 4	Prior to discharge
(TEH-11)			Volume (m3)	Daily during periods of discharge
ST-16	Portage Rock Storage Facility	Late operation	Group 1	Monthly during open water
		Closure	Group 1	Bi-annually during open water
ST-17**	North Portage Pit Sump	Operation	Group 1	Monthly during open water
			Volume (m3)	Daily during periods of discharge
	Portage Pit Lake	Late operation	Group 2	Monthly during open water
		Closure	Group 2	Bi-annually during open water
ST-19**	South Portage Pit Sump	Early operations	Group 1	Monthly during open water
			Volume (m3)	Daily during periods of discharge
	Third Portage Pit Lake	Late operations	Group 2	Monthly during open water
ST-20	Goose Island Pit Sump	Early operations	Group 1	Monthly during open water
			Volume (m3)	Daily during periods of discharge
	Goose Island Pit Lake	Late operations	Group 2	Monthly during open water
		Closure	Group 2	Bi-annually during open water
ST-21	Tailings Reclaim Pond	Late operation	Group 1	Monthly during open water
ST-22	Tailings Storage Facility	Closure (drainage runoff)	Group 2	Bi-annually during open water
ST-23	Vault Pit Sump	Late operations	Group 2	Monthly during open water
			Volume (m3)	Daily during periods of discharge
ST-24	Vault Rock Storage Facility	Late operation	Group 1	Monthly during open water
		Closure	Group 1	Bi-annually during open water

Station	Description	Phase	Monitoring Parameters	Frequency
ST-25	Vault Attenuation Pond	Late operations	Group 1	Monthly during open water
ST-26	Vault Pit Lake	Closure	Group 2	Bi-annually during open water
ST-41	Phaser Pit Sump	Late operations	Group 1	Monthly during open water
ST-42	BB Phaser Pit Sump	Late operations	Group 1	Monthly during open water
ST-43	Phaser Pit Lake	Closure	Group 2	Bi-annually during open water
ST-30	WEP1	Late operations, closure	Group 1	Monthly during open water
ST-31	WEP2	Late operations, closure	Group 1	Monthly during open water
ST-S-1 to TBD	Seeps (to be determined)	Late operations, closure	Group 1	Monthly or as found
ST-GW-1 to TBD	Groundwater wells (to be determined)	Early operations, late operations, closure	Group 2	Annually
ST-AEMP-1 to TBD	Receiving AEMP and CREMP	Late operations, closure	Group 2	A minimum of 5 events per year at CREMP stations. Ideally 3 during open water and 2 during winter (through ice).  TPL assay, NP2, NP1 and Dogleg ponds to be monitored monthly during open water (July, Aug, and Sept.)  Monthly field limnology data collected throughout year at smaller number of locations (through ice)
ST-MMER-1 to TBD	Vault, East Dike and Portage effluent outfall	Late operations	MMER	Weekly during open water
ST-37	Secondary containment sump at the Bulk Fuel Storage Facility at Meadowbank	Late Operation, closure	Group 4	Prior to discharge or transfer of effluent
ST-38	Secondary containment sump at the Bulk Fuel Storage Facility in Baker Lake – Jet-A containment	Late Operation, closure	Group 4	Prior to discharge or transfer of effluent
ST-40 (MEA-4)	Secondary containment sump at the Bulk Fuel Diesel Storage Facility in Baker Lake	Late operation, closure	Group 4	Prior to discharge or transfer of Effluent

Station	Description	Phase	Monitoring Parameters	Frequency
<b>Whale Tail Pit Monitoring Plan</b>				
ST-DC-1 to TBD	Monitoring stations during dike construction as defined in the Whale Tail Water Quality Monitoring and Management Plan for Dike Construction and Dewatering	Construction	As defined in Water Quality Monitoring and Management Plan for Dike Construction and Dewatering referred to in Part D, Item 5	As defined in Water Quality Monitoring and Management Plan for Dike Construction and Dewatering referred to in Part D, Item 5
ST-DD-1 to TBD	Monitoring Program stations during dike dewatering as defined in the Whale Tail Water Quality Monitoring and Management Plan for Dike Construction and Dewatering	Construction	As defined in Water Quality Monitoring and Management Plan for Dike Construction and Dewatering referred to in Part D, Item 5	As defined in Final Water Quality Monitoring and Management Plan for Dike Construction and Dewatering referred to in Part D, Item 5
ST-S-1 to TBD	Seeps (to be determined)	Operations	Group 1	Monthly or as found
		Closure	Group 1	Monthly or as found
ST-GW-1 to TBD	Groundwater wells (to be determined) as required under Groundwater Monitoring Plan	Operations	Group 2	Annually
		Closure	Group 2	Annually
ST-WT-1	Attenuation Pond, pre-treatment	Operations	Group 1	Four times per calendar year
ST-WT-2	Attenuation Pond, post treatment; last point of control before discharge	Operations	Volume (m <sup>3</sup> )	Daily during periods of discharge
			Field Measurements	Weekly during periods of discharge
			Group 2	Weekly during periods of discharge
			Group1-MDMER Effluent characterization	Four times per calendar year
			Group 3-MDMER Acute Toxicity	Once prior to discharge and Monthly thereafter
3-MDMER sub-lethal toxicity	Two times per calendar year			
ST-WT-3	Waste Rock Storage Facility (WRSF) Pond prior to pumping to Attenuation Pond	Operations	Group 1	Four times per calendar year, when water is present.
		Closure	Group 1	Four times per calendar year, when water is present.
	Waste Rock Storage Facility (WRSF) Pond prior to discharge to Mammoth Lake	Post-closure	Group 1	Four times per calendar year, when water is present.
ST-WT-4	Whale Tail Pit or pit sump	Operations	Group 1	Four times per calendar year
ST-WT-5	Water intake from Nemo Lake	Construction	Volume (m <sup>3</sup> )	Monthly
		Operations	Volume (m <sup>3</sup> )	Monthly
ST-WT-6	Lake A47	Construction	Group 2	Monthly during open-water
		Operations	Group 2	Monthly during open-water

Station	Description	Phase	Monitoring Parameters	Frequency
		Closure	Group 2	Monthly during open-water
ST-WT-7	East diversion channel	Operations	Group 3	Three times (freshet, summer, fall) per calendar year
ST-WT-8	Water intake from Whale Tail Lake	Closure	Volume (m <sup>3</sup> )	Monthly
ST-WT-9	North Whale Tail Lake (as the basin fills and when it is connected to the south basin and prior to or when connected to the downstream environment)	Closure	Group 1	Four times per calendar year
		Post-closure	Group 2	Four times per calendar year
ST-WT-10	Pit Lake (as the pit fills)	Closure	Group 2	Four times per calendar year
		Post-closure	Group 2	Four times per calendar year
ST-WT-11	Sewage treatment plant	Operations	Group 1	Four times per calendar year
		Closure	Group 1	Four times per calendar year
ST-WT-12	Secondary containment at Whale Tail Bulk Fuel Storage Facility	Operations	Group 4	Prior to discharge or transfer of effluent
		Closure	Group 4	Prior to discharge or transfer of effluent
ST-WT-13	Lake A45	Operations	Group 3	Flow, Monthly during open-water
		Closure	Group 3	Flow, Monthly during open-water until water level have returned to baseline level
ST-WT-14	Lake A16 outlet	Construction	Group 2	Monthly during open-water
		Operations	Group 2	Monthly during open-water
		Closure	Group 2	Monthly during open-water
ST-WT-15	Lake A15	Construction	Group 2	Monthly during open-water
		Operations	Group 2	Monthly during open-water
		Closure	Group 2	Monthly during open-water



## 3 CROSS-LINKAGES AMONG AEMP-RELATED PROGRAMS

As described in **Section 2**, Agnico Eagle is responsible for implementing numerous monitoring programs related to the local aquatic receiving environment. This section presents a framework that highlights cross-linkages among monitoring programs and conceptually shows how it can be used to make more informed environmental management decisions (note that the latter element is presented in detail in **Section 4**).

### 3.1 Introduction

The framework is founded on the conceptual site model, which is used in ecological risk assessment to help understand potential relationships between site activities and the environment (e.g., water quality or certain ecological receptors). Conceptual site models (CSM) typically consist of the following elements:

- **Stressor Sources** – These are the sources of chemical (e.g., metals) or physical (e.g., total suspended solids) stressors that can potentially impact the environment.
- **Stressors** – These are the actual agents that have the potential to cause adverse effects to the receiving environment.
- **Transport Pathways** – These are the ways in which a stressor is released from the source to the receiving environment.
- **Exposure Media** – These are the media where a stressor occurs in the receiving environment. A single stressor might actually end up in multiple exposure media, with different ones being most important at different times. For example, if an effluent contained mercury, it would initially be found in the water column, then most would settle to sediments where it would then enter the food chain (i.e., biota tissue).
- **Receptors of Concern** – These are ecological entities selected for a variety of reasons, usually including sensitivity to relevant stressors and perceived ecological importance. These entities are often called valued ecosystem components in environmental impact assessments (see Section 4.2.1.2 for more details).

These components are depicted in a variety of ways in ecological risk assessment. An example of a simple pathway-style CSM focusing on a single stressor (total suspended solids [TSS] from dike construction) is presented in **Figure 3-1**. Sediment enters the water column by direct discharge (i.e., fine particulates associated with dike construction material) or by resuspension (i.e.,

disturbance of fine bottom sediments by deposition of construction material). Once in the water column, TSS can affect pelagic receptors through a variety of mechanisms (e.g., reduced light penetration for phytoplankton). TSS can also settle out of the water column to the lake bottom, where it can affect benthic organisms through (for example) smothering of the benthic community.

### 3.2 Cross-Linkages Among Monitoring Programs

Strategic monitoring of various nodes of the CSM helps to build our overall understanding of the situation to make informed management decisions. Independently, the information provided by monitoring a single node of the CSM is just one piece of the puzzle. Integrated into the CSM framework they provide a much better sense of the “big picture.” Ultimately, our ability to mitigate stressors that could potentially affect the receiving environment (e.g., unacceptably high nutrient concentrations) requires identification of the stressor (e.g., nitrate) and its site-related source (e.g., blasting residue). Conceptually and practically, this places an emphasis on the CREMP program results which seek to evaluate potential effects from inputs from all mine related sources (including blasting, effluent, dust, etc.).

The generic principles of the CSM can be applied to any situation, provided that sufficient effort has been expended to adequately characterize each of the key elements. For this project, Agnico relied on the wealth of information generated as part of the environmental impact assessment process for the Meadowbank Gold Project.

- **Sources – The Aquatic Ecosystem/Fish Habitat Impact Assessment (AEIA, 2005)** provides a comprehensive overview of the Meadowbank and Whale Tail Project and its potential effects to the aquatic environment. The AEIA used “linkage matrices” to describe how each mine-related activity could affect water quantity, water quality, fish, or fish habitat for each major development phase (i.e., construction, operations and closure/post-closure). Collectively, these matrices identify all major activities and their potential effects to the receiving environment; compiled lists for each development phase are provided in **Table 3-1** to **Table 3-3**.
- **Transport Pathways** – These are listed in **Figure 3-2**. Effluent has been included as its own transport pathway to distinguish it from other pathways (i.e., increases resolution among pathways).
- **Exposure Media** – These are listed in **Figure 3-2**. Tissue is included to cover potential exposure to contaminants via the food chain.
- **Receptors of Concern** – The receptor groups are listed in **Figure 3-2** and include metrics for primary productivity and secondary productivity for both the benthic and pelagic

zones of the receiving environment. “Fish habitat” represents critical biological or physical aspects of high-value fish habitat.

Each of the monitoring programs undertaken for the Meadowbank and Whale Tail Project (**Section 2**) provides data for one or more of the transport pathways, exposure media, and/or receptors of concern. Collectively, as shown in **Figure 3-2**, they represent a comprehensive monitoring network that addresses the nodes of the CSM. Their inter-linkages are highlighted for any given stressor through the development of a stressor-specific CSM. In the example shown in **Figure 3-3**, zinc has been identified as an effluent-related stressor (through effluent monitoring). Several other monitoring programs (e.g., CREMP water) may provide insights relevant to assessing the significance of the elevated effluent zinc concentrations in the receiving environment.

**Table 3-1. Major mine-related activities and potential effects identified in the *Aquatic Ecosystem/Fish Habitat Impact Assessment (AEIA, 2005)* for the construction phase of the Meadowbank Gold Project.**

Activity	Potential Effects		
	Water Quality	Water Quantity	Fish/Fish Habitat
General Construction	Sedimentation	58% volume of SPL impounded; 0.2% volume of TPL impounded	Barge noise
Dike construction	Emissions (hydrocarbons, incinerated waste)	Pump SPL water to TPL -> 5% volume increase in 3PL	Reduced fish passage: culvert at Turn Lake crossing, SPL/TPL channel closure
Dewatering	Dust (blasting, overburden, stripping, excavation)	TPL water level rise - shoreline erosion	Sedimentation
Pit development	Blasting residues (nitrogen spp.)	Closure of SPL/TPL connecting channel - alternate channel erosion	Construction footprint
Rock storage facilities (Portage and Vault)	Spills (fuel/diesel/explosives/loads on ice)	Vault Lake isolated, no natural outflow	
Main site roads & traffic	Sediment resuspension / increased TSS	Pump water from Vault Lake to Wally/Drilltrail (4.6% volume increase)	
Airstrip & air traffic	Release of soluble dike material	Culvert placement (seasonal increased water levels)	
Mine plant and facilities	Dewatering Effluent (entrained TSS and pore water metals)	Decreased storage capacity in ponds and wetlands	
Freshwater intake and pipeline	Waste rock seepage (metals, acid, TSS)	Change in lakes circulation patterns	
Discharge facilities and pipeline	Release of sediment, metals, and contaminants from surface water runoff	Surface drainage pattern disruption	
Non-contact diversion facilities	Sediment losses via permafrost degradation (mainly in bogs)		
Turn Lake road crossing	Leaching incineration ashes		
Plant site storage	Sewage/waste water discharged to tailings pond		
AN/Explosives storage and emulsion plant	Fires or explosions at the explosives magazine		
Site accommodations			
Sewage and waste disposal			
Access road and traffic			
Barge landing facility			
Barge traffic			
Explosive magazine			
Tank farm			

## Notes

Some of the specific details have changed from the AEIA phase; those changes are not necessarily reflected in this table, so some details may be inaccurate. [c] Dike Construction Monitoring

AN - ammonium nitrate

SPL - Second Portage Lake

TPL - Third Portage Lake

TSS - total suspended solids

**Table 3-2. Major mine-related activities and potential effects identified in the *Aquatic Ecosystem/Fish Habitat Impact Assessment (AEIA, 2005)* for the operations phase of the Meadowbank Gold Project.**

Activity	Potential Effects		
	Water Quality	Water Quantity	Fish/Fish Habitat
General Construction	Release of soluble dike material	Potentially high seepage rates (from lakes into pits)	Fish larvae entrainment into TPL intake pipe
Dikes	Dust (terrain, tailings desiccate)	Lost natural storage capacity in small ponds and wetlands	Sedimentation
Dewatering	Blasting residues	Water circulation pattern change in Wally Lake	Blasting (physical effect)
Pits	Increased TSS	Lost natural surface drainage (project lakes)	Attenuation pond effluent discharge
Rock storage facilities (Portage and Vault)	Emissions (hydrocarbons, incinerated waste)	Decreased water volume (TPL, Phaser Lake)	Reduced fish passage: culvert at Turn Lake crossing, SPL/TPL channel closure
Main site roads & traffic	Runoff from pit walls and tailings (TSS, metals, acid, nitrogen spp., reagent spills)	Increased water volume (Wall/Drilltrail Lake, Turn Lake (1 m))	Noise (Barge)
Airstrip & air traffic	Concentrated pore water release during tailings freeze back	Culvert (seasonal increase in lake water level)	
Mine plant and facilities	Attenuation pond effluent (yr1-5: TSS, metals, acidity, explosives residues; yr 5+: tailings supernatant, cyanide spp.)		
Freshwater intake and pipeline	Sediment losses via permafrost degradation (mainly through bogs)		
Discharge facilities and pipeline	Leaching incineration ashes		
Vault area effluent discharge	Waste water/ sewage discharge to tailings pond		
Non-contact diversion facilities	Sediment loading during drawdown		
Dewatering and draining facility	Release of water from waste rock piles (to attenuation pond)		
Turn Lake road crossing	Spills (fuel, diesel, transferred metals, explosives, tailings, reagents)		
Plant site storage			
AN/Explosives storage and emulsion plant			
Site accommodations			
Sewage and waste disposal			
Access roads and traffic			
Barge landing facility			
Barge traffic			
Explosive magazine			
Tank farm			

## Notes

Some of the specific details have changed from the AEIA phase; those changes are not necessarily reflected in this table, so some details may be inaccurate. [c] Dike Construction Monitoring

AN - ammonium nitrate

SPL - Second Portage Lake

TPS - Third Portage Lake

TSS - total suspended solids

**Table 3-3. Major mine-related activities and potential effects identified in the Aquatic Ecosystem/Fish Habitat Impact Assessment (AEIA, 2005) for the closure/post-closure phase of the Meadowbank Gold Project.**

Activity	Potential Effects		
	Water Quality	Water Quantity	Fish/Fish Habitat
Dikes	Release of soluble metals from pit walls (controlled flooding)	Controlled flooding of pits	Leaching/runoff of metals, acid (from waste rock pile, pit walls, dikes)
Pits/ attenuation pond	Release of metals and acid (waste rock pile, dike material)	Portion of TPL recovered	
Dewatering and draining facility	Pit Lake water into groundwater	Drawdown of TPL during flooding	
Rock storage facility	Pit Lake part of receiving environment (ultimately)	SPL area and volume decrease (permanent)	
	Release of nitrogen and metals (tailings dust)	Recontouring to restore drainage patterns	
	Increased TSS (during flooding)	Alteration of lake circulation patterns	
	Release of concentrated pore water (during tailings freeze back)	Continued disruption of surface drainage patterns	
		Deep pits become deposition area for sediment	
		Loss of storage capacity in ponds and wetlands	

## Notes

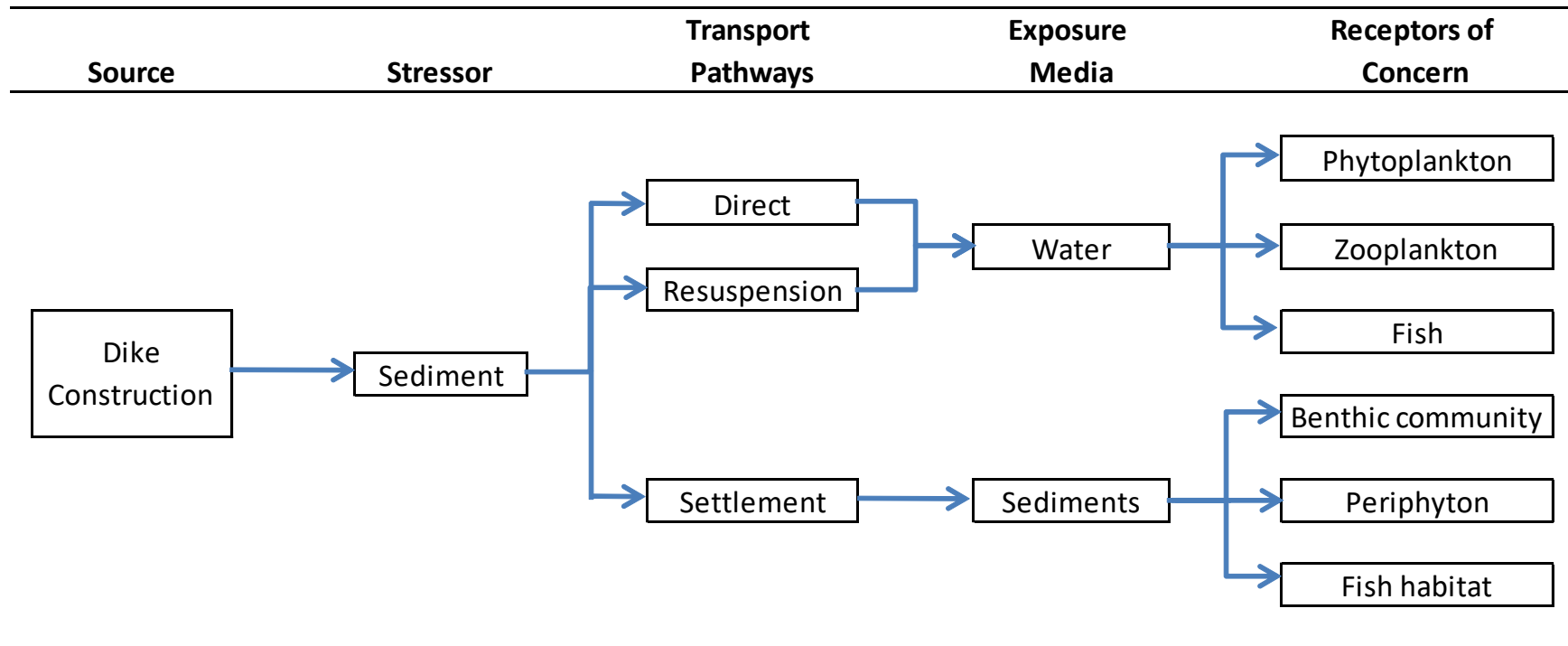
Some of the specific details have changed from the AEIA phase; those changes are not necessarily reflected in this table, so some details may be inaccurate.

SPL - Second Portage Lake

TPS - Third Portage Lake

TSS - total suspended solids

Figure 3-1. Simple pathway-style conceptual site model showing transport, fate and potential effects relationships for construction-related sedimentation.



**Figure 3-2. Primary transport pathways, exposure media, and receptors of concern for the Aquatic Effects Management Program.**

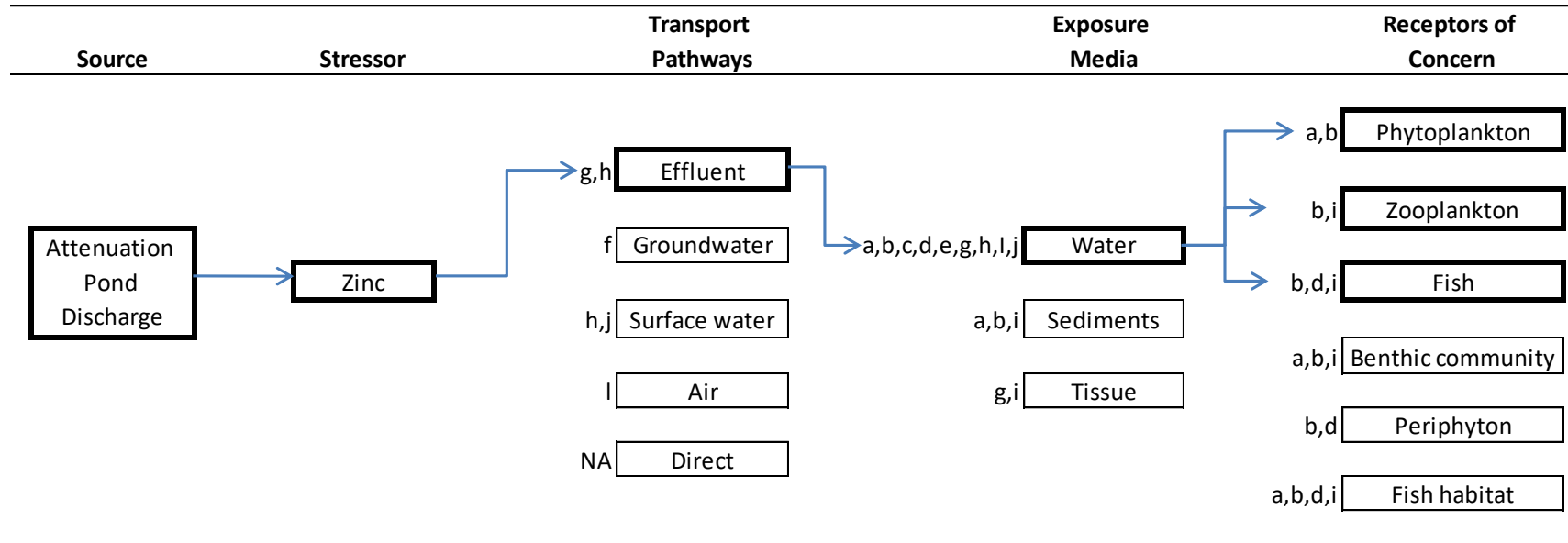
Transport Pathways	Exposure Media	Receptors of Concern
g,h <input type="text" value="Effluent"/>		a,b <input type="text" value="Phytoplankton"/>
f <input type="text" value="Groundwater"/>	a,b,c,d,e,g,h,i,j <input type="text" value="Water"/>	b,i <input type="text" value="Zooplankton"/>
h,j <input type="text" value="Surface water"/>	a,b,i <input type="text" value="Sediments"/>	b,d,i <input type="text" value="Fish"/>
l <input type="text" value="Air"/>	g,i <input type="text" value="Tissue"/>	a,b,i <input type="text" value="Benthic community"/>
NA <input type="text" value="Direct"/>		b,d <input type="text" value="Periphyton"/>
		a,b,d,i <input type="text" value="Fish habitat"/>

Notes

- [a] Core Receiving Environment Monitoring Program
- [b] Effects Assessment Studies
- [c] Dike Construction Monitoring
- [d] Habitat Compensation Monitoring Program
- [e] Dewatering Monitoring
- [f] Groundwater Monitoring
- [g] MDMER Monitoring
- [h] Water Quality and Flow Monitoring
- [i] Fish-Out Studies
- [j] AWPAP and Quarry Water Quality Monitoring
- [k] Blasting
- [l] Air quality monitoring
- [NA] Direct, so measured in exposure medium.



**Figure 3-3. Example of stressor-specific (zinc in effluent) conceptual site model showing cross-linkages among AEMP-related monitoring programs.**



Notes

- [a] Core Receiving Environment Monitoring Program
- [b] Effects Assessment Studies
- [c] Dike Construction Monitoring
- [d] Habitat Compensation Monitoring Program
- [e] Dewatering Monitoring
- [f] Groundwater Monitoring
- [g] MDMER Monitoring
- [h] Water Quality and Flow Monitoring
- [i] Fish-Out Studies
- [j] AWPAP and Quarry Water Quality Monitoring
- [k] Blasting
- [l] Air quality monitoring
- [NA] Direct, so measured in exposure medium.

## 4 MANAGEMENT RESPONSE PLAN

### 4.1 Introduction and Objective

The management response plan (MRP) aims to fulfill the water license requirement for ‘annual reporting for more immediate adaptive management’ (see text box below for discussion of terminology). In simple terms, the MRP describes the process of identifying potential risks to the aquatic environment and developing appropriate management responses.

The generic management response process in the context of the Meadowbank mine AEMP is shown in **Figure 4-1**.

#### **Terminology:**

*The management response plan (MRP) describes the actions that will be taken if potential effects of various magnitudes are predicted or observed (INAC, 2009a). The INAC guidance has replaced the term ‘adaptive management plan’ with MRP because adaptive management refers strictly to the use of deliberate experimental management to improve understanding and reduce uncertainties (Walters, 1986; Greig et al., 2008). Reviewers of adaptive management plans for other northern mines (e.g., Murray and Nelitz, 2008) have correctly pointed out that the scope of those plans was much broader than adaptive management. The potential role of true adaptive management (i.e., experimental management) is likely to be quite limited, because the impacts of such ‘experiments’ may not be acceptable or reversible (Greig et al., 2008). Monitoring for impacts from a mine and reacting to results of monitoring is not adaptive management (Murray and Nelitz, 2008). The A-licence for the Meadowbank Mine requires that the AEMP include ‘annual reporting for more immediate adaptive management’ (H-1(b)). It is assumed that the intent or meaning of that requirement is broad rather than strictly experimental management. Consequently, the term adaptive management is not used in the AEMP.*

The general management response plan for the AEMP is shown in **Figure 4-2**. The development of the MRP is tailored to each program, but response actions are based on the cumulative results of all programs. **Section 4.2** of this document describes the methodology for development and application of the MRP at the program-specific level, while **Section 4.3** describes the methodology and application of the MRP at the AEMP level.

## 4.2 The MRP at the Program-Specific Level

This section describes the methodology for development and application of the portions of the MRP that occur at program-specific levels. The Core Receiving Environment Monitoring Program (CREMP) is the program where the most rigour is needed in determining thresholds and early warning triggers for each variable, since the CREMP is the primary program used to detect impacts in the receiving environment, and unlike monitoring under EEM does not have pre-determined decision rules.

The end goal of applying these principles to the existing monitoring programs is to have clear decision criteria with which to evaluate the status of the results of each program. While a fair amount of detail has been provided herein to support the CREMP, the process for other AEMP-related monitoring programs may follow the same principles, but could be implemented in a simpler manner.

The components of the MRP are covered in this section as follows:

- Risk -based approach for determining which variables under each program may be used for establishing decision rules that will lead to management responses (Section 4.2.1);
- General experimental design and statistical framework to be applied to monitoring under each program (Section 4.2.2);
- Principles for sampling and analysis plans (SAPs) to be applied to each program (Section 4.2.3);
- Methodology for determining decision rules (thresholds and early warning triggers) for monitoring variables under each program (**Section 4.2.4**); and
- Process for summarizing data on a program-specific basis (**Section 4.2.5**).

### 4.2.1 Risk-Based Selection of Key Monitoring Variables

Depending on the program, the variables that are monitored include three types:

- Direct measures of potential effects (e.g., measurement of benthic community abundance and diversity);
- Contaminants or other variables that can cause effects, but that are measures of exposure rather than effects directly; and
- Ancillary variables that modify potential exposure or effects (e.g., water hardness; sediment particle size) or measure general characteristics of a particular environmental medium.

The list of variables that are monitored under each program may be defined in part by legal requirements (e.g., the water license). However where applicable, scientific rationale must be used to determine which subset of variables should be the focus for development of effects-based benchmarks (i.e., thresholds – explained further in Section 4.2.4). This is particularly relevant for the CREMP where some variables, particularly ancillary variables, may not be expected to be affected by the mine. Those variables will still be tracked over time, but their evaluation could be based on statistical triggers rather than effects-based thresholds. This section outlines the process that should be used for selecting variables for which effects-based thresholds should be established – consistent with recommendations in recent guidance for AEMP development (INAC, 2009b), implementation of AEMPs for other northern mines (e.g., Diavik, 2007a; b), and current risk assessment guidance at federal level (Azimuth, 2010a), a risk-based process is outlined with the following components:

- Identify stressors of potential concern (e.g., contaminants) that may impact the aquatic environment, and their characteristics related to (a) transport and fate, and (b) potential effects on aquatic receptors. Of particular importance is the availability of published effects benchmarks representing concentrations above which unacceptable effects might be expected.
- Identify receptors of concern (i.e., species, populations, communities or habitats that need to be protected – equivalent to ‘valued ecosystem components’)
- Characterize the potential exposure pathways by which sources of stressors may impact the receptors, and depict those linkages using a conceptual site model.
- Select assessment endpoints (specific attributes for receptors that are to be protected) and measurement endpoints (the monitoring variables that are to be used to measure exposure or effects). Measurement endpoints are categorized as primary (those which measure effects, or for which effects-based thresholds are established) and secondary (those that are monitored and evaluated on a statistical basis only, since thresholds are either not warranted or can’t be easily developed).

#### 4.2.1.1 Potential Stressors and Their Characteristics

**Identification of SOPCs** – Metals, suspended solids and other chemical or physical variables that may adversely affect aquatic life are referred to as stressors of potential concern (SOPCs). The list of SOPCs will be program-specific to some degree (e.g., suspended solids are not relevant in groundwater), but there will be a high degree of overlap among the programs. The starting point for identifying SOPCs for each AEMP program will be the variables that are listed in the water license, plus any additional variables that were identified in the Environmental Assessment for

the mine as potentially impacting aquatic life. Any variable that can be affected by the mine and could impact aquatic life should be considered.

**Potential Effects of SOPCs** – The effects of each SOPC will be characterized as part of the CREMP re-design, and most of the information will apply directly to other programs. The emphasis will be partly on summarizing primary literature but more on summarizing and evaluating the derivation of CCME guidelines and other effects benchmarks (such benchmarks will later be used for derivation of decision rules).

The review of effects characteristics of a SOPC emphasizes the types of organisms that may be affected by the contaminant of potential concern (COPC) and the relevant mechanisms of action. The concentrations associated with particular effects in particular organisms may be specified, helping to identify the types of effects and receptors that are expected to be most sensitive.

**Transport and Fate Characteristics of SOPCs** – The transport and fate characteristics of a SOPC determine how the contaminant will move from source(s) and partition into various environmental media such as water, sediment and biota. The transport and fate characteristics help determine which receptors and exposure pathways are relevant for each SOPC. For example, sediment benthic organisms may be the most relevant receptor group for stressors that partition primarily into sediment rather than water. Higher trophic level organisms such as fish may be most relevant for stressors that bioaccumulate or biomagnify up the food chain.

#### 4.2.1.2 Receptors of Concern

For AEMP programs that target the receiving environment, in particular the CREMP, it is important to identify what Receptors of Concern (ROCs)<sup>8</sup> could be affected by stressors. A Receptor of Concern (ROC) is any non-human individual, species, population, community, habitat or ecosystem that is potentially exposed to a SOPC. The level of biological organization at which an ROC is defined varies. In the case of lower levels of biological organization, the community is often identified as the ROC (e.g., zooplankton community, benthic community). In the case of higher trophic levels, the ROC is usually defined at the species level (e.g., mink, eagle). In the latter case, the selection of an individual species may be for direct assessment of the identified organism and/or may be selected as a representative (or surrogate) for similar organisms.

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<sup>8</sup> The term Valued Ecosystem Component (VEC) has the same or similar meaning, but ROC is used here for consistency with risk assessment terminology, and to allow for variations from VECs identified during the environmental assessment as appropriate.

The Environmental Assessment for the mine, specifically the identified Valued Ecosystem Components (VECs), will be the starting point for identification of ROCs in the receiving environment. If it is necessary to identify specific surrogate ROCs to represent particular functional groups, or if gaps are identified based on knowledge gained since completion of the EA, the following criteria (from Azimuth, 2010a) will be used to identify appropriate ROCs:

4. **Ecological relevance** – An ecologically ‘relevant’ ROC is an organism that is an appropriate indicator of actual or potential exposures given the environmental conditions germane to the assessment. An ecologically relevant organism should be expected to be found at a site under reasonably foreseeable conditions (e.g., an arctic fox at a site in the arctic). It is usual practice to select ROCs that represent key functional groups that are expected to be exposed to the SOPCs on site. In addition, keystone species that are important to ecosystem stability may be preferentially selected as ROCs.
5. **Degree/mechanism of exposure to the SOPCs on site** – A number of factors have the potential to affect the degree to which ROCs are exposed to the SOPCs on the site, including:
  - The status of the ROC (life stage, migratory versus resident);
  - How the ROC uses the site (feeding guild, feeding behaviour);
  - How much/often the ROC uses the site (home range size, habitat suitability, off-site habitat characteristics); and
  - Number and type of exposure pathways (environmental media, indirect/direct contact/consumption, bioaccumulation and biomagnification processes).
6. **Relative sensitivity to the SOPCs** – It is customary to include species or other receptor types that are relatively sensitive to the SOPCs. The principle for selection of a sensitive species is that demonstration of lack of harm for a sensitive organism conveys protection for the less sensitive taxa in the same functional group.
7. **Relative importance from a conservation perspective** – If rare, endangered or threatened species (i.e., listed species) and/or habitats are confirmed to be present, these species must be considered as potential ROCs. They should also be included if they are likely to be present in the future (based on information regarding geographic distribution, habitat preferences and site-specific habitat availability).
8. **Relative social, economic and/or cultural importance** – Any particular species or group that is of special importance (e.g., species of significance to First Nations, species of commercial or recreational importance) would typically be included as an ROC and may be subjected to more emphasis and more scrutiny than other ROCs.

9. **Availability of ecotoxicological and life history data** – Where effects data will be literature-based, ROCs for which ecotoxicological data are readily available are preferentially selected; otherwise the ability to assess effects on the ROC may be reduced. The benefit of selecting highly-specific ROCs is offset where data related to toxicity thresholds are limited.

#### 4.2.1.3 Exposure Pathways

Exposure pathways are the routes of exposure from environmental media (e.g., soil, water, air, sediment) to the receptors of concern. Examples of exposure pathways include water and food consumption (for wildlife) and direct contact (for invertebrates). The identification of pathways links sources of SOPCs to ROCs based on the characteristics of each. For AEMP programs that specifically target sources (e.g., groundwater, effluent discharges) the evaluation of exposure pathways is not relevant; rather, exposure pathways are most relevant for programs that target the receiving environment (e.g., the CREMP).

The starting point for evaluation of exposure pathways will be the Environmental Assessment findings (e.g., linkage matrices) for the project.

#### 4.2.1.4 Assessment and Measurement Endpoints

An assessment endpoint is an explicit expression of the attribute of a ROC that is to be protected. For example, if the ROC is the benthic invertebrate community, an assessment endpoint might be benthic invertebrate abundance and diversity. The assessment endpoint sets the stage for exactly what effects variables will be measured as measurement endpoints.

Measurement endpoints are the specific exposure and effects variables selected to be measured and then used to evaluate risks. For purposes of the MRP for the AEMP, the measurement endpoints are categorized as primary (those which measure effects, or for which effects-based thresholds are established) and secondary (those that are monitored and evaluated on a statistical basis only, since thresholds are either not warranted or can't be easily developed). Criteria for the selection of measurement endpoints and categorization as primary/secondary are:

- Legal requirement for monitoring (e.g., inclusion in the water license);
- Availability of CCME guidelines or other published benchmarks (for exposure variables);
- Availability of toxicological information on effects (for exposure variables);
- Likelihood that mine-related activities would cause changes in the variable (for exposure variables);

- Likelihood that changes in the variable would cause effects on the receptors at the site, given understanding of sources, fate and transport pathways, and sensitivities of receptors (for exposure variables);
- Ability of the specific variable to represent effects on receptors (for effects variables);
- Ability of a variable to simultaneously represent several individual variables. For example, principal components could be used to represent groups of chemistry variables; and
- Duplication with other variables (a program design that targets every parameter has more change of false positives, i.e., type-I errors).

Since the Meadowbank AEMP has been operating for some time, rationale should be provided not only for the inclusion of specific variables as measurement endpoints, but also for the exclusion of variables.

#### 4.2.2 Experimental Design and Statistical Framework

The monitoring programs outlined in Section 2 vary considerably in terms of focus and content. Some are data rich (e.g., CREMP), allowing for quantitative statistical analyses, and others are constrained by data limitations (e.g., groundwater monitoring) and are assessed without statistical procedures. Some involve explicit comparisons to spatial and temporal reference conditions (e.g., the before-after-control-impact [BACI] design, where data from the ‘before’ period and for ‘control’ stations are used to help make inferences from the data about potential impacts of the mine), whereas others rely on tracking trends at individual monitoring stations over time (e.g., the before-after [BA] design, where temporal changes at individual stations are used to make inferences about mine-related changes). Consequently, no single experimental design and analysis framework will apply to all cases. In general, one or more of the following tools will be used for evaluating potential effects in each of the component programs:

- **Visual trend analysis** – although graphical presentation of data and time trends would be an integral part of all analyses, we specify interpretation of graphical data separately because it may include data that are not used in the formal statistical tools below.
- **Time series analysis** – This approach refers to any methods of evaluating the data where time is treated as a continuous variable. The methods may range from simple linear models (e.g., linear regression) to more complex and formal time series methods (e.g., autoregressive integrated moving average modeling), if warranted and supported by the data. We distinguish time series regression from BACI-style analyses below only for communication purposes – the general modeling framework is the same, with the only distinction being the treatment of time as a continuous variable. Treatment of time as a



continuous variable will become more relevant as the temporal length of the data sets increase.

- **BACI-style (including CI) linear and multi-level modeling** – This refers to a general modeling framework that evaluates measured variables as functions of time, space and other measured variables. It covers statistical tools such as analysis of variance, analysis of covariance, linear regression, and multiple regression. Depending on what type of data are available and how those data are structured, linear and multi-level models encompasses traditional control-impact, before-after, and BACI-style designs (Hewitt et al., 2001) and related formulations such as impact level by time, impact trend by time, and exposure gradient analyses (as described by Wiens and Parker, 1995). The reference to ‘multi-level’ modeling (Gelman and Hill, 2006; Pinheiro and Bates, 2000) refers to model formulations that account for the structured nature of the data (i.e., in cases where data are not independent but rather are grouped by year, month/season, station, or other variables). In this generalized, flexible modeling framework, data may be balanced or unbalanced (e.g., different numbers of replicates per station, missing data for some area / time combinations, etc.), and predictor variables can be treated as continuous or categorical. The levels inherent in any data groupings as well as their interactions are considered. To the extent that the available data support the analyses, model formulations that are relevant from a monitoring viewpoint will be explored. For additional details, the 2009 EAS report (Azimuth, 2010b) is the best example to date of implementation of the statistical modeling framework for the Meadowbank AEMP.

In general, for programs where statistical approaches are appropriate for data analysis, implementation will aim to:

- Use more than one method or model where appropriate.
- Use models that take into account the sources of variability that could affect any measured variable. Key sources of variability likely to be common to all programs are spatial variability, temporal variability (annual or seasonal), subsample variability and measurement error.
- Carefully consider subsampling / replication and the potential impact of pseudoreplication.

#### 4.2.3 Sampling and Analysis Plans

After the monitoring variables are selected, sampling and analysis plans (SAPs) for each program are used to specify how data will be collected and how laboratory analyses will be conducted. Since the programs within the AEMP have been underway for multiple years, the SAPs are

already implemented for the various programs (e.g., CREMP). However, these should be updated as needed. SAP's should cover the following elements:

- Field sampling methods;
- Field QA/QC procedures including storage and transport;
- Data quality objectives;
- Lab methods including sample processing, analytical methods and detection limits; and
- Lab QA/QC procedures.

#### 4.2.4 Thresholds and Triggers

##### 4.2.4.1 Background

The need for and nature of management actions can be based on various criteria, but the most important among these are criteria that measure the *magnitude* of a problem, such as the concentration of suspended solids in the water column. The key principle is to establish an approach that allows actions to be triggered before unacceptable adverse effects occur (INAC, 2009a). In addition, there may be more than one type or level of trigger for a given measured variable.

##### 4.2.4.2 Meadowbank Approach

Despite the varied nature of the monitoring programs contributing to the AEMP (**Section 2**), most benefit from having clear decision criteria to help inform the management response plan. That said, there may be some programs (e.g., fish-out programs) where the approach does not make sense or where it may need to be modified. As an example, the remainder of this section focuses on the decision criteria for the CREMP, where a two-tiered approach is being applied, consisting of:

- **Thresholds** are defined as legal requirements, regulatory guidelines, or other discrete benchmarks, below which unacceptable adverse effects are not expected and above which unacceptable adverse effects may occur. If effects-based thresholds do not exist or are not warranted for a particular variable, then early warning triggers will be developed without thresholds. In such cases, if triggers are exceeded then the implications of such exceedances can only be understood through the integration of results from other AEMP monitoring programs, or, if important information gaps still exist, through focused studies (e.g., risk assessment).

- **Triggers** are early warning criteria that lead to action. The triggers may be based on absolute numbers (e.g., an increase half-way from baseline to an identified effect threshold) or statistical criteria (e.g., statistically significant trend that predicts exceedances of a threshold within 3 years).

The principles to be used for derivation of thresholds and triggers are as follows:

- For exposure variables, thresholds should be based on available benchmarks that relate the variable to potential effects. CCME guidelines are generally appropriate for use as thresholds because they have a toxicological basis and are relatively conservative, but the applicability of the underlying data to the receptors of concern at the site should be evaluated. Where CCME guidelines do not exist, there may be published guidelines or standards in other jurisdictions that could be considered applicable.
- For effects variables, thresholds should be derived by defining a critical effect size of ecological relevance. Effect sizes of relevance may vary depending on the variable but should be consistent with effect sizes that are (a) used in Canada for derivation of environmental quality guidelines, (b) used in Canada for site-specific risk assessments, (c) specified in the Environmental Assessment.
- More than one type of trigger may be appropriate for either exposure or effects variables. It is expected that triggers will be based on statistical analysis of time series data as well as comparison of data for any particular sampling event to baseline data. Time series triggers are expected to become more relevant as the length of the time series grows.

The types of thresholds and triggers that are developed will be different for exposure variables (e.g., chemical concentrations) and effects variables. The derivation process for thresholds and examples of potential triggers are shown in **Figure 4-3** (for exposure variables) and **Figure 4-4** (for effects variables, such as those in the CREMP). These figures are not detailed or specific to particular variables – the application to each variable (or groups of variables) may be developed as appropriate on a program-specific basis (e.g., for the CREMP [Azimuth, 2012]). It should be noted that for many programs (e.g., EEM) thresholds and triggers are pre-defined and are not subject to revision and for others the methods described above may not be applicable (e.g., AWAR habitat compensation monitoring program).

The difference in the derivation processes for exposure variables and effects variables is most easily understood with examples from the CREMP:

- *Exposure Variable Example:*
  - Variable: Zinc concentration in bulk sediment.

- Threshold: CCME sediment quality guideline.
- Triggers: (a) Mean zinc concentration in an area increases halfway from baseline (in a BACI framework) to the CCME ISQG, with a given degree of confidence; (b) Time trend analysis shows zinc concentration likely to exceed the CCME ISQG within three years, with a given degree of confidence.
- *Effects Variable Example:*
  - Variable: Benthic invertebrate community richness measured as total number of taxa.
  - Threshold: x % decrease in the total number of taxa relative to baseline (where x represents an agreed acceptable effect size, and baseline is estimated in a BACI framework).
  - Triggers: (a) Mean estimate of total number of taxa in an area decreases by  $\frac{1}{2}$  (x %) relative to baseline, with a given degree of confidence; (b) Time trend analysis shows that the mean estimate of total number of taxa in an area is expected to decrease by  $\frac{1}{2}$  (x %) relative to baseline within three years, with a given degree of confidence.

A key concept for derivation of thresholds is effect size. Effect sizes are implicit in CCME environmental quality guidelines (or other published benchmarks) and are unlikely to be questioned in those cases since they are already generally acceptable to regulatory agencies. However, for effects variables, a threshold can only be developed through explicit agreement on a critical effect size (an effect size below which effects would be considered acceptable). If a threshold cannot be developed or agreed, early warning triggers will be based purely on statistical criteria.

A key concept for application of triggers is statistical confidence. As part of the design for the CREMP (and other AEMP programs as appropriate), sample sizes required to ensure that exceedances of triggers can reasonably be detected in a BACI-style framework or time series analysis framework will be determined using *a priori* statistical power analysis for typical modeling scenarios and various time frames. Sample sizes may relate to the number of sampling areas and/or the number of samples in a given area depending on what question is being addressed by a statistical model. The desired power and the trade-offs among type 1 and type 2 errors will be determined for the CREMP (and other programs as appropriate) based on review of available guidance and discussion with regulators.

Once details regarding application of triggers are agreed, the subsequent evaluation of data should be based on the level of confidence in results (e.g., probability that the actual effect size is greater than the critical effect size of interest) (Newman, 2008).

#### 4.2.5 Data Summary Framework

If a trigger or threshold is exceeded, a risk-based, integrated evaluation of key results across AEMP programs will be conducted that evaluates monitoring variables according to criteria commonly used in risk assessment (Hull and Swanson, 2006; Azimuth, 2010a):

- **Magnitude** – the degree to which a variable exceeds early warning triggers or thresholds (as described above in [Section 4.2.2](#))
- **Spatial Scale** – the scale at which exceedances of triggers or thresholds occurs.
- **Causation** – the strength of evidence for a mine-related cause.
- **Permanence** – the likelihood and rate of reversal of the effect over time.
- **Uncertainty** – a reflection of confidence (or lack thereof) in the findings regarding magnitude, spatial scale and causation.

Within the annual report for each AEMP-related program, these criteria will be applied to each monitoring variable in each medium, and the results will be summarized using a categorical rating system for magnitude, spatial scale, causation, permanence and uncertainty, as shown in the example in [Figure 4-1](#).

### 4.3 The MRP at AEMP Level

The role of the annual AEMP report is more than a summary of the findings of each program. While each program may identify particular issues, evaluation of the findings across all programs is needed in order to understand the linkages between sources of stressors and potential effects, and to best design management actions. For example, if zinc is found to be elevated in sediment in the receiving environment, it will be important to evaluate the zinc data for groundwater, effluents and other discharges in order to determine the mine-related source, if any.

Once data are summarized for each program, the key findings for each program need to be evaluated together at the AEMP level so that any issues can be identified and understood, and management response actions can be developed. This section describes the process of integrated data evaluation ([Section 4.3.1](#)), and the process of selecting management actions ([Section 4.3.2](#)).

#### 4.3.1 Integrated Data Evaluation

The integrated evaluation of data across all programs begins with a summary of the data. Since magnitude is the most important criterion for determining the need for management actions, a simple table such as that shown in [Table 4-2](#) should be used to summarize under which

programs there were exceedances of triggers and thresholds. **Table 4-2** is the highest level of summary table. For those variables or groups of variables where there are exceedances of triggers or thresholds, a more thorough summary of the data is warranted including the other criteria related to spatial scale, causation, permanence and uncertainty. An example template for such a summary is provided in **Table 4-3** for a stressor variable.

Once the data summary is complete, the patterns among the programs need to be characterized in mechanistic detail. This should be done using an issue-specific conceptual site model. For each issue identified, available information across AEMP-related programs for source, stressor, transport pathways, exposure media, and effects measures will be evaluated. Each stressor/transport-pathway, stressor/medium and medium/effect measure combination related to the issue would be assessed across programs based on the overall evidence for magnitude, spatial scale, causation permanence and uncertainty. In addition, the strength of available information relating stressors to specific sources and effect measures to specific stressors will be assessed. As shown in **Figure 4-2**, understanding both these linkages (i.e., effect to stressor to source) are critical to the identification of effective management actions. An example of an issue-specific conceptual site model for the 2008 sedimentation event during East Dike construction is shown in **Figure 4-5**. This summary is based on a range of data collected in 2008 and 2009 across several programs (CREMP, Dike Construction Monitoring, Effects Assessment Studies, Habitat Compensation Monitoring; Azimuth, 2010b,c,d,e), but all related to East Dike construction.

#### 4.3.2 Management Actions

Management actions will be taken in cases where integrated evaluation of results across AEMP programs identifies a potential impact to the receiving environment; the scope of management actions will depend on the nature of the problem, the spatial scale, evidence for causality, permanence and uncertainty. The process that will be used to identify management actions was shown in **Figure 4-2**. Management actions can be divided into those aimed at further assessment and those aimed at mitigation. A toolbox of assessment options is provided in **Table 4-4** and a toolbox of mitigation options is provided in **Table 4-5**.

The specific management action that would be appropriate in a given case depends on the underlying cause. For example, if a metal becomes elevated in receiving water, the identification of options for further assessment and/or mitigation options would be different if the source of the metal is groundwater versus effluent versus dust.

The timing of management actions is also case-specific. In cases where further monitoring and assessment is warranted, that assessment should begin as soon as practically possible. In cases

where mitigation is considered, mitigation should begin as soon as the weight of evidence indicates that mitigation is warranted, and the benefits of commencing mitigation immediately outweigh the disadvantages of waiting for further information. Consultation with regulators and stakeholders is important for determining management actions.

Importantly, management actions including assessment and mitigation should be considered on a real-time basis. In fact, the EAS studies that have been implemented in 2008 and 2009 were designed for further assessment in real time as TSS levels became elevated during dike construction. The AEMP process should then consider the results of the EAS in developing any additional management actions that may be appropriate. Furthermore, there will be cases where management actions may be implemented in real time based on results of a single program – for example, if a problem is identified in an effluent discharge, action may be taken without considering findings of other ongoing programs.

**Consultation and Communication** – Stakeholder involvement is key to the success of the AEMP. Mechanisms for stakeholder involvement are in place. Annual reporting processes generally have a time lag (e.g., results from one year are not distributed until early the following year). To the extent that data analyses can be completed in advance of finalization of annual reports, any issues that arise should be communicated as soon as they are detected. For some cases (e.g., elevated TSS during dike construction), problems can be detected within a day or two and can be communicated to regulatory agencies immediately.

**Table 4-1. Example template for summarizing results of monitoring under each program.**

Variable Type & Variable group	Magnitude <sup>1</sup>	Spatial Scale <sup>2</sup>	Causation <sup>3</sup>	Permanence <sup>4</sup>	Uncertainty <sup>5</sup>	Comments	Management Action <sup>6</sup>
Sediment Chemistry – total metals	0	n/a	n/a	Moderate	??		0
Benthic Invertebrates – total abundance	1	Small	Moderate	Moderate	?		1
...							

Notes

[1] Magnitude Ratings:

- 0 – no exceedances of early warning triggers or thresholds (or no apparent changes from baseline of concern)
- 1 – early warning trigger exceeded (or change from baseline warranting concern)
- 2 – threshold exceeded (or change from baseline exceeding magnitude of concern)

[2] Spatial Scale Ratings:

- n/a – no magnitude of effect, therefore not evaluated
- Small – localized scale
- Moderate – sub-basin to basin scale
- Large – basin to whole lake scale

[3] Causation Ratings:

- n/a – no magnitude of effect, therefore not evaluated
- Low – no evidence for a mine-related source
- Moderate – some likelihood of a mine-related source
- High – the source of the problem is very likely to be mine-related

[4] Permanence Ratings:

- n/a – no magnitude of effect, therefore not evaluated
- Low – rapidly reversible (e.g., months to years)
- Moderate – slowly reversible (e.g., years to decades)
- High – largely irreversible (e.g., decades +)

[5] Uncertainty Ratings:

- ? – low uncertainty
- ?? – moderate uncertainty
- ??? – high uncertainty

[6] Management Actions:

- 0 – no action
- 1 – continued trend monitoring in following year
- 2 – active follow-up with more detailed quantitative assessment in following year



**Table 4-2. Example / template summary of exceedances of triggers and thresholds for key AEMP monitoring variables.**

	AEMP Program <sup>1,2</sup>											
	Core Receiving Environment Monitoring Program	Effects Assessment Studies	Dike Construction Monitoring	Habitat Compensation Monitoring Program	Dewatering Monitoring	Groundwater Monitoring	MMER Monitoring	Water Quality and Flow Monitoring	Fish-Out Studies	AWPAR and Quarry Water Quality Monitoring	Blasting	Air quality monitoring
<b>Stressor Variables</b>												
suspended solids	●	●	●	NA	●	NA	○	○	●	○	NA	NA
sediment deposition												
water-borne toxicants												
sediment toxicants												
nutrients												
other physical stressors												
<b>Effects Variables</b>												
Phytoplankton												
Zooplankton												
Fish												
Benthic invertebrate community												
Periphyton												
Fish habitat												

Notes:

<sup>1</sup> Maximum values from each program are used.

<sup>2</sup> Codes for exceedances of triggers and thresholds:

○ No observed effects

◐ Trigger or guideline exceedance - early warning, explained in report

● Observed effects, explained in report

**Table 4-3. Example template for integrated evaluation of monitoring results across all programs for a monitoring variable or group of variables<sup>1</sup>.**

Program	Magnitude <sup>2</sup>	Spatial Scale <sup>2</sup>	Causation <sup>2</sup>	Permanence <sup>2</sup>	Uncertainty <sup>2</sup>	Comments
EAS and CREMP	2	Large	High	Low	?	
Dike Construction						
<b>INTEGRATED SUMMARY:</b>						

Notes

[1] The table would be tailored to the relevant media and programs for each variable.

[2] See [Table 4-1](#) for all ratings.

**Table 4-4. Toolbox of some potential receiving environment assessment methods.**

Type of Variable Triggered	Potential Assessment Options
Sediment – Contamination	<ul style="list-style-type: none"> <li>● Bioavailability studies (e.g., ration of AVS:SEM for selected metals)</li> <li>● Bulk sediment toxicity tests for invertebrates</li> <li>● Porewater toxicity tests (e.g., if transport is via groundwater)</li> <li>● Benthic invertebrate abundance / diversity</li> <li>● Development of site-specific sediment quality objectives (if not already done)</li> </ul>
Sediment – Deposition of Particulate Matter	<ul style="list-style-type: none"> <li>● Sediment traps to measure exposure</li> <li>● Literature review and analysis to evaluate likely effect of deposition</li> <li>● Bulk sediment toxicity tests for invertebrates</li> <li>● Benthic invertebrate abundance / diversity</li> <li>● In situ or ex situ experimental testing of effects of different deposition rates of particulate matter</li> </ul>
Water – Contamination	<ul style="list-style-type: none"> <li>● Bioavailability studies (e.g., Biotic Ligand Model for some metals)</li> <li>● Water column toxicity tests for fish and invertebrates</li> <li>● Benthic invertebrate abundance / diversity</li> <li>● In situ or ex situ experimental testing of effects of different contaminant concentrations on receptors</li> <li>● Development of site-specific water quality objectives (if not already done)</li> </ul>
Water – Suspended Solids	<ul style="list-style-type: none"> <li>● Water column toxicity tests for fish and invertebrates</li> <li>● In situ or ex situ experimental testing of effects of different concentrations of suspended solids on receptors</li> </ul>
Water – Decrease in measures of productivity	<ul style="list-style-type: none"> <li>● Literature review and modeling to evaluate likely effect on fish populations</li> </ul>
Effects variables (direct measures of zooplankton, benthos, fish, etc.)	<ul style="list-style-type: none"> <li>● More intensive study to characterize the magnitude of effects, spatial extent, and likely causes (e.g., through evaluation of spatial gradients).</li> </ul>

**Table 4-5. Toolbox of some potential mitigation options.**

<b>Cause of Potential or Known Effect</b>	<b>Potential Mitigation Options</b>
Dike Construction	<ul style="list-style-type: none"> <li>● Modification of use of turbidity barriers (e.g., use more than one barrier, lower barrier to bottom)</li> <li>● Change material used to construct dike</li> <li>● Modify methods of placing dike construction materials</li> <li>● Slow placement rate</li> <li>● Construct causeway prior to open water season</li> </ul>
Dike Materials (e.g., leaching of metals)	<ul style="list-style-type: none"> <li>● Cover with other material types</li> </ul>
Groundwater	<ul style="list-style-type: none"> <li>● Identify and cut-off pathway from source to groundwater</li> <li>● Cut off pathway from groundwater to receiving environment</li> <li>● Treat groundwater</li> </ul>
Effluent and Discharges	<ul style="list-style-type: none"> <li>● Increase settling times prior to discharge</li> <li>● Treat effluent prior to discharge</li> </ul>
Dust	<ul style="list-style-type: none"> <li>● Increase intensity of dust suppression measures (e.g., water trucks)</li> <li>● Change materials used as top layer for exposed surfaces</li> <li>● Use wind breaks in key places</li> </ul>

Figure 4-1. Generic management response process for the AEMP.

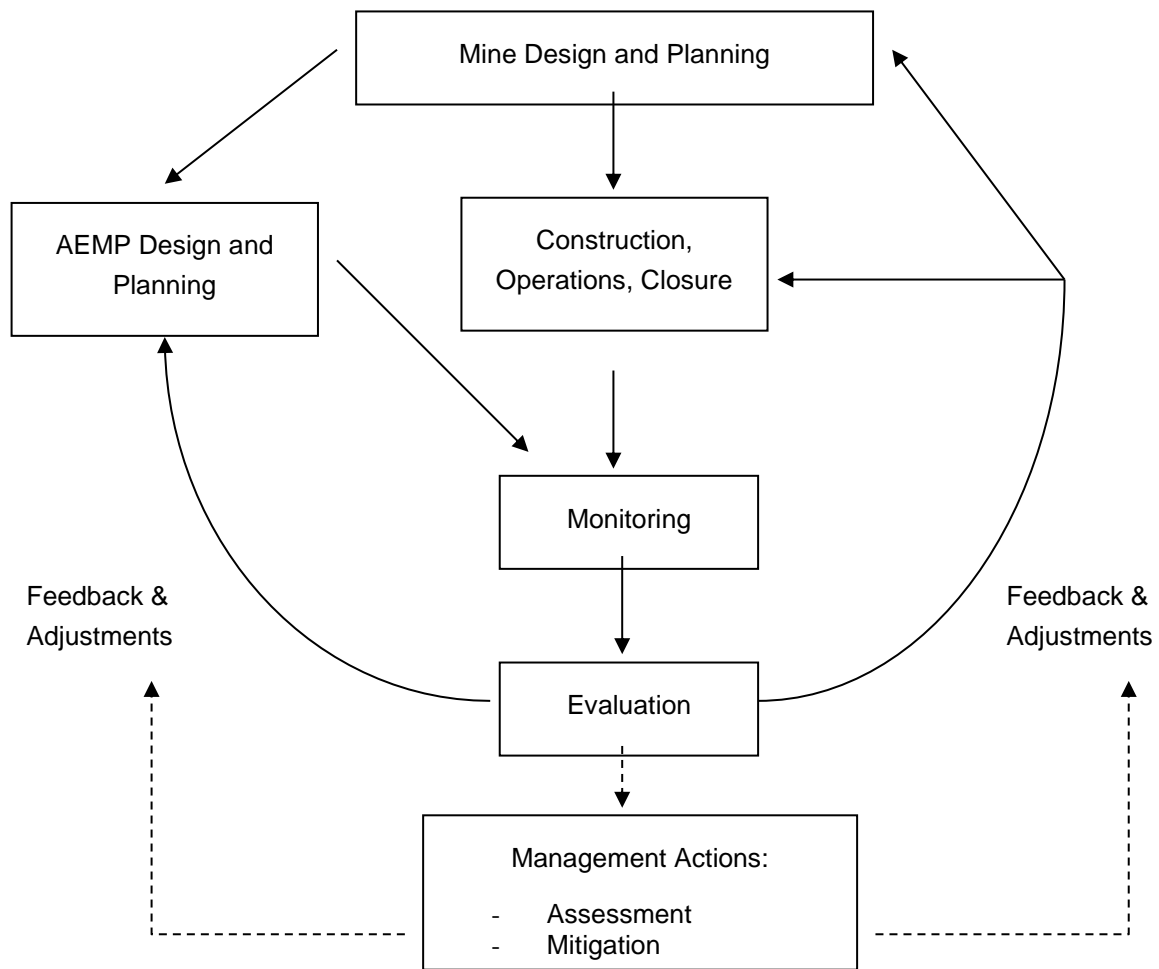


Figure 4-2. Management response plan for the AEMP programs.

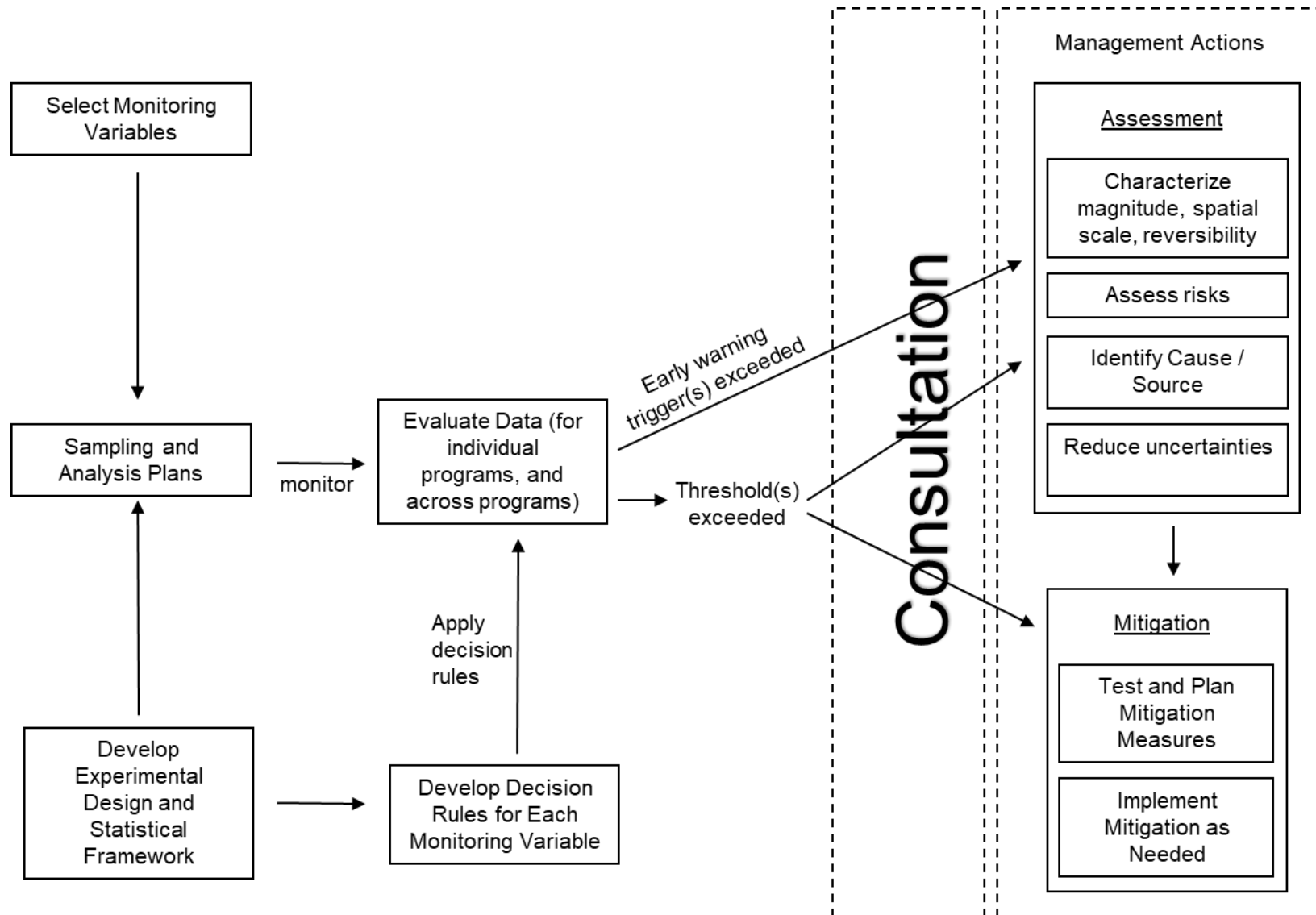
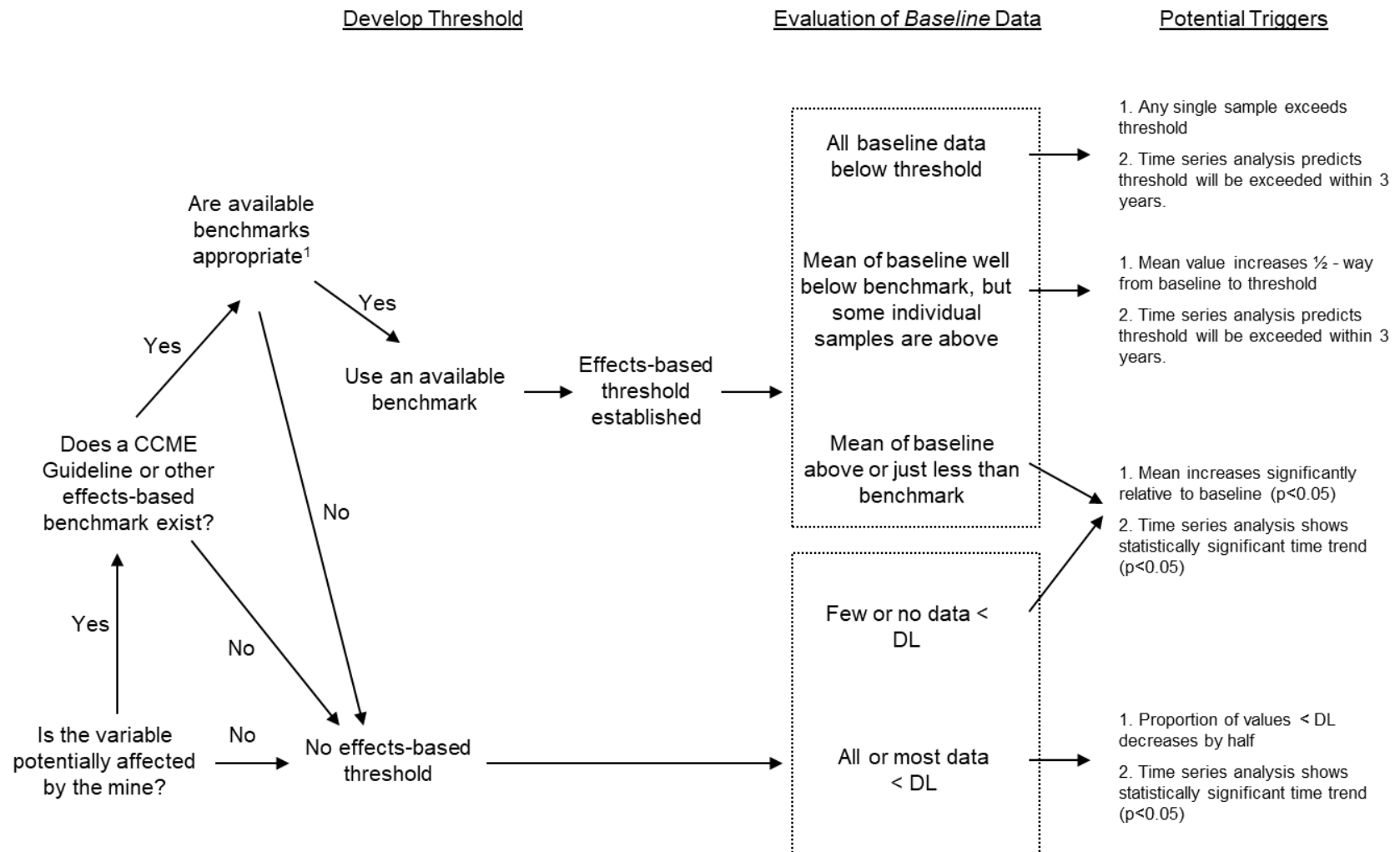
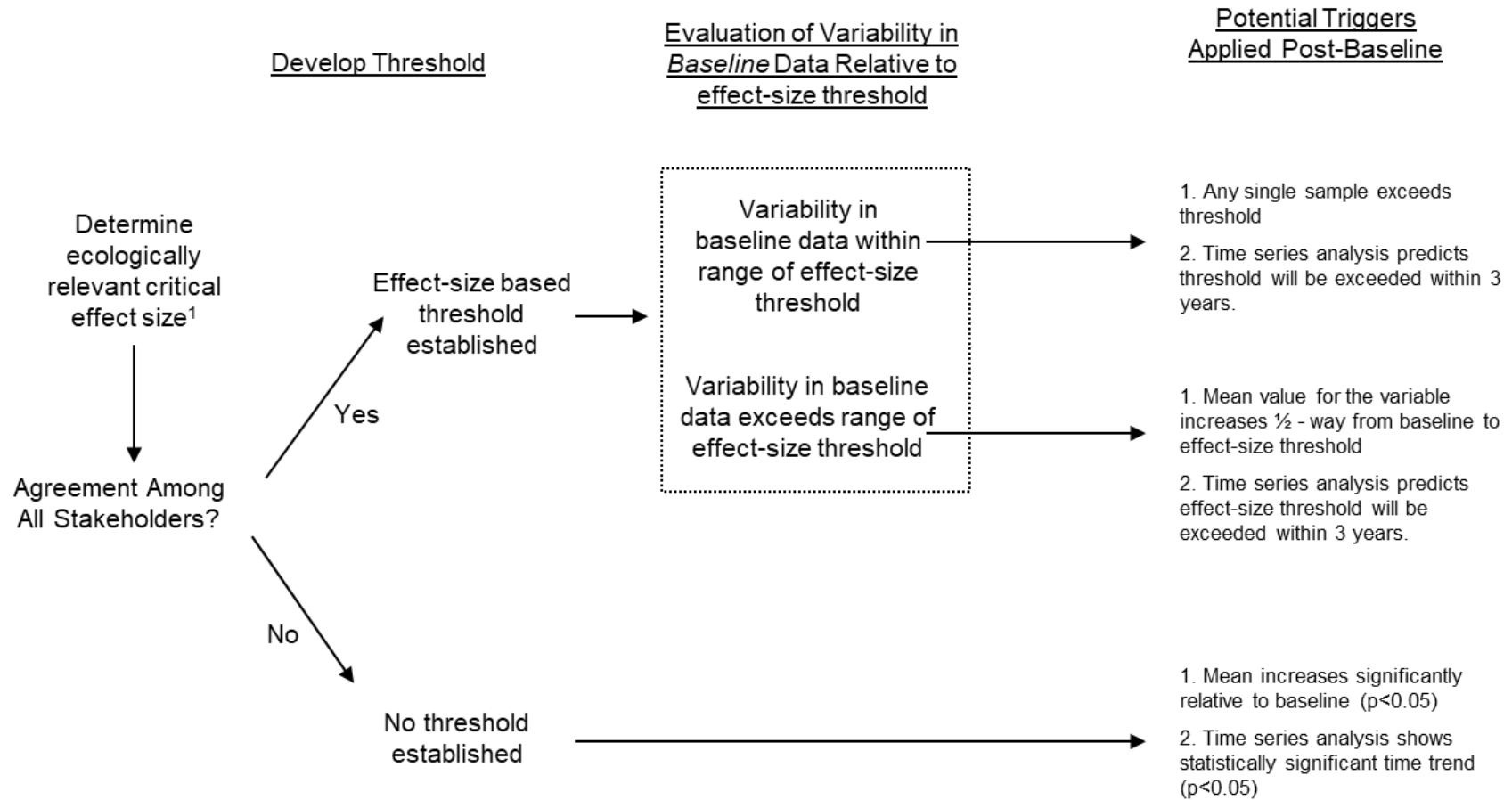


Figure 4-3. Derivation of thresholds and potential triggers for exposure variables.



<sup>1</sup> Considering acceptable effect sizes and site-specific information on receptors and exposure pathways.

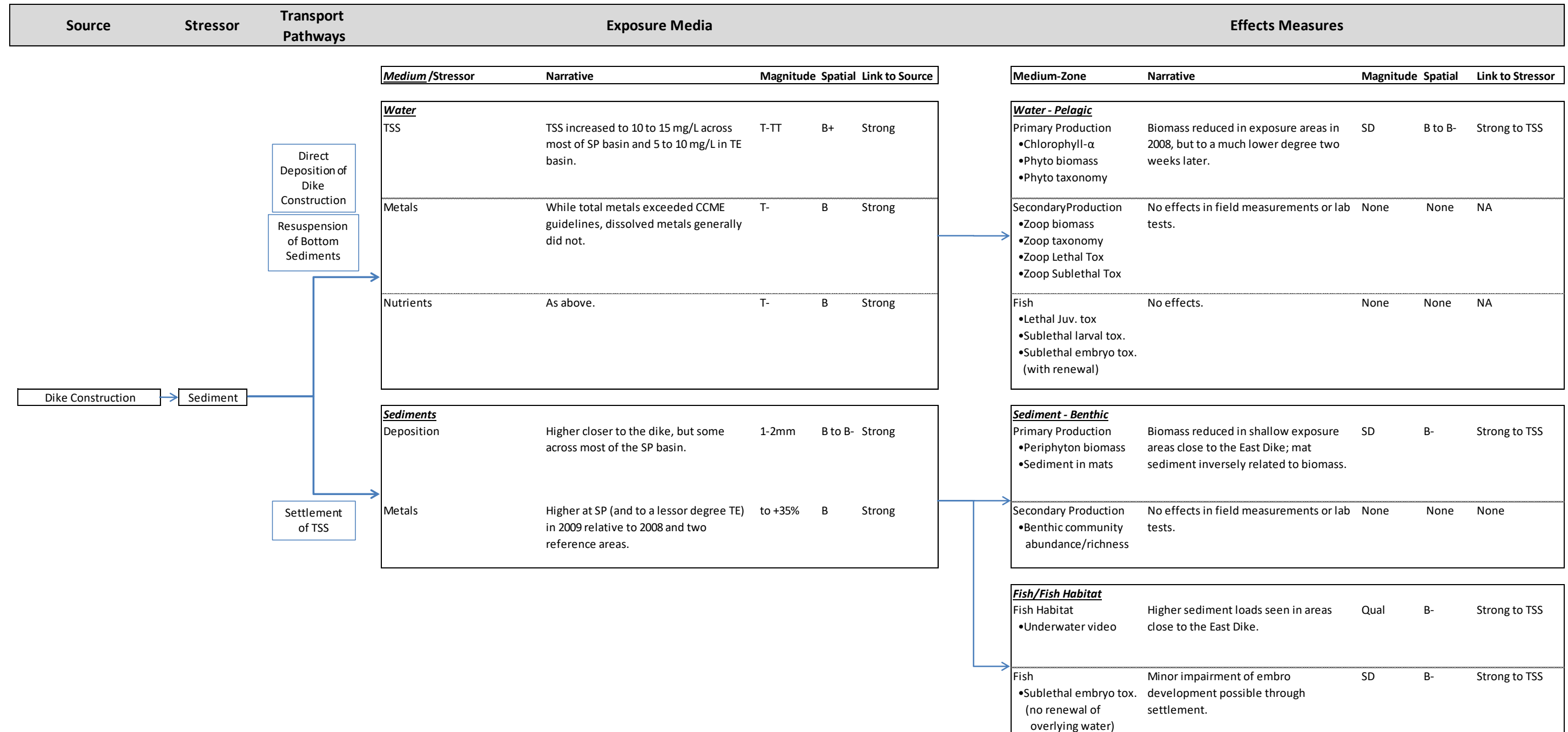
Figure 4-4. Derivation of thresholds and potential triggers for effects variables.



<sup>1</sup> Based on risk assessment policy, protection levels inherent in Canadian (e.g., CCME) environmental quality guidelines, and/or information in the Environmental Assessment.



Figure 4-5. Example of an issue-specific conceptual site model for the 2008 sedimentation event during East Dike construction.



Notes:  
**Magnitudes**  
 T- Exceeds relevant threshold due to particulate form.  
 T- Exceeds relevant threshold.  
 TT Grossly exceeds relevant threshold.  
 SD Statistically significant difference  
 Qual Qualitative assessment

**Spatial Extent**  
 B- scale less than lake basin  
 B basin-wide  
 B+ extending beyond a basin

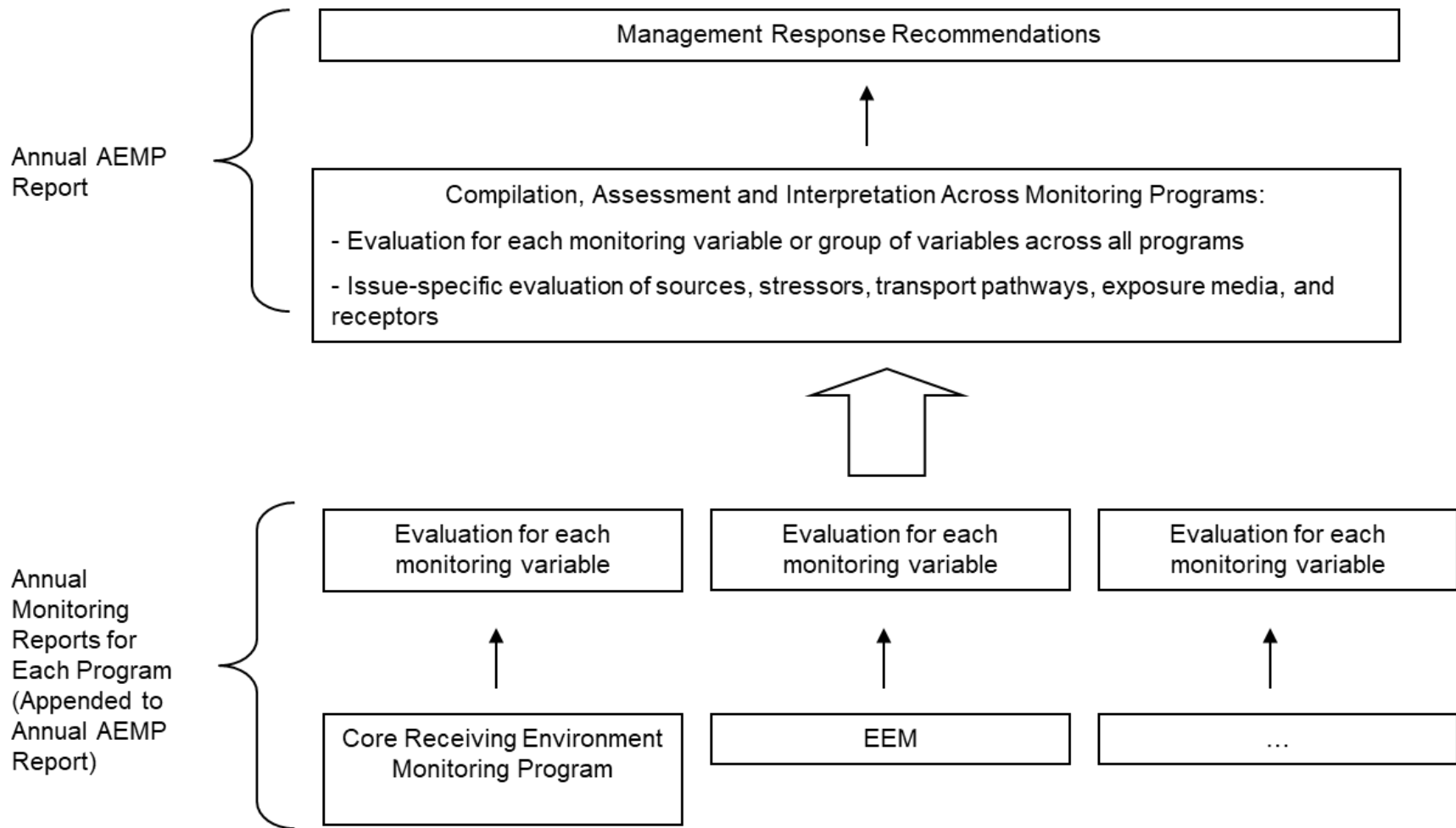
## 5 STRUCTURE AND CONTENT OF THE ANNUAL AEMP REPORTS

Following the process outlined in **Section 4.3.1**, the annual AEMP report would integrate the key findings from all of the component programs, conduct a meta-analysis of findings across the programs (i.e., through development of issue-specific conceptual site models), and develop corresponding recommendations for management response actions for each key issue. The specific monitoring program annual reports would still be published as stand-alone documents. Under this framework, the structure of the annual AEMP report would be as follows:

1. Introduction
2. Summary of AEMP-related programs with a focus on key findings.
3. Compilation and integration of results across all programs.
4. Discussion and assessment of key issues.
5. Recommendations, including (a) suggested revisions to the design of each monitoring program and (b) management response actions for each key issue.

This reporting process is depicted in **Figure 5-1**.

Figure 5-1. AEMP annual reporting process.



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