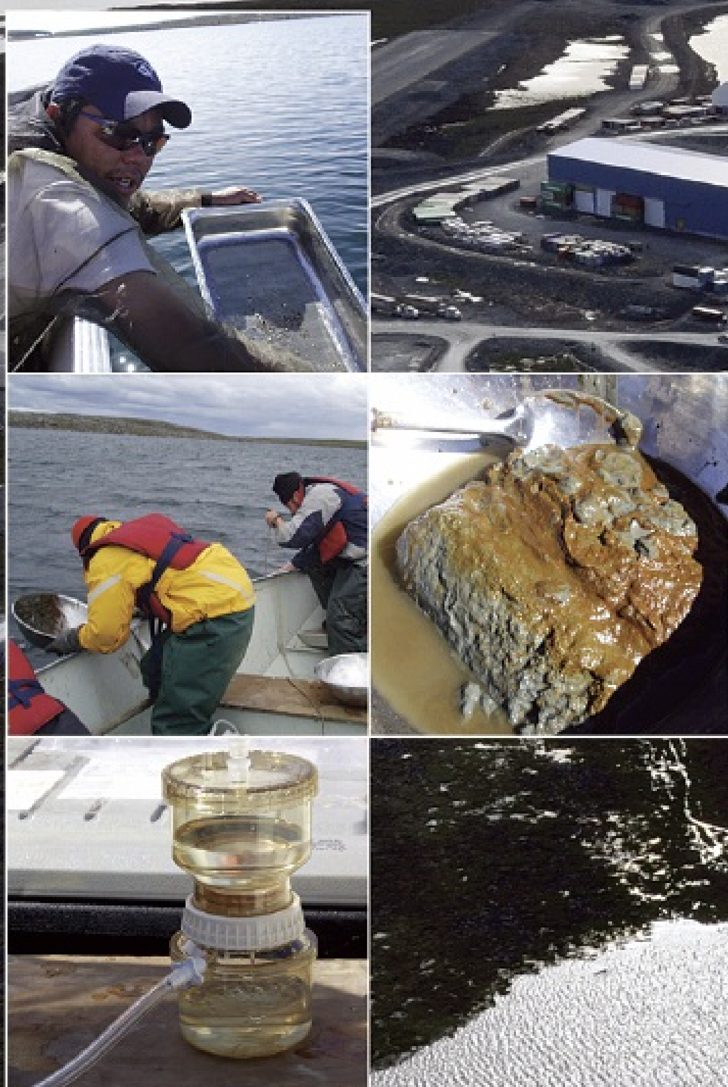
APPENDIX B1- AQUATIC EFFECT MANAGEMENT PROGRAM (AEMP), VERSION 2 (DEC. 2012)

Version 2
Project No. AE-10-01
December 2012

Aquatic Effects Management Program (AEMP)

Meadowbank Mine



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1	2010-05	All	All	Aquatic Effects Management Program (AEMP) Meadowbank Gold Project
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Version 2:
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1. INTRODUCTION

The Aquatic Effects Management Program (AEMP) for Agnico-Eagle Mines' (AEM) 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 water license (2AM-MEA0815) for the project issued by the Nunavut Water Board (NWB) in 2008 required a revised AEMP, and specifies 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):

- *A detailed monitoring protocol to verify that the Canadian Council of Ministers of Environment Fresh Water Aquatic Life Guidelines are met thirty (30) metres from the outfall diffusers*[1]*;*
- *Annual reporting for more immediate adaptive management*[2]*;*
- *Mechanisms to measure changes to productivity in the lake as a result of the mine adding nutrients*[3]*;*
- *Sampling and Analysis Plans*[4]*; and*
- *Monitoring under Fisheries Authorizations, NWB Licence Compliance Monitoring, Environmental Effects Monitoring, and Groundwater Monitoring.*

The last requirement diverges from traditional AEMPs (INAC, 2009) and required AEM 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 under the restructured AEMP and has been renamed the Core Receiving Environment Monitoring Program (CREMP) to minimize confusion.

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[1] This component is included in quarterly environmental effects monitoring (EEM) receiving environment monitoring under the *Metal Mines Effluent Regulation*.

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

[3] This is conducted as part of the Core Receiving Environment Monitoring Program (CREMP).

[4] This is part of the CREMP and other programs.

The restructured AEMP is organized as follows. **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. Finally, **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).

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

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 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"[5] process, supporting the early identification of potential problems and development of mitigation options to address them.

The CREMP study design was tailored based on our understanding of mine construction, operation and infrastructure (e.g., dikes, effluents, stream crossings, roads, etc.) and was developed to detect mine-related impacts at temporal and spatial scales that are ecologically relevant (i.e., on a basin spatial scale). The program targets general limnology, water and sediment quality, primary productivity (phytoplankton and periphyton), and benthic community structure. The core program initially focused solely on the project lakes (i.e., those in close proximity to the mine site), but was expanded to Baker Lake in 2008 to ensure that monitoring was also in place to track project-related activities in that area related primarily to barge traffic and shipping. In 2009, as dike construction and mineral exploration continued to expand, two additional references areas were added; one far-field reference well downstream of the maximum extent of observed water quality effects within Tehek Lake (Tehek Farfield: TEFF) and another remote external reference in Pipedream Lake (PDL).

The CREMP has been implemented as follows:

[5] This terminology is refined in **Section 4.1**.

- 2006 and 2007 – Two complete cycles were conducted prior to initiation of mine construction to characterize baseline conditions.
- 2008 through 2010 – Mine construction started in late July 2008, with dike construction activities occurring directly in the receiving environment. CREMP monitoring was complemented by targeted studies on dike construction monitoring and effects assessment studies for total suspended solids (TSS) (see **Sections 2.2 and 2.3**).
- 2010 – 2012 – In addition to continuing dewatering activities, mine operations commenced in this period.

The CREMP consists of the following general elements:

- Sampling Components – limnology, water and sediment chemistry, phytoplankton, and benthic invertebrate community.
- Sampling Areas – Near-field stations include: TPN, TPE, SP, WAL and Baker Lake stations BBD and BPJ; far-field stations include: TE, TEFF; reference stations include: TPS, INUG, PDL and Baker Lake stations BAP.
- Timing – annual water sampling (including limnology and phytoplankton) will be conducted in two stages: (1) comprehensive monitoring at all areas will be conducted up to 6 months per year (e.g., April, May, July, August, September and November/December pending safe access or logistical constraints) for full quantitative analysis and (2) basic water quality data (focusing on limnology and opportunistic water chemistry if needed) will be collected at key near-field areas (i.e., TPN, TPE, SP and eventually Wally) at least once mid-winter to reduce uncertainty regarding the potential occurrence of ecologically relevant changes over winter. Sediment chemistry and benthic invertebrate sampling will be conducted in August only, as it has been during baseline data collection.
- Spatial coverage – sampling locations are randomly distributed within each lake basin and samples are collected 3 m below the surface.

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. AEM commissioned targeted "effects assessment studies" (EAS) in each of the last two years (2008 and 2009) to address concerns regarding the potential impacts of elevated TSS concentrations on the local receiving environment from dike construction. Based on the literature, elevated TSS concentrations can directly or indirectly affect the entire range of organisms in the aquatic environment, so these studies have addressed a broad array of ecosystem elements.

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.

2.3. 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. 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* (AEM, 2009a).

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 (AEM, 2009a) 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, AEM 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, AEM 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

AEM 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 (**Figure 1-1**). 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 fish-out programs generally consists 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*[6] – 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

[6] This phase was not conducted for the fish-out of the Bay-Goose impoundment of Third Portage Lake due to its marginal utility for the northwest arm impoundment in Second Portage Lake.

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:
  1. No fish are caught for 48 hours, and then after a 24 hour break, no fish are caught for an additional 48 hours; or
  2. 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.

2.4.2. Habitat Compensation Monitoring

2.4.2.1. Mine Site and Western Channel Dike

AEM 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. AEM 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. All-Weather Private Access Road

The construction of the 105-km All-Weather Private Access Road (AWPAR) 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 AWPAR construction, baseline fisheries assessments found Arctic grayling (*Thymallus arcticus*) to be the predominant fish species. Other fish species opportunistically using the AWPAR 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 AWPAR 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 AWPAR 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 AWPAR 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 AWPAR and general fishing patterns of Baker Lake residents.

2.5. Groundwater Monitoring

AEM is responsible for completing annual groundwater monitoring as a condition of the Nunavut Impact Review Board (NIRB) Project Certificate (No. 004) and the NWB Water License. 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.

Overall, the objectives of the groundwater sampling program remains 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, 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.

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. 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. 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) AEM 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) AEM 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 and Second Portage 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 (weekly TSS and turbidity samples),
- Collect water samples in Third Portage Lake receiving environment,
- Ensure the sampling program meets the QA/QC requirements,
- Conduct hydraulic monitoring of the water levels in Third Portage Lake and Second Portage 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-MEA0815.

The Plan summarizes the monitoring locations, sampling frequency, monitored parameters, compliance discharge criteria and an adaptive management plan for water quality at the Meadowbank Gold 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 Gold Project. 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-MEA0815; 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 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. MMER and NWB A License Requirement I-1(a).

In January 2010, AEM's Meadowbank Gold Project became subject to the Metal Mines Effluent Regulations (MMER). AEM has since submitted documentation to MMER authorization officer and registred an environmental monitoring plan which includes the mandatory submission of regulatory data for dewatering discharge characterization, sublethal toxicity testing, water quality monitoring and flow monitoring. Additionally, the biological study design as part of environmental effects monitoring (EEM) will begin development for submission in January 2011. The first interpretive report will be submitted within 30 months of the Meadowbank Gold Project being subject to MMER.

The purpose of the dewatering discharge (effluent) water quality monitoring at the Meadowbank Mine site is to characterize the water quality as per the MMER, ensure that the water quality meets the water license A limits and will provide information for the support of the biological monitoring. Included in the MMER monitoring program at Meadowbank are weekly collections of effluent water quality (*Section 12*) samples from the final dewatering discharge point. Parameters for analysis include: pH, arsenic, copper, cyanide, lead, nickel, zinc, TSS and Radium 226. Monthly volume of discharge is taken (*Section 19*) and once per month effluent toxicity testing (*Section 14*) is completed with rainbow trout and daphnia magna acute lethality as testing endpoints. Under Schedule 5- Section 4 effluent characterization (which includes analysis of aluminum, cadmium, iron, mercury, molybdenum, ammonia and nitrate) is completed at the final dewatering discharge point. Additionally, under Schedule 5- Section 5 AEM completes sublethal toxicity testing two times per year at the final dewatering discharge point with fish, invertebrate, plant and algae species as endpoints. Lastly, four times per year water quality monitoring is completed in the receiving environment. Water quality is analyzed for: temperature, dissolved oxygen, pH, hardness, alkalinity, aluminum, cadmium, iron, mecury, molybdenum, ammonia, nitrate, arsenic, copper, cyanide, lead, nickel, zinc, TSS and Radium 226, at a dewatering discharge area in Third Portage Lake north basin and a reference station in Third Portage Lake south basin.

The objectives of this program are to meet the MME Regulations and the associated Guidance Documents which can be viewed on Environment Canada's Green Lane at the following addresses:

http://www.ec.gc.ca/nopp/docs/regs/mmer/en/index.cfm

http://www.ec.gc.ca/nopp/docs/regs/mmer/fr/index.cfm

The objectives for biological monitoring as part of the EEM will be established during the study design process. This is an iterative process that will require consultation with the EEM program coordinator and AEM.

In addition to MMER, 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 will be either integrated into the MMER program or conducted as part of the CREMP, whichever option does not result in duplication of effort.

2.9. AWPAR and Quarry Water Quality

AEM is responsible to manage erosion, water quality, and the introduction of sediment along the 110-km AWPAR that connects the Hamlet of Baker Lake to the Meadowbank mine site. As part of the water quality management, AEM 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 AWPAR. 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 AWPAR bridge and abutment construction. Water samples are collected at quarries that contain accumulated water.

The objectives of the annual AWPAR 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

AEM has developed a Blasting Monitoring Program for the control of blasting vibrations at Meadowbank (AEM, 2010). 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.

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. 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 two stations: one near the north end of Portage Pit along the shore of Second Portage Lake (north of the East Dike) and the other near the south end of Portage Pit on the shore of Second Portage Lake (south of the East Dike). 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 addresses the concentration of suspended particulate matter and the deposition rate of particles due to mine operation activities (Golder, 2008). 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 NOx 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 (at approximately 3 stations) and the dynamic sampling programs (at 2 stations using equipment such as the Ruppercht and Patashnick Partisol Model 2025). 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 co-located station to monitor Nitrogen dioxide will also be established. Air quality stations will be installed in 2010.

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. 2010. Core Receiving Environment Monitoring Program (CREMP) 2010 Plan Update. Meadowbank Gold Project. Report prepared by Azimuth Consulting Group Inc., Vancouver, BC, for Agnico-Eagle Mines Ltd., Meadowbank Division, Baker Lake, NU. June 2010. AEMP. 2005. Aquatic Effects Management Program. Report prepared by Azimuth Consulting Group Inc., Vancouver, BC, for Cumberland Resources Ltd (now Agnico-Eagle Mines Ltd.), Vancouver, BC. October 2005.	NWB DFO EC INAC	2AM-MEA0815 Part I, Item 1
MMER Plan	AEMP. 2005. Metal Mining Effluent Regulation. Report prepared by Azimuth Consulting Group Inc., Vancouver, BC, for Cumberland Resources Ltd (now Agnico-Eagle Mines Ltd.), Vancouver, BC. October 2005.	EC	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 AWPAR 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	AEM. 2009 . Meadowbank Gold Project Water Quality and Flow Monitoring Plan In Accordance with Water License 2AM-MEA0815 Version 2 May 2009	NWB	2AM-MEA0815 Part I, Item 2
Groundwater Monitoring Plan	Golder. 2008. Technical Memorandum: 2008 Groundwater Monitoring Plan Meadowbank Gold Project. August 1, 2008	NWB	2AM-MEA0815 Part I, Item 3
Water Quality Monitoring Plan for Dike Construction and Dewatering	AEM. 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	NWB	2AM-MEA0815 Part D, Item 11
QAQC Plan	AEM. 2008. Quality Assurance/ Quality Control Plan: Meadowbank Division, December 2008. Prepared by Agnico-Eagle Mines Limited-Meadowbank Division.	NWB INAC NIRB	2AM-MEA0815 Part I, Item 19 Project Certificate 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.	DFO	NU-08-0052
Operational ARD-ML Testing Plan	AEM. 2008. Meadowbank Gold Project Operational ARD/ML Sampling Plan in Accordance with Water License 2AM-MEA0815 Version 1, August 2008	NWB	2AM-MEA0815 Part I, Item 4
Blast Monitoring & Blasting Design Addendum	AEM. 2010 Meadowbank Gold Project Blast Monitoring Program,. Currently in consultation with DFO Version 1 March 2010	NIRB DFO GN	Project Certificate Condition 85
Air Quality Monitoring Plan	Golder. 2008. Addendum Report: Air Quality Monitoring Meadowbank Gold Project Doc 665A May 16, 2008	EC NIRB	Project Certificate Condition 71

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 MEA0815 License A.

Monitoring Program	Station	Description	Phase	Parameters/ Observations	Frequency
Dike Construction Monitoring	ST-DC-1 to TBD	Monitoring stations during dike construction	Construction	As defined in Water Quality Monitoring Plan for Dike Construction and Dewatering	As defined in Water Quality Monitoring Plan for Dike Construction and Dewatering
	ST-DD-1 to TBD	Monitoring stations during Dike Dewatering	Construction	As defined in Water Quality Monitoring Plan for Dike Construction and Dewatering	As defined in Water Quality Monitoring Plan for Dike Construction and Dewatering
Mine Operations Monitoring	ST-1	Water Intake for Camp and mill	Construction, operation, closure	Volume (m3)	Monthly
	ST-2	Reclaim Water Intake	Construction, operation, closure	Volume (m3)	Monthly
	ST-3	Water Intake for Emulsion Plant	Construction, operation, closure	Volume (m3)	Monthly
	ST-4	Water reclaimed from Tailings Storage	Operation, closure	Volume (m3)	Monthly
	ST-5	Portage Area (east) diversion ditch	Operation, closure	Al, pH, arsenic, copper, cyanide, lead, nickel, zinc, TSS, Radium 226, sulphate and turbidity	Monthly during open water
	ST-6	Portage Area (west) diversion ditch	Operation, closure	Al, pH, arsenic, copper, cyanide, lead, nickel, zinc, TSS, Radium 226, sulphate and turbidity	Monthly during open water
	ST-7	Vault Area diversion ditch	Operation, closure	Al, pH, arsenic, copper, cyanide, lead, nickel, zinc, TSS, Radium 226, sulphate and turbidity	Monthly during open water
	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 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 discharge
				Acute Lethality	Once prior to discharge and monthly thereafter
	ST-11	Tailings Storage Facility	Post Closure	MMER: total cyanide, Ar, Cu, Pb,Ni, Zn, radium 226, TSS, pH, effluent volumes, flow rate, acute tox, Daphnia Magna, Ammonia-Nitrogen, Nitrate-Nitrogen, Nitrite-Nitrogen	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-15	Vault non-contact diversion ditch	Operation, closure	Al, pH, arsenic, copper, cyanide, lead, nickel, zinc, TSS, Radium 226, sulphate and turbidity	Monthly during open water
	ST-16	Portage Rock Storage Facility	Early operation	temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn); total	Bi-annually during open water
				Total Metals	Once Annually immediately following spring freshet
			Late Operation	pH, turbidity, TDS, alkalinity, ammonia, arsenic copper, lead, nickel, zinc	Monthly during open water
			Closure	temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn);	Bi-annually during open water
				Total Metals	Once Annually immediately following spring freshet

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 MEA0815 License A.

Monitoring Program	Station	Description	Phase	Parameters/ Observations	Frequency
	ST-17	North Portage Pit Sump	Early operation	pH, turbidity, TDS, alkalinity, ammonia, arsenic copper, lead, nickel, zinc	Monthly during open water
				temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn); total	Bi-annually during open water
				Volume (m3)	daily during discharge
		Portage Pit Lake	Late Operation	Full Suite	Monthly during open water
			Closure	temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn);	Bi-annually during open water
	ST-18	Portage Attenuation Pond	Early operation	pH, turbidity, TDS, alkalinity, ammonia, arsenic copper, lead, nickel, zinc	Monthly during open water
				temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn);	Bi-annually during open water
	ST-19	Third Portage Pit Sump	Early operation	pH, turbidity, TDS, alkalinity, ammonia, arsenic copper, lead, nickel, zinc	Monthly during open water
				temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn); total	Bi-annually during open water
				Volume (m3)	daily during discharge
		Third Portage Pit Lake	Late Operation	Full Suite	Monthly during open water
	ST-20	Goose Island Pit Sump	Early operation	pH, turbidity, TDS, alkalinity, ammonia, arsenic copper, lead, nickel, zinc	Monthly during open water
				temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn);	Bi-annually during open water
				Volume (m3)	daily during discharge
		Goose Island Pit Lake	Late Operation	Full Suite	Monthly during open water
			Closure	temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn);	Bi-annually during open water
	ST-21	Tailings Reclaim Pond	Early operation (south of central dike)	temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn); cyanide	Bi-annually during open water
				Volume (m3)	Once Annually immediately following spring freshet
			Late Operation (north of central dike)	temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn); cyanide	Bi-annually during open water
				Total Metals	Once Annually immediately following spring freshet

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 MEA0815 License A.

Monitoring Program	Station	Description	Phase	Parameters/ Observations	Frequency
	ST-22	Tailings Storage Facility	Late operation	temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn); cyanide	Bi-annually during open water
				Total Metals	Once Annually immediately following spring freshet
	ST-23	Vault Pit Sump	Late operations	pH, turbidity, TDS, alkalinity, ammonia, arsenic copper, lead, nickel, zinc	Monthly during open water
				temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn);	Bi-annually during open water
				Volume (m3)	daily during discharge
	ST-24	Vault Rock Storage Facility	Late operations	pH, turbidity, TDS, alkalinity, ammonia, arsenic copper, lead, nickel, zinc	Monthly during open water
				temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn);	Bi-annually during open water
				Total Metals	Once Annually immediately following spring freshet
			Closure (east ditch) ST-24-A	temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn);	Bi-annually during open water
				Total Metals	Once Annually immediately following spring freshet
			Closure (west ditch) ST-24-B	temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn);	Bi-annually during open water
				Total Metals	Once Annually immediately following spring freshet
	ST-25	Vault Attenuation Pond	Late Operation	pH, turbidity, TDS, alkalinity, ammonia, arsenic copper, lead, nickel, zinc	Monthly during open water
				Total Metals	Once Annually immediately following spring freshet
				temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn);	Bi-annually during open water
	ST-26	Vault Pit Lake	Closure	Full Suite	Monthly during open water (flooding)
				temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn);	Quarterly (fully flooded)
	ST-S1 to TBD	Seeps (to be determined	Construction	temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn);	Monthly during open water
			Operation, closure	pH, alkalinity, turbidity, hardness, ammonia Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn;	Monthly or as found
Ground Water Monitoring	ST-GW-1 to TBD	Ground water wells (to be determined)	Construction, operation, closure	temperature, pH, conductivity, redox, DO, alkalinity, turbidity, hardness, ammonia nitrogen, nitrate, nitrite, chloride, fluoride, sulphate, TDS, dissolved metals (Al, As, Ba, Cd, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Zn); total and free cyanide for wells in ground water flow path of the TSF	Annually
Core Receiving Environmental Monitoring	ST-AEMP-1 to TBD	Receiving AEMP	Construction, operation, closure	Full Suite	Monthly during open water season all AEMP stations. Monthly throughout year at a smaller number of locations (through ice)
MMER	ST-MMER-1 to TBD	Vault and Portage effluent outfall	Early and late Operation	MMER: total cyanide, Ar, Cu, Pb,Ni, Zn, radium 226, TSS, pH, effluent volumes, flow rate, acute tox, Daphnia Magna	Weekly during open water season

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 MEA0815 License A.

Monitoring Program	Station	Description	Phase	Parameters/ Observations	Frequency
8BC-TEH0809					
Mine Operations Monitoring	ST-27 and ST-28	Water Intake for camp and concrete batch plant purposes	Pre-development, Construction	Volume for each purpose (m3)	Monthly
	ST-29 and 30	Water, if any, accumulated in north and south pre-development zones	Pre-development	pH, Turbidity	Weekly
				Metals using ICP-Metals 36 element scan, Total Ammonia, Nitrate, Sulphate	Monthly
	ST-32 and ST-32	Water pumped from north and south pre-development zones to Contact Water	Pre-development	pH, Turbidity	Daily during pumping periods
	ST-33 and ST-34	Contact Water Collection System Lakes #1 and #2	Pre-development	Metals using ICP-Metals 36 element scan, Total Ammonia, Nitrate, Sulphate	Monthly
	ST-35	Discharge from Lake #1 of Contact Water Collection System (Stormwater Management Pond) to Second Portage Lake	Pre-development, construction	ph, TSS, BOD, Fecal Coliforms, Total Metals (Al, As, Cu, CN, Pb, Ni, Zn) and Radium 226	Once prior to discharge and Weekly during periods of discharge
				Acute Lethality	Once prior to discharge and monthly thereafter
				Volume (m3)	Daily during periods of discharge
	ST-36	Discharge from Lake #2 of Contact Water Collection System (Stormwater Management Pond) to Second Portage Lake	Pre-development, construction	ph, TSS, Total Metals (Al, As, Cu, CN, Pb, Ni, Zn) and Radium 226	Once prior to discharge and Weekly during periods of discharge
				Acute Lethality	Once prior to discharge and monthly thereafter
				Volume (m3)	Daily during periods of discharge
8BC-MEA0709					
Mine Operations Monitoring	ST-37 (MEA-1)	Water sample location at Baker Lake in close proximity to the construction facility	Pre-development, Construction, operations, closure	pH, TSS, Cond, Total Ammonia, Total Arsenic, Total Metals thru ICP Scan, Oil and Grease, TPH, BTEX	Annually
	ST-38 (MEA-2)	East Contact water pond located in the south-east corner of the lay-down area	Pre-development, Construction, operations, closure	pH, TSS, Cond, Total Ammonia, Total Arsenic, Total Metals thru ICP Scan, Oil and Grease, TPH, BTEX	Prior to discharge or transfer of Effluent
				Total Metals (Ar, Cu, Pb, Ni), TSS, Ammonia, Cyanide, Benzene, Toluene, Ethlybenzene, Oil and Grease, pH	
				Volume (m3)	Monthly
	ST-39 (MEA-3)	West Contact Collection Pond located in the south-west corner of the lay-down area	Pre-development, Construction, operations, closure	pH, TSS, Cond, Total Ammonia, Total Arsenic, Total Metals thru ICP Scan, Oil and Grease, TPH, BTEX	Prior to discharge or transfer of Effluent
				Total Metals (Ar, Cu, Pb, Ni), TSS, Ammonia, Cyanide, Benzene, Toluene, Ethlybenzene, Oil and Grease, pH	
				Volume (m3)	Monthly
	ST-41 (MEA-5)	Water sample location at the ammonium nitrate storage area	Pre-development, Construction, operations, closure	Total Metals (Ar, Cu, Pb, Ni), TSS, Ammonia, Cyanide, Benzene, Toluene, Ethlybenzene, Oil and Grease, pH	Prior to discharge or transfer of Effluent
	ST-42 (MEA-6)	Water sample location at the explosive storage area	Pre-development, Construction, operations, closure	Total Metals (Ar, Cu, Pb, Ni), TSS, Ammonia, Cyanide, Benzene, Toluene, Ethlybenzene, Oil and Grease, pH	Prior to discharge or transfer of Effluent

3. CROSS-LINKAGES AMONG AEMP-RELATED PROGRAMS

As described in **Section 2**, AEM 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 to 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, we 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 Gold 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 **Tables 3-1 to 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 Gold Mine (**Section 2**) provides data for one or more of the transport pathways, exposure media, and/or receptors of concern. Collectively, as shown in **Figure 3-3**, 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 (e.g., **Figure 3-4**). In the example shown in **Figure 3-4**, 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 accomodations			
Sewage and waste disposal			
Access road and traffic			
Barge landing facility			
Barge traffic			
Explosive magazine			
Tank farm			

Note:

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.

AN - ammonium nitrate

SPL - Second Portage Lake

TPS - 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 dessicate)	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 degredation (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 accomodations			
Sewage and waste disposal			
Access roads and traffic			
Barge landing facility			
Barge traffic			
Explosive magazine			
Tank farm			

Note:

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.

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 restor 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	

Note:

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.

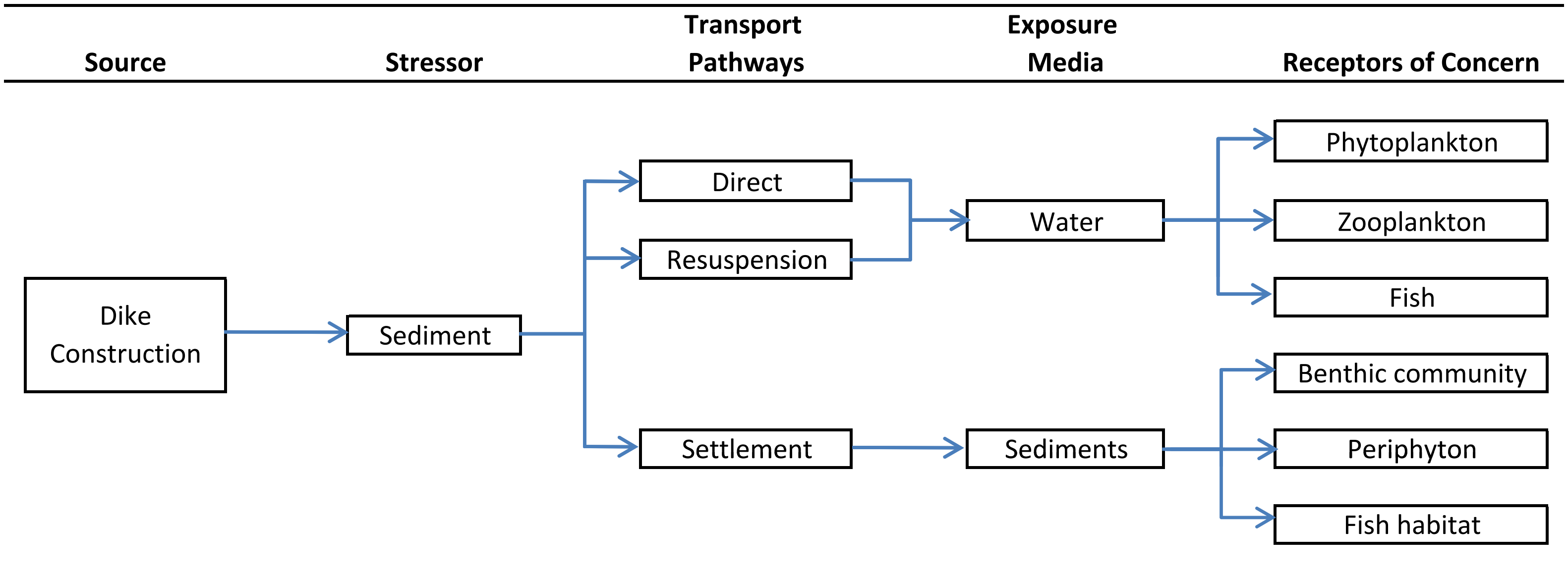


Figure 3-2. Primary transport pathways, exposure media, and receptors of concern for the Meadowbank Gold Project's Aquatic Effects Management Program.

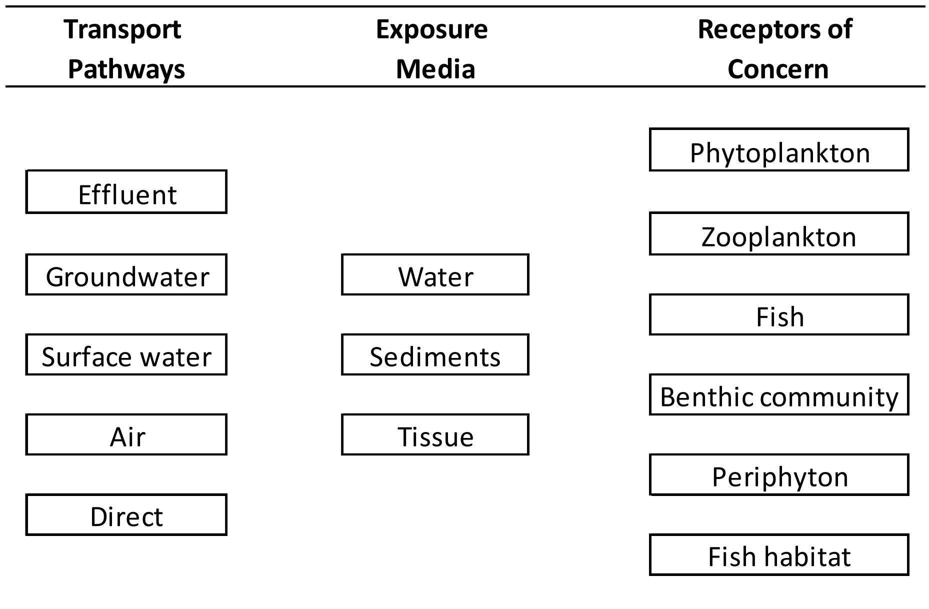


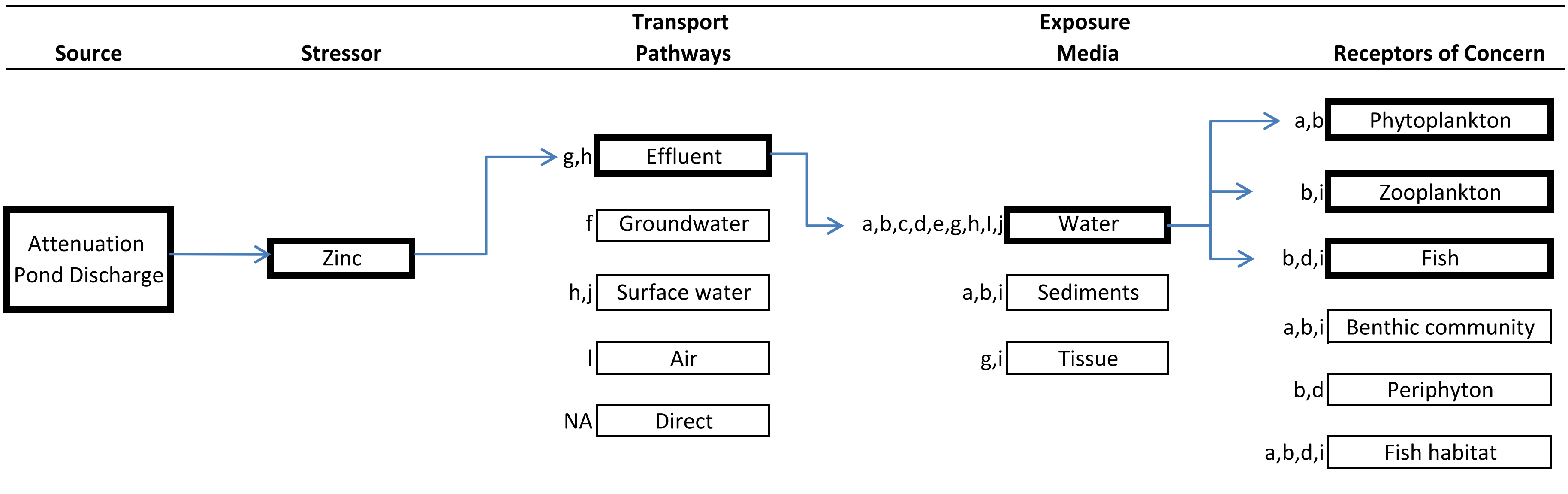
Figure 3-3. Primary transport pathways, exposure media, and receptors of concern for the Meadowbank Gold Project's Aquatic Effects Management Program.

Transport Pathways		Exposure Media		Receptors of Concern	
				a,b	Phytoplankton
g,h	Effluent			b,i	Zooplankton
f	Groundwater	a,b,c,d,e,g,h,l,j	Water	b,d,i	Fish
h,j	Surface water	a,b,i	Sediments	a,b,i	Benthic community
l	Air	g,i	Tissue	b,d	Periphyton
NA	Direct			a,b,d,i	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	MMER Monitoring
h	Water Quality and Flow Monitoring
i	Fish-Out Studies
j	AWPAR and Quarry Water Quality Montoring
k	Blasting
l	Air quality monitoring
NA	Direct, so measured in exposure medium.

Figure 3-4. 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	MMER Monitoring
h	Water Quality and Flow Monitoring
i	Fish-Out Studies
j	AWPAR and Quarry Water Quality Montoring
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 Meadowbank Mine 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 more simple 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 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)[7] 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.

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:

1. Ecological relevance – An ecologically ‘relevant’ ROC is an organism that is an appropriate indicator of actual or potential exposures given the environmental conditions

[7] 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.

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.

2. 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).

3. 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.

4. 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).

5. 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.

6. 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 an 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:

- <u>Visual trend analysis</u> – 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.
- <u>Time series analysis</u> – 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.
- <u>BACI-style (including CI) linear and multi-level modeling</u> – 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. A SAP 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 increases half-way from baseline to an identified effects 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 SQG, with a given degree of confidence; (b) Time trend analysis shows zinc concentration likely to exceed the CCME SQG 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 agree 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 ½ (*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 ½ (*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 4.2.4**)
- *Spatial Scale* – the scale at which exceedances of triggers or thresholds occurs.
- *Causation* – the strength of evidence for a mine-related cause.
- *Reversibility* – 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, reversibility and uncertainty, as shown in the example in **Table 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, reversibility 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 reversibility 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, reversibility 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	Medium	Magnitude[1]	Spatial Scale[2]	Causation[3]	Reversibility[4]	Uncertainty[5]	Comments
Lead	Sediment	○	n/a	n/a	Moderate	??	
Zinc	Sediment	◍	Small	Moderate	Moderate	?	
…							

[1] **Magnitude Ratings:**

○ - no exceedances of early warning triggers or thresholds

◍ - early warning trigger exceeded.

● - threshold exceeded.

[2] **Spatial Scale Ratings:**

n/a – not applicable, because no exceedances of triggers or thresholds

Small – Isolated occurrence or very small area

Moderate – Moderately sized area affected, such as a portion of a basin

Large – An entire lake basin (or lake) is likely to be affected

[3] **Causation Ratings:**

n/a There is no magnitude of effect, therefore causation is not evaluated.

Low – There is no evidence for a mine-related source.

Moderate – There is some likelihood of a mine-related source.

High – The source of the problem is very likely to be mine-related.

[4] **Reversibility Ratings:** bad = largely irreversible for at least several decades; moderate = reversible over long time periods (e.g., decades); good = most reversible in less than 10 years.

[5] **Uncertainty Ratings:** ? = low uncertainty; ?? = moderate uncertainty; ??? = high uncertainty.

Table 4-2. Example / Template Summary of Exceedances of Triggers and Thresholds for Key AEMP Monitoring Variables.

	AEMP Program[1,2]											
	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 Montoring	Blasting	Air quality monitoring
Stressor Variables												
suspended solids	●	●	●	NA	●	NA	○	○	●	◐	NA	NA
sediment deposition												
water-borne toxicants												
sediment toxicants												
nutrients												
other physical stressors												
Effects Variables												
Phytoplankton												
Zooplankton												
Fish												
Benthic invertebrate community												
Periphyton												
Fish habitat												

Notes:

[1] Maximum values from each program are used.

[2] Codes for exceedances of triggers and thresholds:

○ No exceedance of early warning triggers or thresholds

◐ Early warning trigger exceeded

● Threshold exceeded

Table 4-3. Example template for integrated evaluation of monitoring results across all programs for a monitoring variable or group of variables[1].

Variable – TSS (a stressor)

	Magnitude[2]	**Spatial Scale**[2]	**Causation**[2]	**Reversibility**[2]	**Uncertainty**[2]	**Comments**
EAS and CREMP	●	Large	High	Good	?	
Dike Construction						
INTEGRATED SUMMARY:						

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

[2] For all ratings, see Table 4-1.

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

Type of Variable Triggered	Potential Assessment Options
Sediment – Contamination	• Bioavailability studies (e.g., ration of AVS:SEM for selected metals) • Bulk sediment toxicity tests for invertebrates • Porewater toxicity tests (e.g., if transport is via groundwater) • Benthic invertebrate abundance / diversity • Development of site-specific sediment quality objectives (if not already done)
Sediment – Deposition of Particulate Matter	• Sediment traps to measure exposure • Literature review and analysis to evaluate likely effect of deposition • Bulk sediment toxicity tests for invertebrates • Benthic invertebrate abundance / diversity • In situ or ex situ experimental testing of effects of different deposition rates of particulate matter
Water – Contamination	• Bioavailability studies (e.g., Biotic Ligand Model for some metals) • Water column toxicity tests for fish and invertebrates • Benthic invertebrate abundance / diversity • In situ or ex situ experimental testing of effects of different contaminant concentrations on receptors • Development of site-specific water quality objectives (if not already done)
Water – Suspended Solids	• Water column toxicity tests for fish and invertebrates • In situ or ex situ experimental testing of effects of different concentrations of suspended solids on receptors
Water – Decrease in measures of productivity	• Literature review and modeling to evaluate likely effect on fish populations
Effects variables (direct measures of zooplankton, benthos, fish, etc.)	• More intensive study to characterize the magnitude of effects, spatial extent, and likely causes (e.g., through evaluation of spatial gradients).

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

Cause of Potential or Known Effect	Potential Mitigation Options
Dike Construction	• Modification of use of turbidity barriers (e.g., use more than one barrier, lower barrier to bottom) • Change material used to construct dike • Modify methods of placing dike construction materials • Slow placement rate • Construct causeway prior to open water season
Dike Materials (e.g., leaching of metals)	• Cover with other material types
Groundwater	• Identify and cut-off pathway from source to groundwater • Cut off pathway from groundwater to receiving environment • Treat groundwater
Effluent and Discharges	• Increase settling times prior to discharge • Treat effluent prior to discharge
Dust	• Increase intensity of dust suppression measures (e.g., water trucks) • Change materials used as top layer for exposed surfaces • Use wind breaks in key places
	•

Figure 4-1. Generic Management Response Process in the Context of the Meadowbank Mine AEMP.

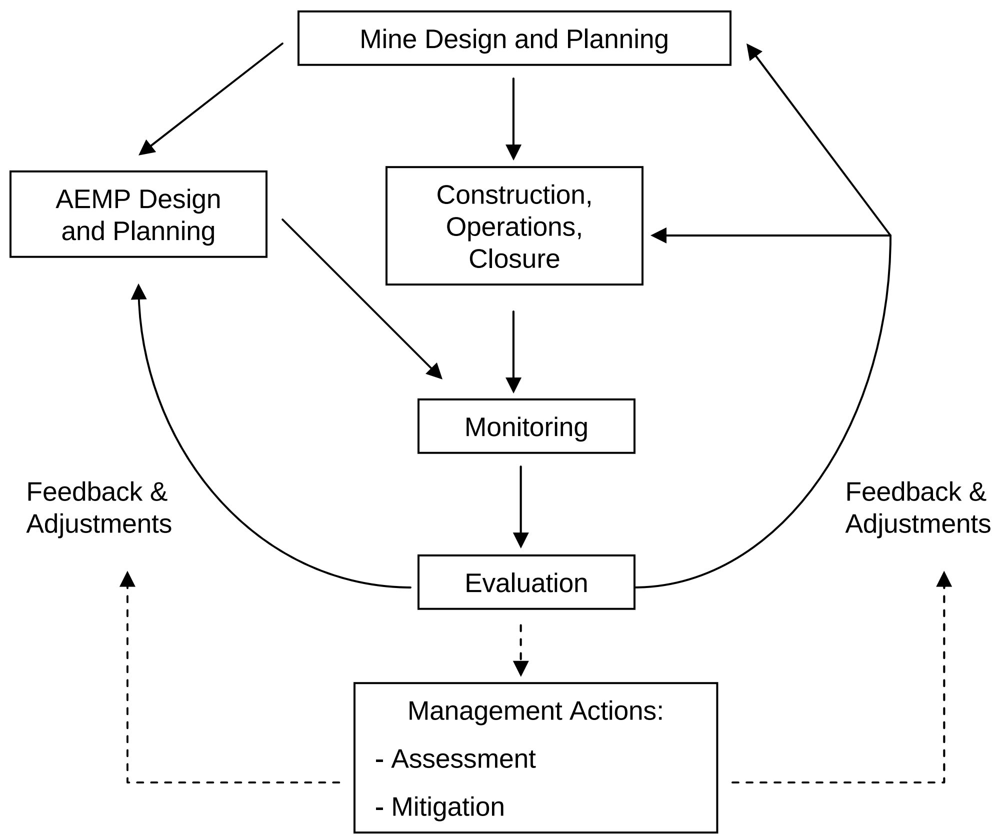


Figure 4-2. Management Response Plan for the Meadowbank Mine AEMP

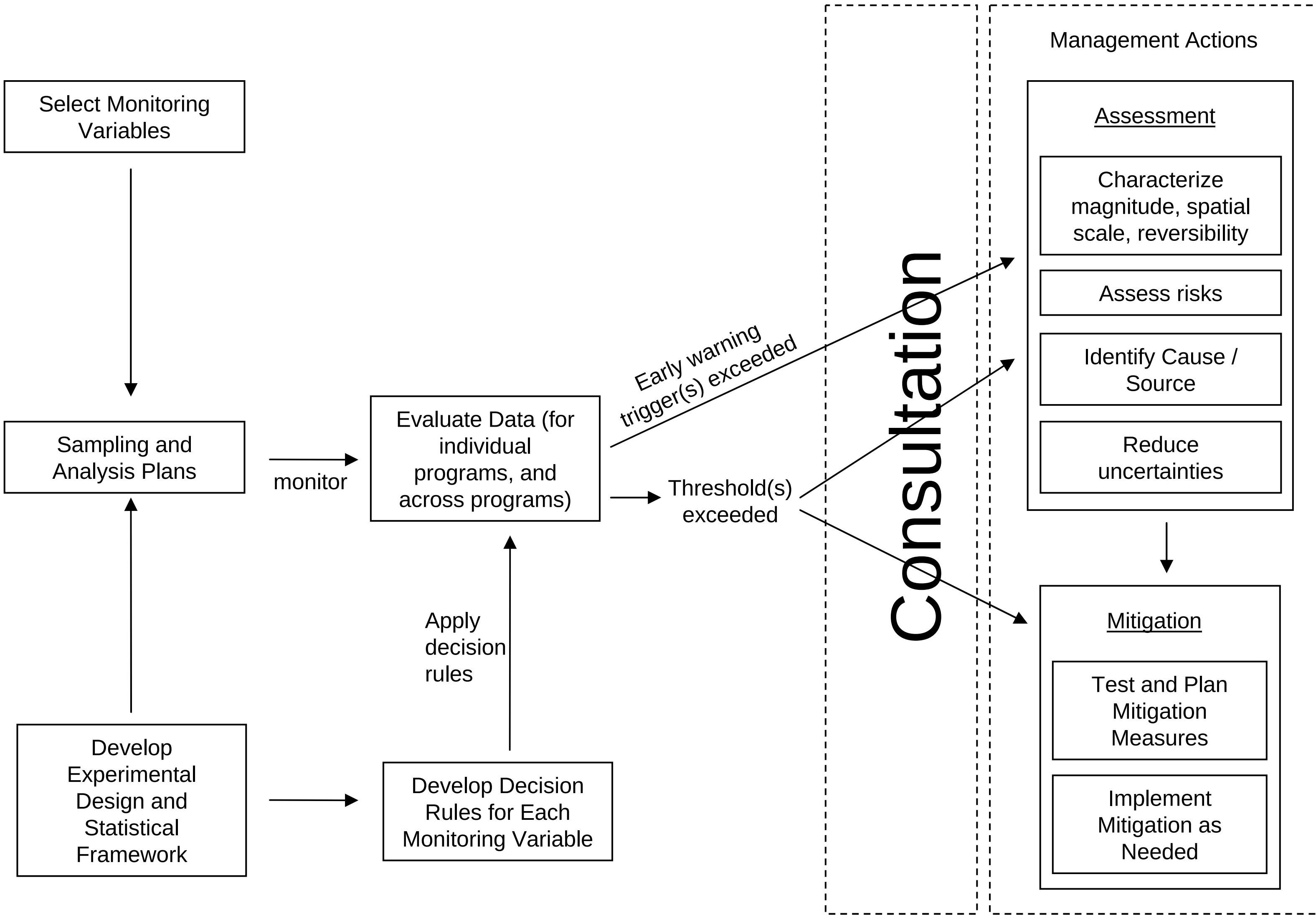
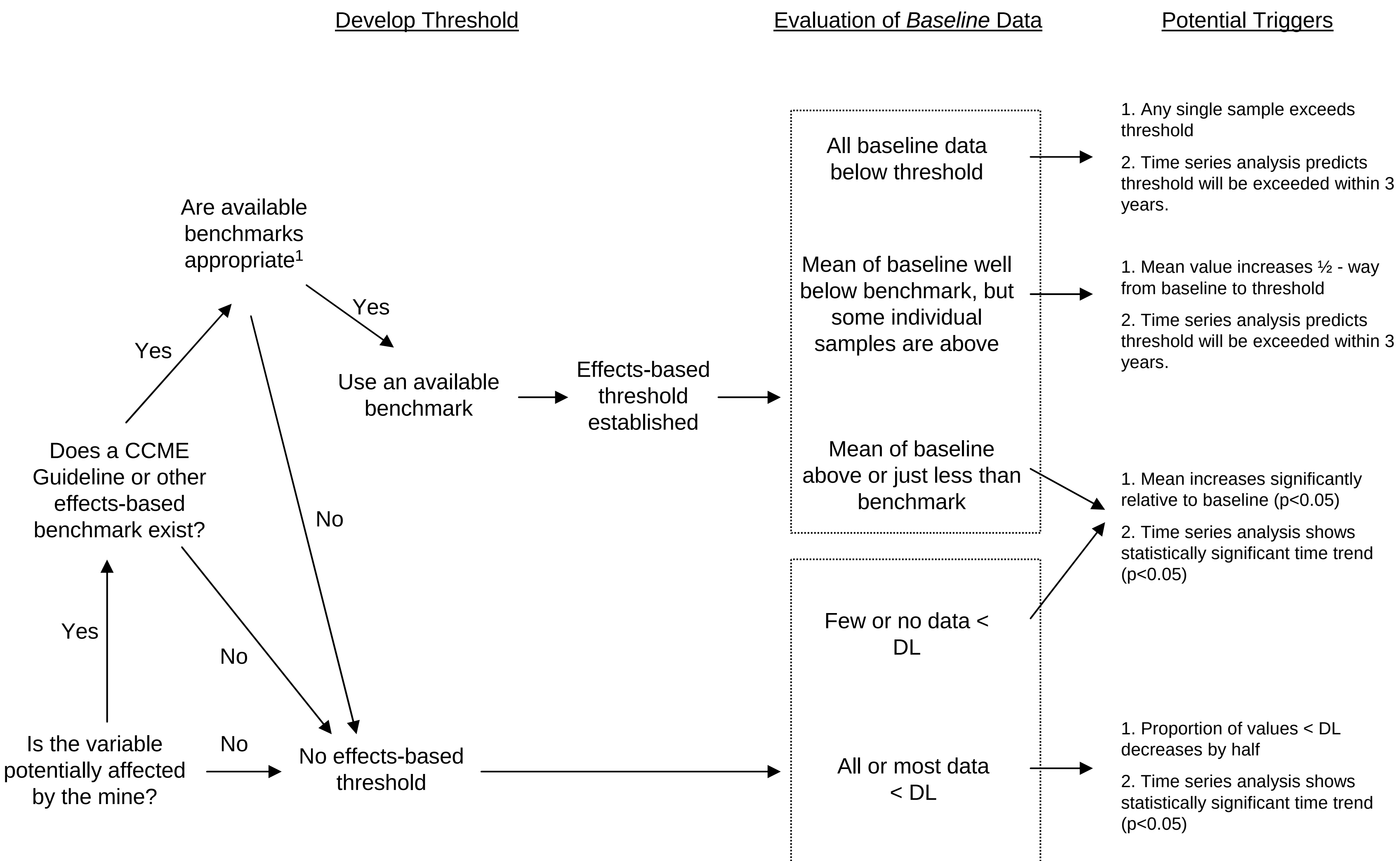
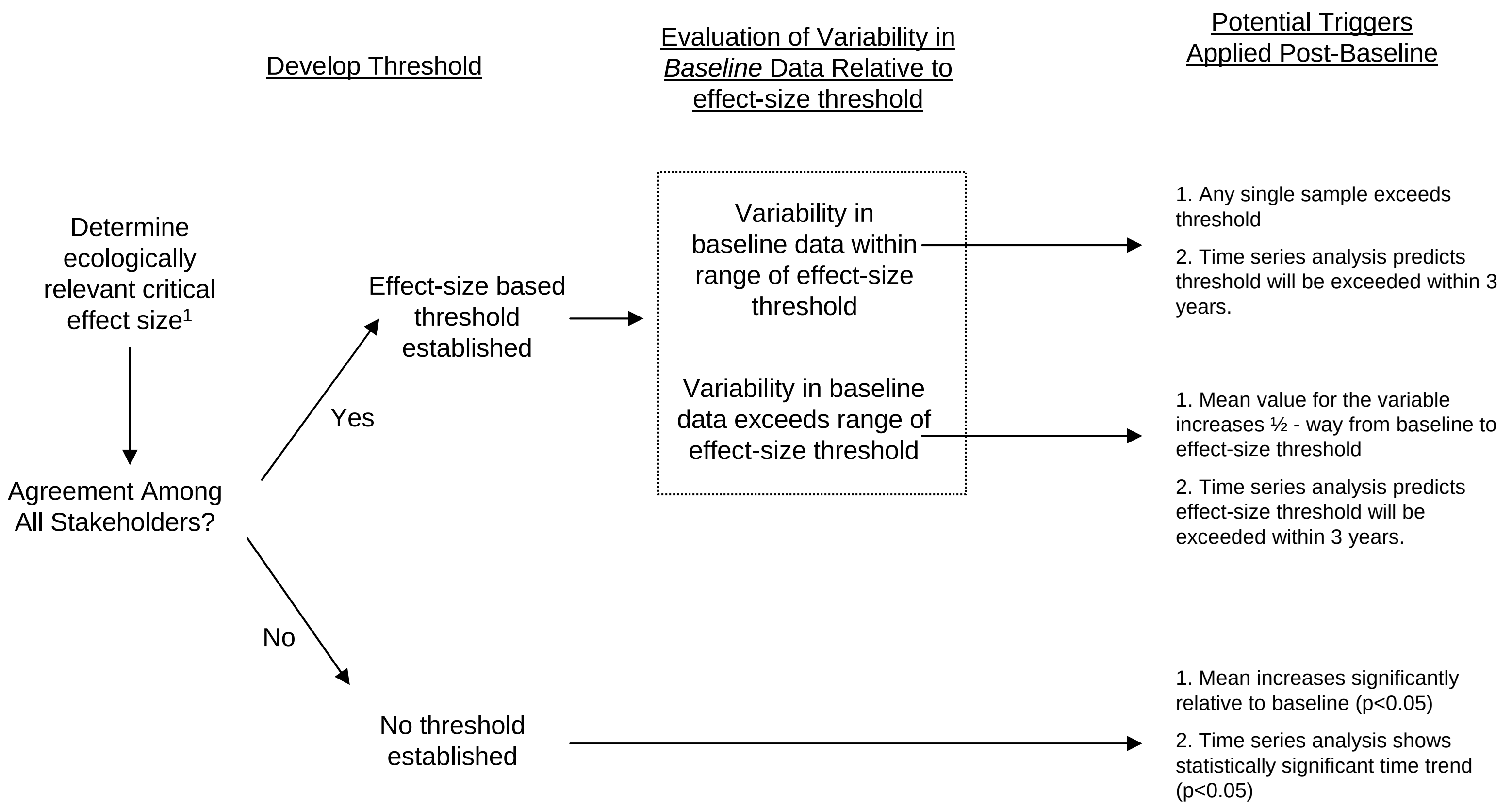


Figure 4-3. Derivation of Thresholds and Potential Triggers for Exposure Variables



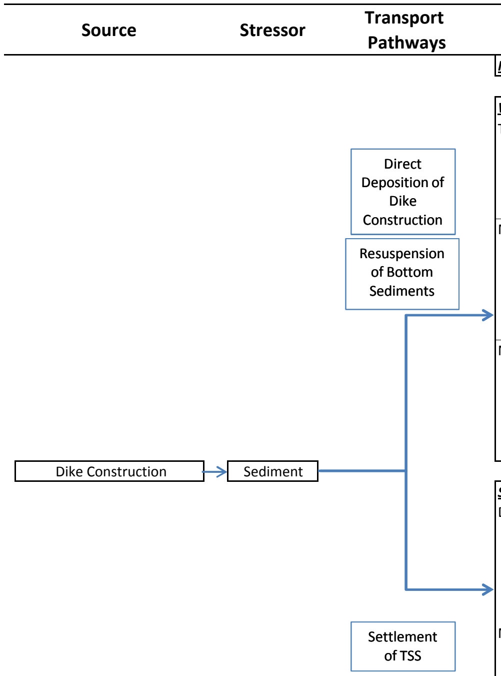
[1] Considering acceptable effect sizes and site-specific information on receptors and exposure pathways.

Figure 4-4. Derivation of Thresholds and Potential Triggers for Effects Variables



[1] 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 constructior



Exposure Media

Medium /Stressor	Narrative	Magnitude	Spatial	Link to Source
Water				
TSS	TSS increased to 10 to 15 mg/L across most of SP basin and 5 to 10 mg/L in TE basin.	T-TT	B+	Strong
Metals	While total metals exceeded CCME guidelines, dissolved metals generally did not.	T-	B	Strong
Nutrients	As above.	T-	B	Strong
Sediments				
Deposition	Higher closer to the dike, but some across most of the SP basin.	1-2mm	B to B-	Strong
Metals	Higher at SP (and to a lessor degree TE) in 2009 relative to 2008 and two reference areas.	to +35%	B	Strong

Effects Measures

Medium-Zone	Narrative	Magnitude	Spatial	Link to Stressor
Water - Pelagic				
Primary Production •Chlorophyll-α •Phyto biomass •Phyto taxonomy	Biomass reduced in exposure areas in 2008, but to a much lower degree two weeks later.	SD	B to B-	Strong to TSS
SecondaryProduction •Zoop biomass •Zoop taxonomy •Zoop Lethal Tox •Zoop Sublethal Tox	No effects in field measurements or lab tests.	None	None	NA
Fish •Lethal Juv. tox •Sublethal larval tox. •Sublethal embryo tox. (with renewal)	No effects.	None	None	NA
Sediment - Benthic				
Primary Production •Periphyton biomass •Sediment in mats	Biomass reduced in shallow exposure areas close to the East Dike; mat sediment inversely related to biomass.	SD	B-	Strong to TSS
Secondary Production •Benthic community abundance/richness	No effects in field measurements or lab tests.	None	None	None
Fish/Fish Habitat				
Fish Habitat •Underwater video	Higher sediment loads seen in areas close to the East Dike.	Qual	B-	Strong to TSS
Fish •Sublethal embryo tox. (no renewal of overlying water)	Minor impairment of embro development possible through settlement.	SD	B-	Strong to TSS

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

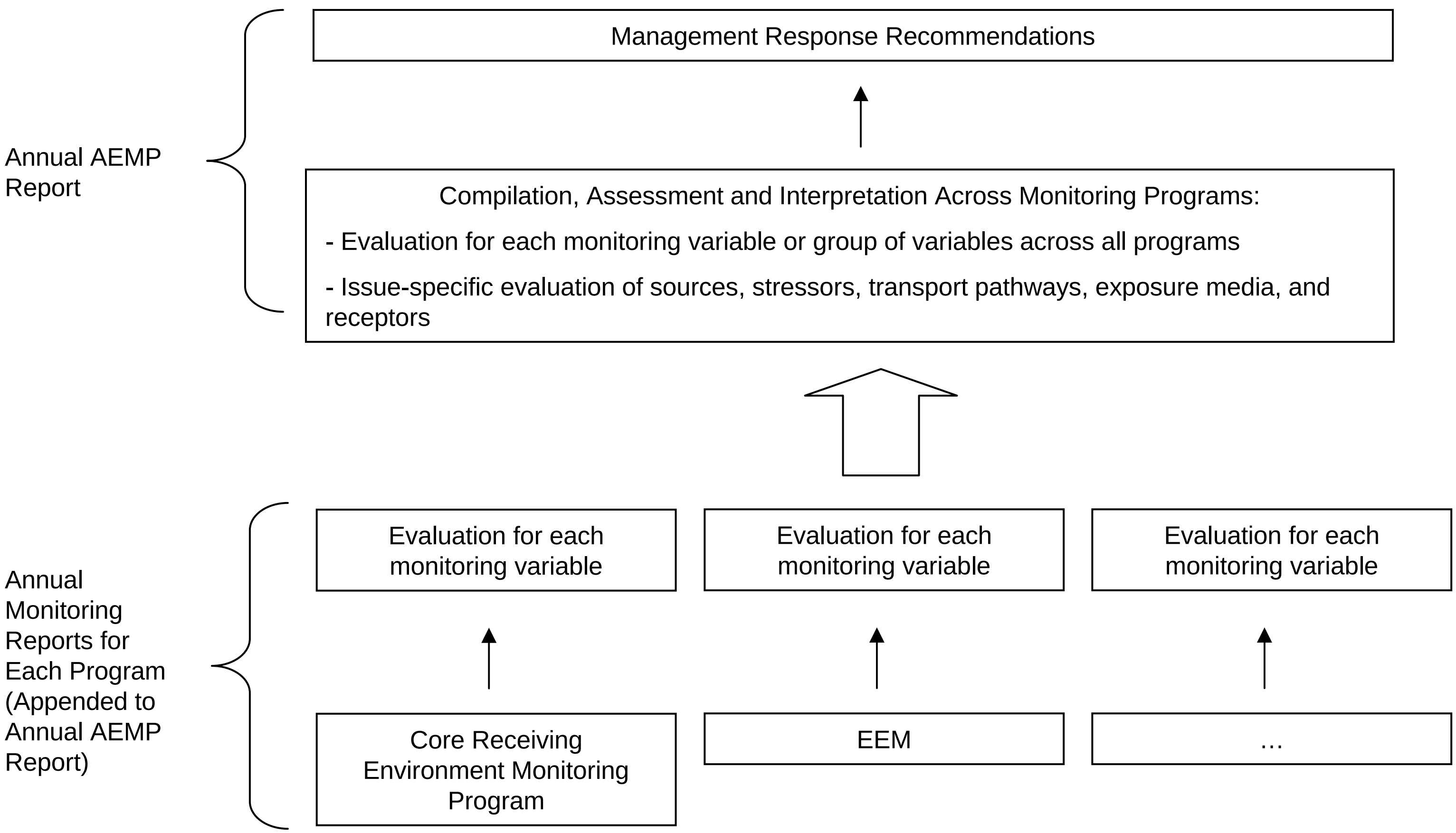
5. STRUCTURE AND CONTENT OF ANNUAL AEMP REPORTS

Following the process outlined in **Section 4**, 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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