A CASE STUDY APPROACH TO UNDERSTANDING PROVINCIAL AQUATIC ENVIRONMENTAL EFFECTS MONITORING REQUIREMENTS FOR MINES

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ABSTRACT

The British Columbia Ministry of Environment regulates mine discharges to water through *Environmental Management Act* permits. These authorizations specify discharge standards for quality and quantity of contaminants, and specify what monitoring and assessment programs must accompany the discharges. This includes "end of pipe" and "receiving environment" monitoring requirements, which together form an Environmental Effects Monitoring program. The presentation provides 2 case studies of effects monitoring programs for receiving environments: Huckleberry and Equity mines. Together, they provide a snapshot of the range of environmental effects monitoring tools currently in use, and their applicability to mining discharge regulation in Skeena Region.

INTRODUCTION

The BC Ministry of Environment, Environmental Protection Division (EPD), is responsible for ensuring that mine development, operation, and closure do not cause unacceptable impacts to the environment. A primary tool EPD uses to achieve this goal is the regulation of mining related discharges through *Environmental Management Act* [1] permits. Permits specify both allowable limits for the type and quantity of contaminants discharged to the environment, and the monitoring and assessment programs that must accompany the discharges.

Prior to entering the permit process, new mine projects (beyond a threshold size), must be certified under the *BC Environmental Assessment Act (EMA)*. This certification is based on assessments that ensure that in concept, the mine can be built, operated and decommissioned using the best, most practical pollution control technology available, in a manner which safeguards people and the environment. The test of certification is whether unacceptable impacts can be avoided or mitigated with known technology, should they occur. A variety of permits (including EMA permits) are then used to refine and assess final designs for mine infrastructure, operation and decommissioning and to provide ongoing regulation, monitoring and impact assessment.

Throughout the environmental assessment and permitting processes, environmental impact assessment tools are used. These include ecological risk assessment, definition of desirable receiving environment

[1] The *Environmental Management Act*, implemented in 2004, replaced the *Waste Management Act*.

conditions related to the range of existing water uses (including protection of aquatic life), and environmental effects monitoring. Environmental Effects Monitoring (EEM) programs use a range of methods to verify and refine judgements regarding whether mine influences on aquatic resources remain within the bounds of acceptability, and to provide "goal posts" around which mine pollution control works can be designed.

Fundamental to whether a mine is certified and permitted is whether it is possible to detect an unacceptable impact if it were to occur. This necessitates a thorough knowledge of the values of the receiving environment, the risks to these values, the sensitivities of aquatic resources to impacts, and the application of impact monitoring and assessment science including rigorous statistics.

This paper outlines the development of an aquatic Environmental Effects Monitoring program within the context of the Environmental Assessment process and permitting. We provide examples of EEM programs in permits using two local case studies: Huckleberry and Equity mines.

ENVIRONMENTAL EFFECTS MONITORING IN MINE CERTIFICATION AND PERMITTING

Environmental Effects Monitoring focuses on determining the effects of land use (e.g. mining discharge) on aquatic resources and values. Within an EEM program, quantitative means are used to establish whether changes to aquatic resources remain within acceptable limits, which are described in receiving environment objectives. Such objectives state desirable conditions in the receiving environment (in this case, a waterbody), defined in terms of water and sediment quality criteria and objectives, measures of ecosystem health and function, and discharge toxicity testing. Targets set within the objectives are used to determine if existing environmental protection measures are effective. The monitoring program is set within an adaptive management framework to ensure that if mitigation is not effective, additional measures will be adopted to meet the objectives.

A provincial EEM program is site specific, based on the risks to resource values related to a particular project. It is based on measurable attributes of water, sediment and/ or biota and applied at specific locations where valued resources exist in the receiving environment. Parameters of interest include:

- concentrations of water-borne contaminants such as metals, blasting and milling residues;
- sediment quality and quantity; and
- organisms as a measure of ecosystem health including algae, invertebrates, and fish.

The sampling design of an EEM program must be sufficient to provide early warning of unacceptable impacts and to allow implementation of predefined contingencies. As such, a program may be phased. The most efficient EEM program is a small scale monitoring program focussed on the critical aspects of discharge and water quality, with pre-defined triggers for more detailed assessments.

Designing an appropriate Environmental Effects Monitoring program to be included in a permit starts at the environmental assessment stage of a proposed mine and can be broken into a number of steps, each requiring assessments or studies:

1. **Identify resources at risk**
   - Identify environmental or social values at risk from mining related discharges to the aquatic environment.
     - These values are defined in terms of specified water uses including protection of aquatic life, drinking water sources, agricultural uses such as crop irrigation and livestock watering, and industrial uses including food processing.
   - Identify possible impact pathways or mechanism (e.g. biological – ingestion, absorption; physical – smothering, altering flows; biochemical – physiological)

2. **Describe baseline conditions in receiving waters which define ecosystem health**.
   Crucial to both environmental assessment and permitting is characterizing existing environmental conditions throughout the year using baseline studies. Enough information must be collected (in time and space) and interpreted to both determine natural variation and establish thresholds for acceptable biological, chemical or physical change in parameters which are indicators of ecosystem health.

3. **Conduct Risk Assessment**
   Define types, severity, and likelihood of impacts which may occur during the life of the project, including closure period. The risk assessment should incorporate the range and extent of uncertainties associated with identified probable outcomes.

4. **Identify Mitigation Strategies**
   It is necessary to demonstrate that hazardous conditions can be mitigated in order to avoid or minimize mining related impacts. To develop mitigation strategies, there must be an understanding of the nature and extent of aquatic resources which are at risk, current and potential stresses on them, and the potential hazards to these resources as a result of mining related activities. It is also necessary to consider what kind of contingencies may be employed to avert impacts. Mitigation strategies include procedures outlined in Environmental Management Plans.

5. **Develop an EEM program**
   The Ministry of Environment designs an EEM program for a mine in conjunction with the proponent. This monitoring program is then integrated into the proponent's waste discharge permit. Environment Canada also requires a federally mandated EEM program[2] under the Metal Mining Effluent Regulations of the *Fisheries Act*. BC's system predates the more formalized federal program, and is a stand alone site-specific approach.

[2] Conducting EEM efficiently requires a high degree of technical knowledge and proficiency. As a result, CANMET, a federal government department, has conducted an extensive aquatic effects technology evaluation program (AETE), which has identified and approved a range of appropriate impact assessment tools. These tools are incorporated in a national mining EEM framework under an amendment to the Metal Mining Effluent Regulations of the Canada *Fisheries Act*. This standardised system is being applied across Canada to augment and improve existing provincial and federal EEM requirements. The basis of the federal EEM system is to determine whether mining related contaminants are finding their way into the aquatic environment and whether they are

EEM studies are inclusive of water and sediment chemistry, suspended sediment loadings, flow rates, and the range of aquatic life present in the receiving environment (including population, community or toxicity assessments). They must be sufficient to determine whether conditions in the aquatic environment remain within the bounds of acceptability. It is crucial that the program is capable of detecting impacts to aquatic resources should they occur. This must be accomplished through the use of a rigorous experimental design which uses *a priori* determinations of sample size and the degree of effect or impact to be detected (i.e. a power analysis is required).

An important step is to develop a database which will serve as a baseline (time "0") for an EEM program spanning the life of the project, and into the post closure period. The adequacy of this database for the purpose must be judged by its predictive power.

6. **Propose a safe discharge plan**
   The proponent develops a plan to discharge wastewater. This plan includes concentration and volume limits that are protective of identified aquatic resources. Limits should be proposed so that there is no acute lethality to aquatic organisms at the point of discharge. The plan and proposed limits will be reviewed by the Ministry of Environment and used as a basis for EMA permit limits. Point source discharge limits are set by MOE based on attainment of BC Water Quality Guidelines or site specific Water Quality Objectives in the receiving environment downstream of the mixing zone or initial dilution zone.

7. **Monitor / Evaluate performance**
   Once decisions regarding risk reduction have been made (permit discharge limits for example), it is necessary to evaluate risk management performance through the implementation of the Environmental Effects Monitoring program. In addition to this cyclic process, evaluation and revision may occur whenever operating parameters change, or when new information for any of the process components becomes available.

ENVIRONMENTAL EFFECTS MONITORING CASE STUDIES

Equity Silver Mine

Equity Silver Mine is located 35 kilometres southeast of Houston British Columbia. The mine began mining and milling operations in 1980 and ceased in 1994. The environmental assessment and permitting processes for Equity Silver Mine initially characterized the baseline environmental conditions, identified the resources at risk, and identified a monitoring program. Through evaluation revisions have occurred in response to changing operating conditions and the dynamic nature of the environment.

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causing a measurable negative response. Once this is determined using the range of sanctioned EEM tools, then permitting authorities (provincial) will be advised, and expected to act to eliminate or reduce impacts.

Equity Silver Mine was first issued a Discharge Authorization (permit) in 1977 under the provisions of the *Waste Management Act.* The permit and the associated Environmental Effects Monitoring program have been amended several times throughout the life of the mine and through closure:

- In 1981, Acid Rock Drainage (ARD) was found to be occurring from the oxidization of sulphides contained in the mined waste rock (Placer Dome Canada, 2001), and
- In 2002 high peak flows at the Equity site exceeded the capacity of the ARD treatment and containment facilities (Placer Dome Canada, 2003).

Throughout the mine operation and closure, the dynamic nature of the environment has resulted in changes to the environmental impact assessment tools used to measure biologically significant effects to the aquatic ecosystems influenced by the mine. There are two components to monitoring detailed in the permit requirements. The first component is the day-to-day monitoring requirements allowing for adaptive management of the discharge to the receiving environment. These monitoring tools include:

- Water quality sampling to ensure the effluent quality does not exceed the permitted discharge concentrations;
- Toxicity testing using rainbow trout and *Ceriodaphnia dubi; and*
- Flow calculations for the discharge and receiving environment.

The second element of the EEM program involves detailed ecological and toxilogical sampling every five years. The last round was completed in 2001, with sampling to occur again this year. The objective of this program is to monitor and evaluate the conditions in the receiving environment to identify any negative effects to the receiving environment from the release of mine water. The environmental assessment tools used in 2001 included:

- Fish population assessments;
- Fish histopathology;
- Fish health assessment;
- Benthic community assessment;
- Sediment quality and toxicity assessments; and
- Periphyton assessment.

The combination of assessment tools attempts to identify unacceptable changes or negative impacts in the aquatic ecosystems of the area due to mine discharges.

Huckleberry Mine

Huckleberry Mine is a copper molybdenum mine located approximately 86 km southwest of Houston, British Columbia. Huckleberry Mine was first issued a discharge permit under the *Waste Management Act* in 1998. The permit outlined the disposal and storage of the mine effluent, with the majority of the mine effluent to be collected in the tailings impoundment.

The tailings containment facility at Huckleberry Mine is approaching capacity as the mine life nears completion. As a result, Huckleberry has proposed to discharge water from the tailings pond to Tahtsa Reach (part of the Nechako Reservoir). The planned water release from the mine is via a pipeline into the Reach. However, prior to releasing waste water into Tahtsa Reach, amendments to the previous discharge permit will be required. Huckleberry Mine and the Ministry of Environment are currently working together to permit a safe discharge from the tailings facility.

Baseline data was colleted prior to the mine beginning operations and steps are being taken to collect further data to fully understand the aquatic resources in Tahtsa Reach. Once the baseline conditions and the resources at risk are quantified, the next step will be to design an Environmental Effects Monitoring program. This monitoring program will be designed to detect and measure changes in aquatic ecosystems potentially affected by the proposed effluent discharges. The EEM program for Huckleberry Mine has been prepared and submitted to the Ministry of Environment for review (Hatfield, 2006). This document outlines the monitoring studies for the mine effluent and the receiving environment. The different biological monitoring tools for the Huckleberry Mine include:

- Water Quality Monitoring for the tailings water and the receiving environment;
- Acute toxicity testing using rainbow trout and *Daphnia magna;*
- Chronic toxicity testing using rainbow trout, *Ceriodaphnia*, *Lemna minor* (duck weed) and *Selenastrum spp.* (algae);
- Benthic invertebrate community survey;
- Sediment quality; and
- Adult fish tissue analyses.

A key component to permitting this discharge will be the ability to adaptively manage the discharge based on natural variations in the receiving environment. Discharge volume, receiving environment conditions, and effluent characteristics will be monitored to allow modifications should the discharge at any point result in negative impacts to the aquatic ecosystem.

Based on the effluent water chemistry, parameter concentrations and discharge volume limits are included in the permit. The final limits for Huckleberry Mine will be set to ensure there is no acute lethality or biologically significant impacts to the aquatic ecosystem.

Once the final discharge permit is finalized the EEM will be established for long term monitoring. As the mine and the receiving environment change it may be necessary to evaluate the performance of the permit and the associated monitoring programs and revisions may occur whenever operating parameters change, or when new information for any of the process components becomes available.

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