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Assessing the Significance of Surface Water Quality Effects for All Stages of a Mine Project

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Abstract

The determination of significance of an effect on the environment is typically based on six characteristics that describe an expected change to the environment: magnitude, geographic extent, duration, frequency, reversibility and likelihood. The characteristics are gauged by predicting change from the existing environmental condition and comparing that change to an environmental benchmark beyond which the effect would be considered significant. In Canada, effects on water quality can be achieved through the use of substantive thresholds to characterize effects. The substantive thresholds are typically based on a use-protection approach, where the use to be protected may be aquatic life, recreation, drinking water, or others which have been defined by the provincial or territorial jurisdiction. The selected threshold defines the assimilative capacity of the receiving watercourse and determines the maximum level of acceptable loadings to the environment. More and more, the public, environmental assessors and regulators are pressing for higher standards after closure. While regulators may consider a greater allocation of the available assimilative capacity during construction, operation and closure phases, they are considering a reduced allocation of the available assimilative capacity during post-operation. In this paper, we set out a framework for proponents for using the assimilative capacity of a receiving environment to provide a clear and transparent evaluation of the significance of projected effects to water quality in environmental assessments. We identify typical areas where the lack of clarity in the definition of significance slows down environmental review processes, and provide arguments for a consistent approach between environmental assessment and regulatory processes in matters of water quality.

Key Words

Assimilative capacity, significance, significant adverse effect, environmental assessment, water quality

Introduction

The determination of what is considered to be a *significant* adverse effect is an essential part of the environmental assessment process in Canada. When considering issues relating to water and aquatic resources, proponents and regulators alike may often wrestle with the question– what is a significant adverse effect? - when assessing the significance of effects for all stages of a mine project. Answering this question can be a problem with respect to water quality for there may be confusion on this issue between environmental assessment processes and licensing processes. Typically there are separate government authorities involved in the two processes and the guidance available with respect to the two processes can vary with regards to the level of clarity with the environmental assessment process tending to the qualitative and

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licensing/permitting to the quantitative. There may also be differences in how effects are interpreted between the various life-cycle stages of a mine development.

In this paper, we attempt to set forth a framework for proponents to provide clarity in the environmental assessment and licensing processes for all mine stages. Our experience is that a use-protection approach, addressing assimilative capacity for a receiving waterbody, can provide a clear and transparent framework for proponents and regulators to assess the significance of projected effects to water quality in environmental assessments. The same approach can be used to find commonality between the assessment and licensing processes and can be applied to all life-cycle phases of a project. Based on our experience, we identify typical areas where the lack of clarity in the definition of significance slows down environmental review processes, and we provide arguments for a consistent approach between environmental assessment and regulatory processes in matters of water quality. Finally, we show how common environmental assessment tools can be used to facilitate application of the use-protection approach throughout the life of a mine project.

Source or Nature of the Problem

To advance a mining project through its phases – exploration, feasibility, planning and design, construction, operations, decommissioning and closure –requires significant expenditures of time and resources on behalf of a proponent. Proponents have an interest, therefore, in having some sense of certainty that projects they believe to be feasible, and submit to government for the purposes of environmental assessment, can be successfully licensed for construction and operations.

From a proponent perspective, advancing a mining proposal through the environmental assessment process also often requires a significant expenditure of time and resources on behalf of the environmental assessment authorities. While they do not have the same economic interest as the proponent, environmental assessment authorities are nonetheless also interested in having some sense that the project they are assessing could, if approved (with or without conditions), be successfully licensed or permitted.

Additionally, permitting and licensing authorities, which may be separate from the environmental assessment authorities, have a strong interest in receiving applications for projects that can be licensed. This strong interest arises from both their place in a project's approval and licensing process, following a proponent's determination of feasibility and an environmental assessment approval, and from their own and at times separate regulatory authority to give meaning to EA approval conditions in a very concrete manner.

So, given the apparently common interest between proponents, assessors and regulators, why could or would there be a problem?

A number of common process-related and assessment-related reasons can be cited, including:

- Process-related Reasons: Proposed mining projects are typically required to meet the environmental assessment and/or permitting requirements of two levels of government -

federal and provincial/territory. While Canada has taken steps to minimize overlap and duplication in environmental assessments, such as provisions in CEAA 2012 to allow for a "one-project, one review process", for example, the environmental assessment laws and regulations also typically differ between jurisdictions.

Mining permits or authorizations are usually granted by provincial and territorial mines ministries, whereas permits for discharges to air, land and water are regulated by provincial and territorial environment ministries and/or Federal authorities such as Environment Canada or Fisheries and Oceans Canada. Mining legislation commonly contains elements of environmental regulation dealing with matters such as land reclamation and rehabilitation, mine closure and financial security requirements.

- Assessment-related Reasons: Environmental assessment laws in Canada, be they federal, provincial or territorial, do not define the term "significant adverse effect". As a result, the determination of significance is recognized as being a highly subjective part of effects assessments, and, in the absence of definition or guidance, impact significance determinations tend to be subjective, normative and value-dependent.

  In most Canadian jurisdictions the proponent is generally responsible for identifying and evaluating the significance of adverse environmental effects for the assessment process, whereas many regulators have clear guidelines for permitting releases to surface water that are meant to be protective of the environment.

Connecting the Assessment and Licensing Approaches

The approval process generally includes four phases: project discussion, assessment, regulatory and decision.

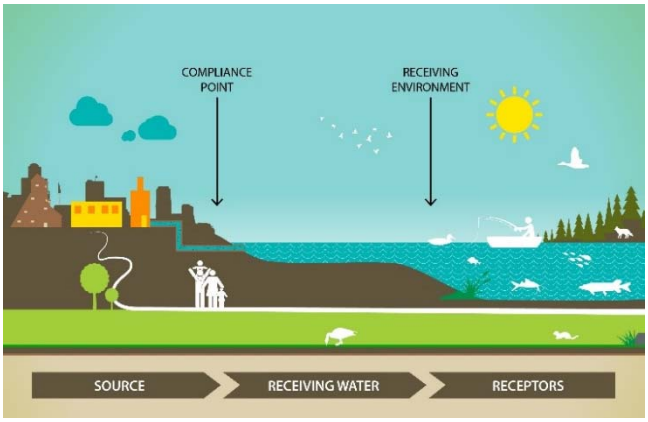
Figure 1: The Development Approval Process

This figure shows that while each stage is distinct, they are related, in that the outputs of one phase become inputs to the next. For example, pre-proposal discussions between proponents, assessment authorities and regulatory agencies can inform the preparation and submission of a project proposal. The project proposal initiates the environmental assessment phase. The decision at the end of the assessment phase can include approval as proposed, approval with conditions, or not approved and the outcome informs the regulatory phase. At the conclusion of the regulatory phase, a project may be permitted or licensed to proceed, and a decision is made to develop the project.

For environmental assessment purposes, in general terms, environmental effects refer to changes in conditions related to particular valued ecosystem components. The changes may

be considered significant if adverse, as well as: frequent; long-lasting; representing a broad spatial scale; irreversible; detracting from the sustainability of environmental and socio-economic systems; affecting ecological function; exceeding assimilative capacity; associated with variables of societal importance and public concern; not in compliance with standards or regulations; and/or exceeding desired levels of change (Noble, 2006[3]).

For licensing purposes, government policy in turn is generally described in the form of principles and technically or functionally defined thresholds. In the case of British Columbia, Ontario and Quebec, substantive thresholds have been developed for licensing purposes based on interpretation of the policies, principles or purposes. The application of substantive thresholds for licensing may consider protection of the most sensitive use in the defined receiving environment, defined probabilities of exceedance of the threshold, and compliance limits for releases to water. Non-exceedances of the substantive thresholds are interpreted as levels of effects that can be considered acceptable for licensing.



In Canada, the substantive thresholds for water resources are typically based on a use-protection approach, for which the use to be protected may be aquatic life, recreation, drinking water, or others which have been defined by the provincial or territorial jurisdiction. The use-based threshold is understood to be an upper limit for allowable change from the original background condition, and, in the case of a water resource, defines the assimilative capacity as shown in Figure 2.

Figure 2: Assimilative Capacity

What Recent Experience is Telling Us

As consultants, we become involved with the assessment and licensing of mining projects at all phases. We work with proponents to prepare environmental assessments and to support them through the licensing phase. We also work with government agencies to review the environmental assessments submitted by proponents.

It is our experience that environmental assessors in Canada are considering the substantive thresholds used for licensing to draw the line for evaluating the significance of adverse effects on water and aquatic resources. As it would be unusual for the environmental assessment process to deem a less stringent benchmark as acceptable. This can be illustrated through some of our recent case histories.

[3] Noble, B.F. 2006. Introduction to Environmental Impact Assessment. A Guide to Principles and Practice. Oxford University Press.

- We supported the EA for a greenfield mining project in Northern Ontario. It was a joint provincial and federal process. At the onset, the review agencies all agreed to a terms of reference for the EA. The terms of reference focused on the usual elements of an EA, but as the process evolved, the government agencies, particularly those with the province, involved with the review sought more and more detail until the EA mirrored a typical license submission. This would not have been an issue had this level of complexity been defined in the initial terms of reference for the EA. But redefining the terms of reference well within the EA process created confusion and resulted in delays.

- We have reviewed EA documents for assessment authorities for mining developments in northern Canada. In the absence of clear guidelines, we have seen proponents develop their own definitions for the term "*significant adverse effects*". Some have taken very liberal positions while others have taken more conservative positions. Some distinguished between mine life-cycle phases while others did not. The assessment authorities either accepted the proponent's definition of "*significant adverse effect*" or they imposed their own definition, which may or may not have been consistent among assessors or among mine projects. Inconsistencies and confusion in the interpretation of what constitutes a "*significant adverse effect*" have led to delays in the assessment processes.

Through these experiences we have made a number of observations which support the adoption of a use-protection or assimilative capacity approach for assessing adverse effects on receiving waterbodies. For example:

- Cases in which the EA process distinguishes effects related to different life-cycle phases of a mine development. When phases were distinguished, higher standards of protection were selected for the post-closure period than during operations. This is rational considering that closure is forever and has implications on both current and future uses of water resources.

- Cases where the EA process concluded "*no significant adverse effects*" but the mine project was rejected at the licensing stage because the two processes where not aligned. In such cases, the licensing process imposed a substantive threshold that was more conservative than the "*significant adverse effect*" threshold defined in the EA.

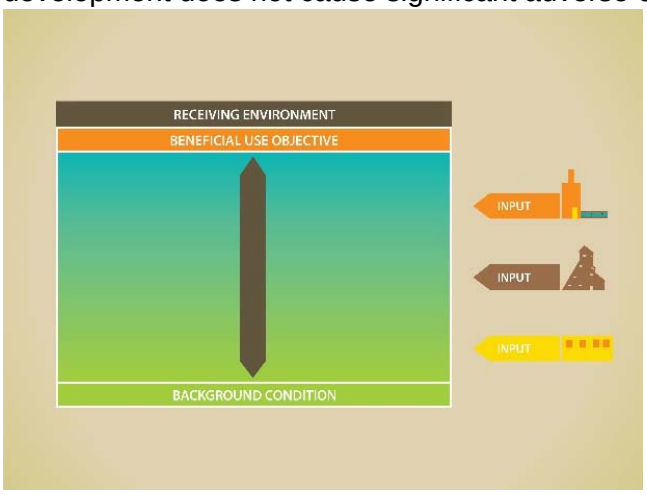
For these cases, the use-protection approach can provide a clear, transparent and consistent framework for proponents, environmental assessors and regulators involved in the assessment and licensing phases. This approach can be used to find commonality between the assessment and licensing processes and can be applied to all life-cycle phases of a project.

Why Would This Work for Assessing Adverse Effects for Water Quality

This works for water quality, as numeric benchmarks, source term modelling and receiving environment modelling are well known, and can be adapted and improved over the life of the project as additional monitoring information (water quality and environmental effects) becomes available. In the context of water and aquatic resources, changes can be measured

quantitatively or narratively. For example common metrics exist to characterize changes to water in terms of water quality (concentrations, pH) or quantity (flows), and changes to aquatic resources in terms of changes to fish (tissue quality, productivity, health, community) or fish habitat (water, sediments, vegetation, invertebrate community). The adversity and significance of these effects can be related to science based criteria that use the same metrics, above which adverse effects may occur as bounded by substantive thresholds.

In a typical mine development project the EA will consider potential effects of the mine on downstream water quality and aquatic biota. A typical EA may conclude that the mine development does not cause significant adverse effects to water quality or aquatic biota. They may consider typical operating conditions and average environmental conditions.



In contrast, the substantive threshold used for licensing may focus on compliance with defined surface water quality objectives under authorized discharged limits and extreme environmental conditions. Alignment of the two processes would require use of the more conservative approach—the substantive thresholds used for licensing.

Figure 3: Conceptual Use-protection and Assimilative Capacity Approach

As the illustration shows, a typical mine project includes various activities that can potential release constituents of potential concern (COPC) to the environment. These constituents enter the receiving environment, move downstream and potentially expose aquatic biota, other wildlife and humans. Alignment of the EA and licensing processes would share a common objective of protecting receptors within the downstream receiving environment. More importantly, an aligned process would target the same degree of environmental protection—both seeking the same objective under the same discharge and environmental conditions.

We usually define a receiving environment as the nearest downstream point where valued aquatic resources exist, and we usually define a compliance point as the last point of control before the discharge is released to the environment. Since the objective is to protect the receiving environment, the water quality at this point should comply with defined surface water quality objectives or guidelines, with few exceptions.

The accepted frequency of potential exceedances are determined by the occurrence of infrequent and low probability low flow events in the receiving waters. Such extreme events are usually defined based on discharge at the authorized limit and a low probability environmental condition such as a 7Q10 low flow (a seven-day low flow event that occurs once every 10 years) or a 7Q20 low flow (which occurs once every 20 years). Such conditions are usually defined

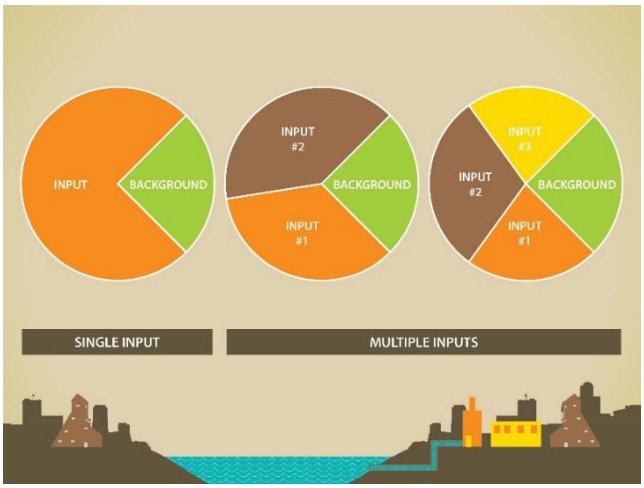
through government regulations or policy as we will mention, and would allocate all of the assimilative capacity of the receiving environment to a single resource user, for example one mine upstream of the receiving environment.

Examples for three Canadian jurisdictions are provided in Table 1, to illustrate how thresholds were used for licensing to provide clarity for effects assessments. Comparable substantive thresholds are used in British Columbia, Quebec and Ontario for licensing projects, based on interpretation of the policies, principles or purposes. A defined water quality objective (WQO) such as a provincial water quality guidelines or site-specific water quality objectives, is applied to a waterbody beyond the edge of an initial dilution zone. The extent of the initial dilution zone may be pre-determined as in the case of Quebec, or defined on a site-specific basis, with due regards to water uses, aquatic life, including migratory fish, and the presence of other existing or anticipated discharges. The likelihood that an exceedance of the threshold will occur is defined by the prescribed low flow conditions.

The substantive thresholds developed for licensing purposes can be used to clarify four of the five general qualifiers for determining the significance of an adverse effect: the magnitude by the use-objective; the geographic extent by the mixing zone; the duration by exceedance of a water quality objective that is either short-term (acute) or longer term (chronic). Reversibility is generally implied if releases to the receiving waters are ceased. An adverse effect on water, and implicitly on aquatic resources, may be considered significant if thresholds are exceeded for magnitude, geographic extent, duration and frequency, and/or reversibility.

Table 1: Approaches to Assigning Substantive Thresholds for the Assessment of Significant Adverse Effects to Water and Aquatic Resources

Effect Characteristic	British Columbia	Ontario	Quebec
Policy	• Sustainable, efficient, adaptive. • Secure and transparent. • Water, aquatic ecosystems are healthy and protected.	Ensure that the surface waters of the province are of a quality which is satisfactory for aquatic life and recreation.	Protection of the receiving environment consistent with sensitive uses.
Magnitude	BC WQG or SSWQO	Provincial WQO	Quebec WQO
Geographic extent	Initial dilution zone	Location of resource-use	Allowable mixing zone: 300 m; maximum dilution of 1:100 (with some exceptions), 50% of the low flow for toxic constituents and 100% of low flow for conventional constituents
Duration	Instantaneous, compared to both acute and chronic exposure durations	-	4 days for chronic exposure to aquatic life and 30 days for human health
Frequency	Minimum flow 7Q10 and summer 7Q10.	7Q20 for rivers and streams.	Effluent release objectives for mining projects are calculated for 7Q2, 7Q20 and 30Q5
Reversibility	-	-	-
References	BC MOE 2012 BC MOE 2013	OMOEE 1994	MDDEP 2008



Many jurisdictions now consider the cumulative effects of multiple discharges within a receiving environment. The method by which they account for cumulative effects is often poorly defined. It can be defined merely by sharing the assimilative capacity between users. The approach is also capable of taking into account multiple users and historic issues within a drainage system. As shown in Figure 4, the full extent of the assimilative capacity of the water resource at the receiving environment can be shared by multiple users.

Figure 4: Assimilative Capacity – Cumulative Effects

We address the assimilative capacity and risk exposure issues with quantitative models that include quantified geochemical source terms, water balance and receiving water characteristics, illustrated in Figure 5. The mine site model (MineMod™) includes all the proposed or existing mine components for water balance and source term chemistry as well as the receiving environment where compliance with water quality objectives is required. This model is commonly sufficient to address assimilative capacity requirements. In other cases, a full ecological and human health risk model can be used to assess effects when predefined water quality objectives for COPCs are not available or not applicable. The pathways exposure model (IMPACT™) includes sources, pathways and receptors in a fully quantified flow and material balance framework that included relevant benchmarks and thresholds for valued ecosystem components ranging from aquatic organisms to wildlife and humans.

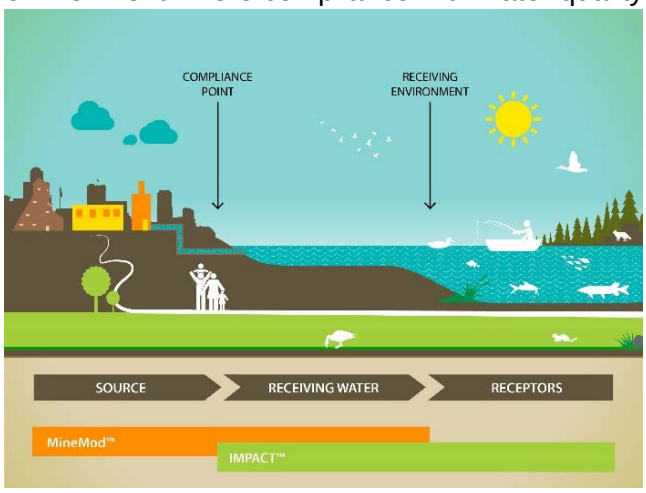


Figure 5: Modelling Approaches for the Conceptual Use-protection Approach

Our proposed approach also applies to shared use and cumulative effects because site water balances, source term models and water quality models, illustrated in Figure 5, are generally developed to support both assessment and licensing processes thereby providing the basic tools for mine project proponents to understand their site conditions and potential releases to the aquatic environment. Combined, these common tools provide the basis for estimating future changes to the receiving environment and, if required, to environmental receptors and potential human receptors. For proponents, this supports project development and environmental assessments. For assessors and regulators this provides confident projections for the future

that can be validated as the project progresses and can be used to design monitoring and follow-up programs to verify predictions.

Making it Work for Closure

During the environmental assessment process most jurisdictions consider the different life-cycle stages for a mine. It is now common practice for conceptual mine closure plans to be proposed during environmental assessment and licensing. Such plans are further developed and revised during operations so as to allow for the effective consideration of closure options and costs for new mines prior to entering production. However the potential impacts after closure are reviewed during environmental assessment to determine the significance of potential adverse effects.

It is our experience that closure objectives are typically different than those during operations when there is active management of water on-site. Whereas, assessors and regulators may consider allocating up to 100% of the assimilative capacity during operations they may only consider allocating some fraction of that capacity post-closure, as illustrated in Figures 6 and 7.

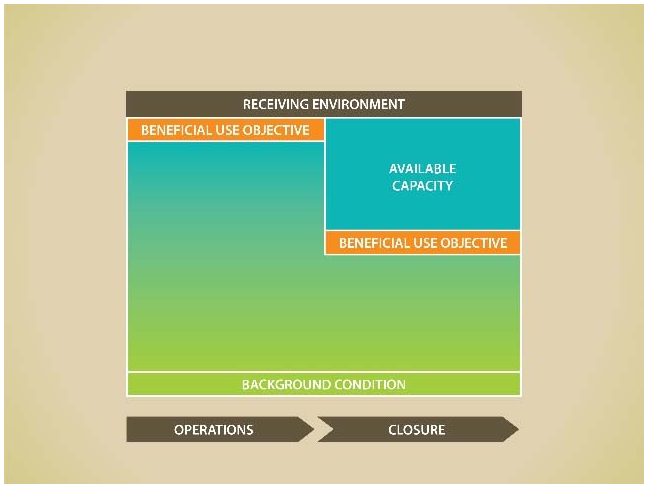


Figure 6: Assimilative Capacity – Life Cycle Approach

Figure 7: Assimilative Capacity – Post-Closure

Again clarity is needed on the part of proponents, assessors and regulators. Regulators need to provide clear policy on, and compliance measures for, closure and the potential to relinquish a mine site back to the crown. Proponents need to set clear policy for closure so that "design for closure" can be implemented as a "process" during the operation and in a consistent fashion. Needs as per future water resources should also be developed with the regulator and community in consideration of existing water uses and potential future developments.

The different objectives used during the various phases of a project may be expressed in terms of a non-degradation approach as compared to a use-protection approach, illustrated in Figure 7. A non-degradation approach looks to ensure that natural reference or background levels of COPCs are maintained in the receiving environment. The intent of this approach is to ensure that environmental receptors are not exposed to elevated levels of environmental stressors and,

hence, have no incremental risk of adverse effects due to project releases (CCME, 2003). The non-degradation approach also results in the maintenance of the assimilative capacity of the receiving environment. In this way, the environmental quality of the receiving environment can be maintained and the full assimilative capacity is made available for future resource uses.

Summary

The EA process is used to identify potential adverse effects on water and aquatic resources but the determination of significance of potential adverse effects is generally left to the proponent to be evaluated by assessors after the fact. In contrast, regulators often have clear guidance for licensing purposes. Using licensing benchmarks to inform the determination of significance will facilitate the process since it is unlikely that environmental assessors will accept benchmarks that are less stringent than those that are applicable for licensing.

Substantive benchmarks deemed protective of water and aquatic resources are well supported by science and commonly used in the licensing process. The assimilative capacity approach can be used to develop mine projects and provide confidence that the project will meet environmental objectives for water and aquatic resources.

Tools are available for modelling water quantity and quality both on- and off-site, including water balance, geochemical source loadings and water quality in the receiving environment. The use of these tools is an efficient way to develop the mine project and understand implications of project changes before heading into the environmental assessments and regulatory processes. As well, they build confidence with regulators and the public. The tools developed to support the assessment and licensing processes are equally relevant for developing closure plans as they allow proponents to “design for closure”, taking into account different objectives for water uses than those considered during operations.