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# Using Water Quality Criteria To sustain Priority Water Uses Downstream From Mines

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Abstract

Sustainable development in mining means that mines need to safeguard resource values such as water quality in their immediate vicinity. Once aquatic resource values are properly defined, water quality objectives should be set for receiving waters. If met, these ensure that the aquatic resource values are sustained. In general, objectives can be set. using criteria already in existence published by B.C. Environment and CCME. With recieving water objectives known at the planning stages, mines can engineer treatment works to deliver the effluent quality required. Therefore water quality criteria based objectives are useful to both sustain aquatic resources, and also for providing realistic targets for mine development or upgrade planning.

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## INTRODUCTION

The publication of the Water Quality Guidelines by CCME in 1987 (CCREM,1987), and approved and working Criteria by the Ministry of Environment in British Columbia (Pommen, 1989), has encouraged the development and use of water quality objectives in British Columbia. The procedure undertaken to create objectives for individual watercourses is described by Buchanan (1988). A Basic summary follows.

For any specific water body or drainage the appropriate priority use for the water is chosen, such as aquatic life or drinking water. This becomes the designated use to be protected by the objectives. Objectives are chosen for that waterbody based on published criteria or guidelines, taking local circumstances into account. Objectives can be chosen above or below published criteria depending on the situation, and what is at risk. The final step in British Columbia is to have the objectives for the specific case approved at the Deputy Minister level.

For this discussion, the distinction *I* make; between criteria and objectives is that a formal objective is a simply a criterion that has been chosen for a specific water body. Where objectives exist for streams, they will be used. However, formal objectives have not been chosen for virtually all the streams into which mining discharges flow. In these situations, we use criteria as if they were objectives.

It is still not strongly established how water quality criteria and objectives relate to the regulation of pollution discharges. There is a practical use of water quality criteria for the regulation of industrial effluent discharges into surface waters. Sustaining the quality of surface waters means regulating the contaminants in pollution discharges so that quality objectives are met at the point downstream where the resources to be protected occur. This paper describes the experience we have had in the Skeena Region of North Western British Columbia in using criteria to protect water uses and sustain surface water quality near new mining developments.

## MINING AND WATER QUALITY

Mine development activities have been extremely intense in this area of the Province over the past several years. Ore milling, runoff from waste rock, and other mining activities produce effluent which can pose a significant threat to aquatic environments. This threat stems from the nature of the contaminants produced by mining, which include sulphates, cyanide, nitrates, suspended solids and heavy metals. Also, mines are usually located in the head waters of river systems which are, at some point down stream, significant habitats for valuable fisheries, particularly salmon and trout fisheries.

Mining does not fit nicely into the notion of sustainable development largely because the mineral resource is not renewable, and mines come and go. However, the principle to apply is that a new mine must not erode the sustainability of the other resource values on the adjacent landscape. To place the mining industry in the context of sustainable development it is necessary to find a means of being able to sustain downstream water quality, and thereby the priority uses of the water.

In order to properly link water quality objectives with protecting the priority use of the water, it is absolutely critical to have a good understanding of both the nature and sensitivity of the resources at risk downstream, and at what point relative to the location of the mine they are placed at risk. Further, we have found that the type of ore body to be mined is also a factor in the establishment of the risk to aquatic resources. For some pyritic ores having the potential to generate acid mine drainage, the threat to the aquatic environment increases due to the risk that the drainage may need to be treated long after the mine closes (Wilkes, 1987).

Under the British Columbia Waste Management Act, the Waste Management Branch of the Ministry of Environment issues permits which specify what quality the effluent must meet before it is discharged to the environment. The established Pollution Control Objectives for the Mining Industry (B.C. MOE, 1979), specify a range of concentration for each contaminant which can be permitted, depending on the dilution available in the receiving environment. While this provides a general guide to what permit limits should be, it is preferable to specify environmental quality objectives, and then design the discharge to meet these objectives.

New mine development proposals in B.C. follow a staged government review process prior to receiving an approval in principle to proceed. During the preparation of the environmental impact assessment for a new mine, background water quality and flow data are used to assess the existing water quality. Biological studies are used to assess the aquatic resources at risk adjacent to the mine property. These factors play a significant role in determining the limits for contaminants in the discharge permitted by government. A key component to permitting has been whether or not the surface water criteria, usually for the protection of aquatic life, can be achieved at the point downstream from the mine where aquatic resources occur and are at risk.

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## DESIGNATED WATER USES AND EFFLUENT DISCHARGES

We have found that it is practical to use water quality criteria and guidelines as targets for companies to engineer At the early stages of mine development planning it is practical to designate where we expect water quality objectives or criteria to be met in the receiving environment. Then, a simple back calculation can determine what effluent quality is necessary to meet the downstream requirement. This assumes that good flow data exists for the receiving water, and highlights the need for this information well before permitting.

Proponents who clearly demonstrate that they can meet the required effluent quality obtain the necessary approvals from government. The ones who cannot must re-engineer any or all of the relevant mine components, which can include the mill circuit, cyanide destruction or tailings management plan.

The link between water quality criteria and the permit comes in writing into the permit whatever effluent limits are necessary to meet the receiving water quality needed to protect the most sensitive use of the water. The permit may specify limits lower than the published Pollution Control Objectives where, in our opinion, it is necessary to do so to protect the environment. A monitoring program is then specified in the permit and carried out by the permittee, which reveals whether or not the permit limits and the receiving environment objectives are met. In principle, provided that the background chemistry and hydrology is adequate, the engineering of the mine development should produce an effluent of sufficient quality and quantity to assure that the receiving environment objectives are met.

This is the ideal way of sustaining water quality adjacent to mine developments. It is practical, and gives the industrial interests an idea what the limits are in advance. In the long term it saves money by allowing the company to focus in on the key issues early, and not have to fight a rear guard action to protect water quality after the mining development has already been put in place.

In order to implement this use of water quality criteria it is necessary to accept two major assumptions as articles of faith. The first is that if water quality criteria are met, then bhe designated use is automatically protected. This assumption is implied by the CCME Water Quality Guidelines arid the provincial criteria documents.

The second assumption is that it is acceptable to use simple dilution calculations as the sole means of predicting downstream concentrations of contaminants after mixing. Simple mass balanci dilution calculations have been used by our office to Predict downstream water quality. In doing this, it has been assumed 1 there are no other significant factors to take into account.

Under certain circumstances, companies have been required to perform site specific programs of bioassays to confirm that their effluent will protect aquatic resources. Situations requiring this have been:

a) If there is some doubt that a criterion will protect a designated use.
b) A dilution calculation does not properly predict downstream concentration.
c) Background water quality already exceeds criteria.
d) Circumstances where an effluent is a complex mixture of contaminants.

Our experience has been that advising a mining company in advance what water quality is expected, and where in the receiving environment it is expected to be achieved, provides a clear picture for properly engineering the development. The treatment process, the tailings impoundment structure, water balance and runoff management can be planned to achieve the quality and quantity of effluent necessary to meet the preset objectives.

In water quality assessment, the use of a sensitivity analysis is encouraged by our office. The form of this is to stucture a computer spreadsheet which contains upstream baseline water quality, effluent quality, dilution data and downstream quality. By adjusting the effluent quality, dilutions, or both, insight is gained on the resulting downstream mixture. The concentration of contaminants in this mixture is then compared to the water quality criteria, in order to see which effluent strength or minimum flow represents a potential environmental problem. Metal ions, nutrients, and cyanide concentrationa can be modeled using this technique.

In this region, the reason for sustaining water quality is usually the protection of aquatic life, especially salmonid fishes and their supporting aquatic environment. Therefore, the criteria that the mining companies are designing to are usually those specified for the protection of aquatic life.

## EXAMPLES

Below, I describe several examples of new mine developments in Northwest British Columbia where the principle of designating receiving water objectives in the early planning stages has been applied. These examples illustrate that the companies were able to respond and meet specified receiving environment water quality. Again, the purpose was to ensure the sustained production of aquatic life in surrounding waters. Initially, miners tend to be unhappy about having to meet receiving water guidelines. However, when the relationship is understood between meeting the guidelines and the relative ease of obtaining permits, then the benefits of this approach become clear.

The first example is a gold mine development at Muddy Lake northwest of Telegraph Creek. The proposal called for a 360 tonne per day gold mine and mill circuit requiring cyanidation followed by deposition of tailing into a small lake. The lake was devoid of fish. There were none present for approximately six kilometres downstream from the lake at the base of a high falls on the creek which exits the lake.

The company's initial proposal was to discharge the mine tailings directly into the lake. The tailings supernatant would mix with lake water and discharge down the creek. In this example, we felt it was necessary to stipulate that the company should meet the surface water criteria for aquatic life at the falls. This requirement needed to be met during all hydrological conditions and during all seasons of the year, because important aquatic resources were identified to be there continuously.

The key contaminants of concern in the effluent were cyanide, mercury and copper. The company's consultants developed a lake mixing model which predicted the concentration of contaminants in the lake, according to projected mine effluent quality. The model contained a number of assumptions, such as complete whole lake mixing, which might not necessarily happen. The predictions showed that the company was unable, given the predicted mill effluent quality, to achieve the CCME surface water quality guidelines for copper during all hydrological regimes and all seasons at the Falls.

Consequently it became clear that direct lake discharge would not be acceptable and the company was required to engineer a tailing facility on the upland. This was done and was subsequently followed by a debate about whether the tailings pond needed to be lined or managed in a subaerial deposition mode. (Subaerial deposition involves the discharge of tailings effluent in layers and consolidation of the tailing solids forming a dense almost impervious tailings mass.)

The company also provided the assurance that if cyanide concentration limits could not be met in the effluent, the mill circuit would be upgraded to two parallel cyanide destruction facilities. Additional measures were required to assure safe copper levels downstream. These included increasing the supernatant recycle capability from 50% to 100%, and provision of a system for preventing freeze-up of the subaerial tailings pond. All the discussion was based on meeting a water quality objective preselected for the receiving environment. Meeting this would then protect aquatic life resources at a critical point down stream.

A similar situation exists for the development of a gold mine in the area known as the Iskut Gold Camp near the junction of the Iskut and Stikine Rivers. Here the company finally abandoned the plan to use cyanide on the crushed ore because of an inability to meet the required copper objective in Bronson Creek. Instead of using total copper, in this case we used an objective based on dissolved copper. This was because the background levels of total copper in Bronson Creek were already higher than the published criterion, due to the great amount of sediment from glacial runoff upstream. The use of dissolved copper may be a viable alternative under circumstances where the background exceeds published criteria. Here again, it is appropriate to conduct on-site in situ bioassays to confirm that the environment is protected.

In the case a mine located south east of Houston, B.C., a permit has been developed which allows the discharge of treated acid mine drainage to a small creek at a flexible rate depending on the amount of dissolved copper in the effluent. The system involves the discharge of more treated effluent if the copper concentration in it is low, and less if the copper is high. The absolute upper limit for dissolved copper is still the low end of the range in the Pollution Control Objectives, 0.05 mg/1 dissolved. However, the discharge rate is also affected by the flow in the receiving stream. The intention is to make sure there is a minimum 20:1 dilution ratio of receiving water to effluent in the environment at all times. In this case, the permit also specifies dissolved copper. This is a departure from both the CCME guidelines and Ministry criteria, which are for total copper.

Because dissolved, not total copper, is specified, it needed to be confirmed that the environment was protected by the provisions of the permit. Therefore, during the summer of 1989 and 1990, a sophisticated arrangement of in situ trough bioassays were conducted focusing on periphyton, invertebrate drift, benthos and emerging adult insects. The results of this work will be used to refine the permit conditions, with the objective of determining what level of treatment and rate of discharge will protect aquatic resources.

## CONCLUSIONS

Both the Federal and Provincial Government have endorsed the concept of sustainable development. The mining industry seems the odd man out since metal ores and coal are not renewable in the short term, and therefore their use does not fit into the usual concept of sustainable development.

But the mining industry must try to identify itself as resource development activity which can respond to current trends. The industry must be able to fit itself into a public conception of helping to achieve sustainable development.

The industry needs to do this to enhance its public image, but also, planning new mines to achieve sustainable development objectives will greatly shorten government approvals and simplify permitting.

Below I have summarized three principles, which in my opinion if the mining industry followed, would achieve these objectives.

1) The industry should commit to the principle that new mines should be planned and implemented in such a way as to maintain the sustainability of the natural resources surrounding it.

2) The industry should focus each new mine development from the beginning on the final ultimate closure plan. This "planning for closure" principle requires a clear plan, not simply a bonded reclamation program.

3) The industry must declare and maintain its commitment to achieve emissions or discharge quality that will meet the ambient criteria for protecting the resources placed at risk by the mine.

Most new mines will be in wilderness settings on land that most miners regard *as* empty and otherwise unused. In reality, no land is truly empty; it all contains living or renewable components that somebody else cares about. By committing to maintaining the sustainability of resource values at minesites, those who would otherwise oppose mining may be less concerned.

Generally our finding is that by designating water quality objectives in advance, proponents understand the environmental quality targets they are expected to achieve. This assists them in the engineering design necessary to build a mine that will in fact protect the environment and sustain local water quality. Because there are clear goal posts, the industry can respond in meaningful ways and shorten the government approval process.

Perhaps most interestingly, we have found that it is unnecessary to develop formal objectives for surface waters. The existence of criteria alone are sufficient to induce mining companies to design treatment facilities to meet them. The use of the published criteria in this way is a practical means of ensuring mines can be developed without threatening the sustainability of adjacent aquatic systems.

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