Water Quality

Ambient Water Quality Objectives For Cahill Creek

Overview Report

Water Management Branch
Environment And Resource Division
Ministry Of Environment, Lands And Parks

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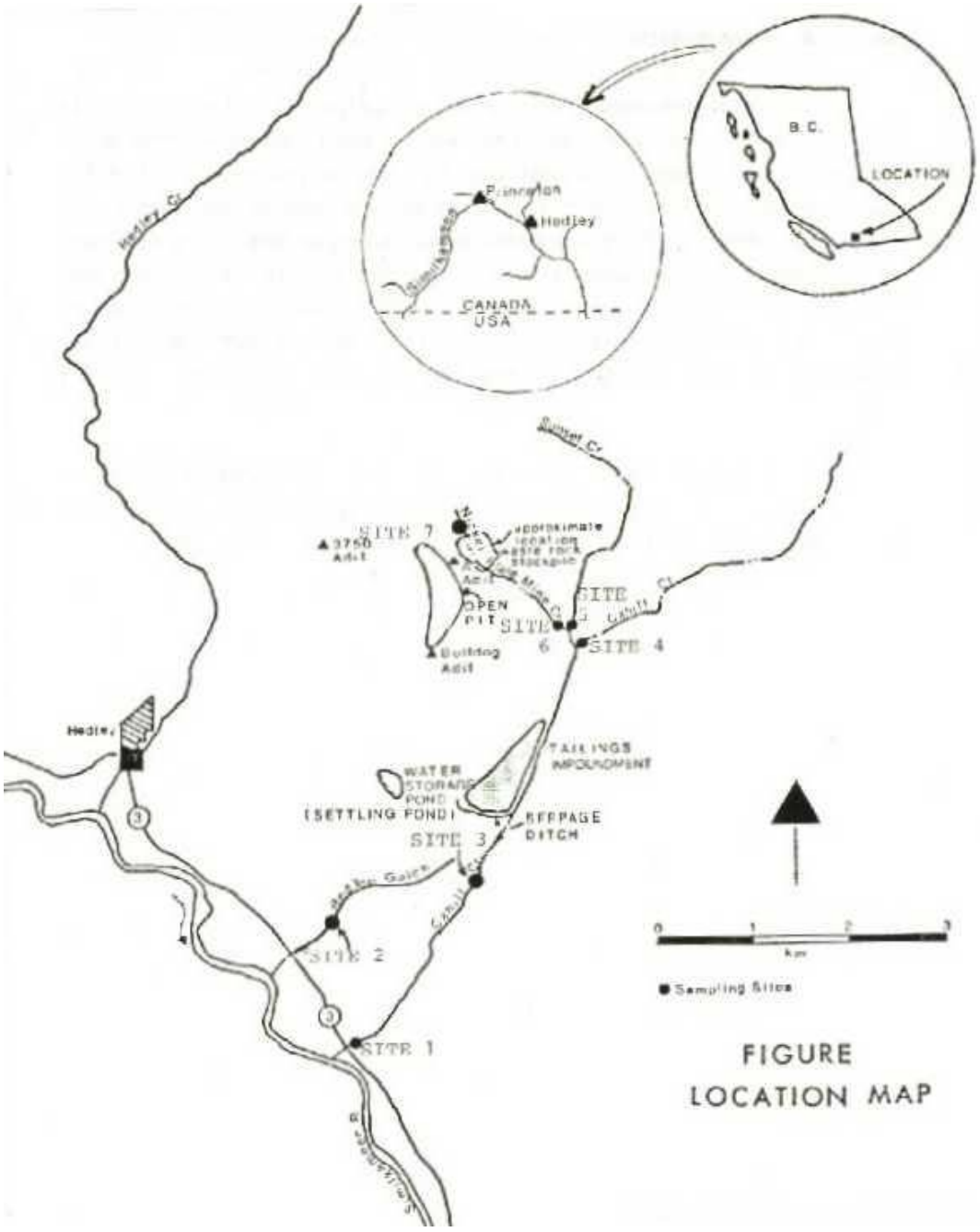
Figure 1. Cahill Creek Mine Site Location Map



PREFACE
Purpose of Water Quality Objectives

Water quality objectives are prepared for specific bodies of fresh, estuarine and coastal marine surface waters of British Columbia as part of the Ministry of Environment, Lands and Parks' mandate to manage water quality. Objectives are prepared only for those waterbodies and water quality characteristics that may be affected by human activity now or in the near future.

How Objectives Are Determined

Water quality objectives are based the BC approved and working criteria as well as national water quality guidelines. Water quality criteria and guidelines are safe limits of the physical, chemical, or biological characteristics of water, biota (plant and animal life) or sediment which protect water use. Objectives are established in British Columbia for waterbodies on a site-specific basis. They are derived from the criteria by considering local water quality, water uses, water movement, waste discharges, and socio-economic factors.

Water quality objectives are set to protect the most sensitive designated water use at a specific location. A designated water use is one that is protected in a given location and is one of the following:

- raw drinking water, public water supply, and food processing
- aquatic life and wildlife
- agriculture (livestock watering and irrigation)
- recreation and aesthetics
- industrial water supplies.

Each objective for a location may be based on the protection of a different water use, depending on the uses that are most sensitive to the physical, chemical or biological characteristics affecting that waterbody.

How Objectives Are Used

Water quality objectives routinely provide policy direction for resource managers for the protection of water uses in specific waterbodies. Objectives guide the evaluation of water quality, the issuing of permits, licences and orders, and the management of fisheries and the province's land base. They also provide a reference against which the state of water quality in a particular waterbody can be checked, and help to determine whether basin-wide water quality studies should be initiated.

Water quality objectives are also a standard for assessing the Ministry's performance in protecting water uses. While water quality objectives have no legal standing and are not directly enforced, these objectives become legally enforceable when included as a requirement of a permit, licence, order, or regulation, such as the Forest Practices Code Act, Water Act regulations or Waste Management Act regulations.

Objectives and Monitoring

Water quality objectives are established to protect all uses which may take place in a waterbody. Monitoring (sometimes called sampling) is undertaken to determine if all the designated water uses are being protected. The monitoring usually takes place at a critical time when a water quality specialist has determined that the water quality objectives may not be met. It is assumed that if all designated water uses are protected at the critical time, then they also will be protected at other times when the threat is less.

The monitoring usually takes place during a five week period, which allows the specialists to measure the worst, as well as the average condition in the water.

For some waterbodies, the monitoring period and frequency may vary, depending upon the nature of the problem, severity of threats to designated water uses, and the way the objectives are expressed (*i.e.*, mean value, maximum value).

INTRODUCTION

Cahill Creek is a tributary to the Similkameen from the northeast, just downstream from Hedley (see Figure 1. The issue here is the water quality which could be affected by a proposed gold mine and mill complex through release of contaminants such as heavy metals, suspended solids and cyanide. Two tributaries join Cahill Creek in its upper reaches, Nickel Plate Mine Creek and Sunset Creek. Red Top Gulch Creek is a small tributary to the Similkameen, which parallels Cahill Creek to the west.

A water quality assessment of Cahill Creek, these two tributaries, and Red Top Gulch Creek was undertaken to develop water quality objectives in areas where designated water uses may be threatened. The gold mining project, Nickel Plate Gold Mine, is operated by Mascot Gold Mines Limited and will include a mill complex. It has been proposed for the upper reaches of Cahill Creek. If discharges occur, they potentially could enter Red Top Gulch or Cahill Creek

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HYDROLOGY

Infrequent flow measurements have been made in Sunset, Cahill and Nickel Plate Mine Creeks. Flows in Cahill Creek have ranged from 0.006 m^3/s to 0.675 m^3/s, with a mean of all recorded flows of 0.166 m^3/s near the proposed mine project. This mean flow would increase to about 0.25 m^3/s at the confluence of Cahill Creek with the Similkameen River. The mean flow in the Similkameen River at this point is about 260 m^3/s.

Flows in Sunset Creek ranged from 0.002 m^3/s to 0.227 m^3/s, while those in Nickel Plate Mine Creek ranged from 0.00 m^3/s to 0.090 m^3/s. In Red Top Gulch Creek, flows ranged from 0.002 m^3/s to 0.008 m^3/s (mean flow of 0.007 m^3/s).

WATER USES

The Similkameen watershed contains high quality fisheries. In the Similkameen River, rainbow trout, and whitefish spawn in the mouths of tributary creeks. In Cahill and Red Top Gulch Creeks, fish are not found upstream from the highway #3 crossing, since the stream grades increase substantially with a large number of small falls. Fish species encountered in Cahill Creek in the short reach downstream from the highway crossing include rainbow trout, longnose dace and sculpin. These species likely would also be encountered in Red Top Gulch Creek.

Consumptive water uses occur only on Cahill Creek, where 1147 dam^3/year is licensed for withdrawal for irrigation purposes. Some of this water can be diverted into Red Top Gulch Creek, for withdrawal further downstream. It is not known if there are any water withdrawals along Cahill Creek for human consumption, since domestic water users withdrawing small quantities do not require a license. It is doubtful if any water is withdrawn from Sunset or Nickel Plate Mine Creeks for human consumption. Mascot Gold Mines Limited has a water license allowing the withdrawal of 295 m^3/d (0.003 m^3/s) from Sunset Creek for mining purposes.

WASTE DISCHARGES

Mascot Gold Mines Limited is proposing an open pit mining operation with an associated gold extraction mill near the headwaters of Cahill Creek. It plans to employ open pit mining methods using drilling, blasting, loading and hauling. Underground mining is not planned to begin until at least one year after the start-up of open pit operations. Production is planned to be 2450 tonnes of ore per day.

Mining of gold ore at and near this site began in 1904, with the final mine shutdown in 1955 when all the physical plant was removed or destroyed. Mascot Gold Mines Limited plans to mine in the same general area as was mined in the past.

The ore will be processed using crushing, thickening, cyanidation, zinc precipitation and refining. Tailings from the mineral processing circuit will go to an impoundment. Effluents containing cyanide are to be treated using sulphur dioxide and air, or hydrogen peroxide, with supernatant from the tailings pond being recycled to the mill. Seepage from the tailings impoundment is the only anticipated discharge. Seepage will be controlled through the use of a drainage blanket, a barrier of pumping wells and a drainage collection ditch. Water from the pumps could be used as process make-up water or recycled with ditch water to the tailings impoundment.

Other drainage water would originate in the open pit and underground mining areas, the waste rock dumps and runoff from above and around the tailings pond. Surface runoff is to be diverted from above the waste rock stockpile. Due to the impermeable nature of the gravels located at the toe of the waste rock stockpile, no discharge to surface water is expected by the company. A collection well is to be drilled below the waste rock stockpile so that seepage through the ground can be pumped to the mill.

Due to the permeable nature of the area, no direct discharge is expected into Cahill Creek or Red Top Gulch Creek.

Combustible and domestic solid waste will be hauled to a landfill site in Penticton. Sewage will be treated in septic tanks and discharged to the tailings pond.

WATER QUALITY

Cahill, Red Top Gulch, Sunset and Nickel Plate Mine Creeks had a slight to moderate buffering capacity to acidic inputs and were moderately hard. Most metals have been undetectable and/or below working water quality criteria for the protection of aquatic life. An exception to this was aluminum, which was higher than criteria and detectable in Sunset Creek, causing coincidentally high values in Cahill Creek. Uranium values, measured by Mascot Gold Mines Limited in 1985, were found to meet water quality criteria. Nutrients and solids values were at levels which would not cause problems.

PROVISIONAL WATER QUALITY OBJECTIVES

Provisional water quality objectives proposed for Cahill, Red Top Gulch, Sunset and Nickel Plate Mine Creeks are summarised in Table 1. The objectives are based on working criteria for water quality and on available data on ambient water quality, waste discharges, water uses and stream flows. The objectives will remain provisional until receiving water monitoring programs provide adequate data and the Ministry has established approved water quality criteria for the characteristics of concern. Objectives proposed for Sunset Creek are related to general land disturbances whereas those for Cahill, Red Top Gulch and Nickel Plate Mine Creeks are related to concerns about the specific proposal of Mascot Gold Mines Limited.

Water quality objectives have no legal standing and would not be directly enforced. The objectives can be considered as policy guidelines for resource managers to protect water uses in the specified water bodies. They will guide the evaluation of water quality, the issuing of permits, licenses and orders, and the management of the fisheries and of the Province's land base. They will also provide a reference againsdt which the state of water quality in a particular water body can be checked, and serve to make decisions on whether to initiate basin-wide water quality stdies.

Depending on the circumstances, water quality objectives may already be met in a water body, or may describe water quality conditions which can be met in the future. To limit the scope of the work, objectives are only being prepared for water bodies and for water quality characteristics which may be affected by man's activity now and in the foreseeable future.

Designated water uses for Sunset and Nickel Plate Mine Creeks are for the protection of wildlife and livestock. Mascot Gold Mines has indicated livestock could use nearby land for grazing.

Cahill and Red Top Gulch Creeks have been sub-divided into twp reaches for the purpose of designating water uses. The reason for this is that fish cannot access the upper reaches of the creeks, due to the

channel slope and a series of waterfalls. In the short reaches between between the highway #3 crossing and the Similkameen River confluence, the designated use is protection of aquatic life, in addition to the uses designated for the upstream reaches of Cahill and Red Top Gulch Creeks. In thopse portions of Cahill and Red Top Gulch Creeks above the highway #3 crossing to the headwaters, designated uses include use for drinking water with disinfection only, protection of wildlife and livestock and use for irrigation.

Some of the objectives downstream from the highwway crossing are more restrictive than upstream because aquatic life is protected in the lower reaches. In practice this could nmean that levels in the upper reaches need to be maintained at values below the objectives set for these reaches. The extent to which this will be required will depend on dilution and on processes which occur, such as ultra-violet radiation, precipitation and microbial action which reduce contaminant concentrations. The background concentrations of some metals can, at times, exceed the average and maximum objective values proposed. To allow for this situation a further maximum objective is proposed which is not to exceed the background or upstream value by more than 20 percent. This percentage increase allows for variations between measurements arising from random sampling or analytical error while still protecting designated uses. In some cases it covers the reaches both upstream and downstream from the highway crossing.

Provisional water quality objectives are proposed for several characteristics, since the proposed operation has the potential to relaease many contaminants into adjacent water bodies. The iompact that these contaminants will have on water quality will depend upon the success that Mascot Gold Mines Limited has in capturing seepage flows from the tailings impoundment, minimising water flows through the waste rock stockpile and recycling tailings supernatant.

Analysis of drainage water associated with old mine workings have shown that arsenic, cadmium, mercury, selenium, zinc and sulphate are released through oxidation of the orebody. Provisional objectives are proposed for these characteristics.

The mining and milling operation potentially can introduce certain contaminants. These include aluminum, nitrate, nitrite or ammonia which can be released from blasting compounds. Cyanide and small quantities of lead nitrate are used in the mill. Thiocyanate and cyanate may be generated in the tailings impoundment or the treatment of mill effluents. Molybdenum, copper, iron and silver can be released through the milling of the ore. Turbidity and suspended solids could be increased due to activities associated with the mine. Provisional objectives are proposed for these characteristics.

Since there are no literature criteria for cycanate, the objective was established on the basis of one-tenth the lowest 96 hour LC_{50} value for rainbow trout. Several values are proposed as objectives for copper. Each is related to the most sensitive use in the water body. For silver, the criterion for drinking water has been assumed adequate to protect wildlife, a use for which no criteria exist.

Since water in Cahioll Creek is used to irrigate forage crops, maximum and mean molybdenum values are proposed for the irrigation season to protect ruminant animals, such as cattle, from molybdenosis. In addition, other values to protect wildlife, applicable year-round. are proposed for Cahill and Nickel Plate Mine Creeks. Molbdenosis is associated with forage crops with high molybdenum values. Sulphate and copper affect the molybdenum levels at which molybdenosis occurs.

The proposed molybdenum objectives are site-specific and are to protect forage crops grown on poorly drained soils. These objectives should not be taken as a precedent for other ares in the region, since

factors such as the type of crops irrigated, soil pH, drainage and the amount of copper present would have to be examined on a site-specific basis.

WATER QUALITY MONITORING

A summary of recommended routine water quality monitoring is given in Table 4. Recommended monitoring is the minimum required to check that water quality objectives are being achieved, to finalize provisional objectives that have been proposed, or to increrase the accuracy of the information collected. Weekly sampling has been proposed during a 30-day period in each of the freshet and irrigation seasons since these are the time periods when discharges are likely to occur. The time period when irrigation is occurring requires that the maximum protection for certain characteristics be provided, and thus higher frequency sam,pling must take place at those times.

The recommended monitoring program is based upon technical considerations. Regional priorities and available funding are factors whiuch could either limit or expand the program. This program should be reviewed once the mine complex has been operational for one year.

TABLES

Table 1: Provisional Water Quality Objectives for Cahill Creek and its Tributaries

water bodies	**Cahill Creek**		**Nickel Plate Mine Creek**	**Sunset Creek**	**Red Top Gulch Creek**	
	Highway crossing to the Similkameen River	**Headwaters to the Highway crossing**			**Highway crossing to the Similkameen River**	**Headwaters to the Highway crossing**
designated water uses	**aquatic life**	**not applicable**	**wildlife and livestock**		**aquatic life**	**not applicable**
	drinking water (filtration or equivalent plus disinfection), wildlife, livestock, irrigation				**drinking water (filtration or equivalent plus disinfection), wildlife, livestock, irrigation**	
suspended	**10 mg/L**	**20 mg/L max increase when u/s is**			**10 mg/L**	**20 mg/L**

solids	**max increase when u/s is less than or equal to 100 mg/L 10% maximum increase when u/s exceeds 100 mg/L**	**less than or equal to 100 mg/L 20% maximum increase when u/s exceeds 100 mg/L**	**max increase when u/s is less than or equal to 100 mg/L 10% maximum increase when u/s exceeds 100 mg/L**	**max increase when u/s is less than or equal to 100 mg/L 20% maximum increase when u/s exceeds 100 mg/L**
turbidity	**5 NTU max increase when u/s is less than or equal to 50 NTU 10% maximum increase when u/s exceeds 50 NTU**	**10 NTU max increase when u/s is less than or equal to 50 NTU 20% maximum increase when u/s exceeds 50 NTU**	**5 NTU max increase when u/s is less than or equal to 50 NTU 10% maximum increase when u/s exceeds 50 NTU**	
dissolved solids	**500 mg/L maximum**	**not applicable**	**500 mg/L maximum**	
total sulphate	**less than or equal to 50 mg/L average 150 mg/L maximum**	**not applicable**	**less than or equal to 50 mg/L average 150 mg/L maximum**	
weak acid dissociable cyanide	**less than or equal to 0.005 mg/L average 0.010 mg/L maximum**	**not applicable**	**less than or equal to 0.005 mg/L average 0.010 mg/L maximum**	**not applicable**
strong acid dissociable cyanide plus thiocyanate	**0.20 mg/L maximum**	**not applicable**	**0.20 mg/L maximum**	
cyanates	**0.45 mg/L**	**not applicable**	**0.45 mg/L**	**not**

	maximum				maximum	applicable
total arsenicx	0.05 mg/L maximum		0.5 mg/L maximum	not applicable	0.05 mg/L maximum	
total ammonia	ammonia guideline	not applicable			ammonia guideline	not applicable
nitrite nitrogen	less than or equal to 0.02 mg/L average 0.06 mg/L maximum	1 mg/L maximum	10 mg/L maximum	not applicable	less than or equal to 0.02 mg/L average 0.06 mg/L maximum	1 mg/L maximum
nitrate nitrogen	10 mg/L maximum		100 mg/L maximum	not applicable	10 mg/L maximum	
total aluminum	0.30 mg/L maximum or 20% maximum increase, whichever is greater when pH is greater than or equal to 7 use equation 1. when pH is less than 7	not applicable			0.30 mg/L maximum when pH is greater than or equal to 7 use equation 1. when pH is less than 7	not applicable
total cadmium	0.0002 mg/L maximum	0.005 mg/L maximum	0.02 mg/L maximum	not applicable	0.0002 mg/L maximum	0.005 mg/L maximum
total	less than or	0.2 mg/L	0.3 mg/L	not	less than or	0.2 mg/L

copper	**equal to 0.005 mg/L average 0.007 mg/L maximum or 20% maximum increase whichever is greater**	**maximum**	**maximum**	**applicable**	**equal to 0.005 mg/L average 0.007 mg/L maximum**	**maximum**
dissolved iron	**0.3 mg/L maximum**			**not applicable**	**0.3 mg/L maximum**	
total lead	**less than or equal to 0.005 mg/L average 0.015 mg/L maximum or 20% maximum increase, whichever is greater**	**0.05 mg/L maximum**	**0.1 mg/L maximum**	**not applicable**	**less than or equal to 0.005 mg/L average 0.015 mg/L maximum**	**0.05 mg/L maximum**
total mercury	**0.0001 mg/L maximum in water 0.5 micrograms /g wet weight maximum in fish muscle**	**0.001 mg/L maximum**	**0.003 mg/L maximum**	**not applicable**	**0.0001 mg/L maximum in water 0.5 micrograms /g wet weight maximum in fish muscle**	**0.001 mg/L maximum**
total molybdenum	**less than or equal to 0.01 mg/L average from May to September 0.05 mg/L maximum or 20% maximum increase,**		**0.05 mg/L or 20% maximum**	**not applicable**	**less than or equal to 0.01 mg/L average from May to September 0.05 mg/L maximum**	

	whichever is greater		**increase, whichever is greater**			
total selenium	**0.001 mg/L maximum or 20% increase, whichever ios greater**	**0.01 mg/L maximum**	**0.05 mg/L maximum**	**not applicable**	**0.001 mg/L maximumx**	**0.01 mg/L maximum**
total silver	**0.0001 mg/L maximum or 20% maximum increase, whichever is greater**	**0.05 mg/L maximum or 20% maximum increase, whichever is greater**		**not applicable**	**0.0001 mg/L maximum or 20% maximum increase, whichever is greater**	**0.05 mg/L maximum or 20% maximum increase, whichever is greater**
total zinc	**0.05 mg/L maximum**			**not applicable**	**0.05 mg/L maximum**	

Note: The objectives apply to discrete samples from all parts of the water bodies, except the initial dilution zones. These excluded initial dilution zones extend up to 100 m downstream from the tailings impoundment, and occupy no more than 50% of the stream width, from the bed of the stream to the surface. In the case of Nickel Plate Mine Creek, the initial dilution zone is defined as being between the toe of the waste rock pile and the sampling site above the confluence with Sunset Creek.
1. For turbidity, suspended solids, and total aluminum, copper, lead, molybdenum, selenium and silver, the increase in mg/L, NTU or %, is over levels measured at a site upstream from the mining operation and as close to it as possible, and applies to downstream levels.
2. For total sulphate, copper, lead and molybdenum and nitrite nitrogen, the average is calculated from at least 5 samples collected weekly in a period of 30 days. For values recorded as less than the detection limit, the detection limit itself should be used in calculating the average.

3. For pH measurements can be made in-situ but must be confirmed in the laboratory if the objective is exceeded.
4. For total aluminum, lead, molybdenum, selenium and silver, to allow for input from tributaries, upstream values in Cahill Creek are determined according to the following general formula:
.....
$Conc_{Cahill} = [(Conc_{NP} * Flow_{NP}) + (Conc_{Sun} * Flow_{Sun}) + (Conc_{UpCah} * Flow_{UpCah})] / (Flow_{NP} + Flow_{Sun} + Flow_{UpCah})$
.....
where:
Conc = the concentration of the characteristic
Cahill = Cahill Creek just above the mine site
NP = Nickel Plate Mine Creek near the mouth
Sun = Sunset Creek near the mouth
UpCah = Cahill Creek above Sunset Creek
Flow = flows in the creeks at the designated sites
5. For weak and strong acid dissociable cyanide and thiocyanate, if strong-acid dissociable cyanide values are greater than the objective for weak-acid dissociable cyanide, further sampling is recommended at the same site during bright sunlight and at sites further downstream.
6. For aluminum the equation is:
.....
$Maximum\ total\ aluminum = e^{(0.66Z - 8.3)}$
.....
where:
$Z = e^{0.34 * pH}$

Table 4: Recommended Water Quality Monitoring for Cahill Creek and its Tributaries

Sites	Frequency and Timing	Characteristics to be Measured
Cahill Creek at Highway Crossing ... Red Top Gulch Creek at Highway Crossing	monthly except during freshet or irrigation when it is weekly for a 30-day period	pH; total aluminum, arsenic, cadmium, copper, lead, mercury, molybdenum, selenium, silver, and zinc; dissolved iron; nitrate, nitrite and ammonia nitrogen; suspended and total dissolved solids; turbidity; sulphate; cyanate; weak acid dissociable cyanide; strong acid

		dissociable cyanide and thiocyanate
Cahill Creek below tailings impoundment		**pH; total arsenic, cadmium, copper, lead, mercury, molybdenum, selenium, silver, and zinc; dissolved iron; nitrate, nitrite and ammonia nitrogen; suspended and total dissolved solids; turbidity; sulphate; strong acid dissociable cyanide and thiocyanate**
Cahill Creek above confluence, Sunset Creek, Nickel Plate Mine Creek u/s and d/s from waste rock stockpile		**pH; total aluminum, copper, lead, molybdenum, selenium and silver; suspended solids; turbidity**

Sampling may need to be increased to check objectives, depending on circumstances.

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