M-200

Accost
95-1684
Box 30

Mount Polley Mining Corporation

Mount Polley Mine

Tailings Cyclone Sands Geochemical Evaluation Update

MP00024

February 2000

Mount Polley Mining Corporation
Mount Polley Mine

Tailings Cyclone Sands Geochemical Evaluation – Update February 2000

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICIES

Mount Polley Mining Corporation
Mount Polley Mine

Tailings Cyclone Sands Geochemical Evaluation

FRAMEWORK

The objective of this report is to delineate the metal leaching (ML) and acid rock drainage (ARD) potential from cycloned tailings sands and to estimate the Environmental Effects on downstream water quality from the utilization of the sand product as construction fill.

This report shows that there is no potential for ARD, and only relatively minor levels of metal leaching are expected. A mass balance spreadsheet illustrates that there would be no Environmental Effects on receiving water quality under two sensitive low flow conditions (See *Section 3.0, Environmental Effects on Receiving Water Quality*).

At Mount Polley, the low amounts of net acid generating sulphide minerals like pyrite, and the high neutralization potentials (NP), mean that the volume of net-acid-generating rock will be negligible in the material that will be used in construction of TSF Stage 3. Also, metal leaching in this material is associated with non-sulphide minerals, rather than sulphide controlled minerals. This creates some challenges in prediction for Mount Polley, because standard techniques are generally oriented towards sulphide controlled minesites.

While some generally accepted techniques are applicable to oxide-controlled metal leaching, these techniques and their objectives have to be adapted to site specific circumstances. For oxide-controlled metal leaching, 24-hour shake flasks are important in explaining and predicting metal leaching, but they are rarely used in high-sulphide systems because the sulphides are not rapidly soluble. Also, humidity cells are designed to obtain kinetic reaction rates that are not affected by mineral solubility. However, oxide-controlled metal leaching can reach, and, at Mount Polley, has reached, solubility levels for some metals like copper in cells as well as in shake flasks. Therefore, the classic interpretation of geochemical testwork in British Columbia is not directly applicable to Mount Polley. A different approach is required and, to the best of our knowledge, this approach is unique in British Columbia to Mount Polley.

Because the standard sulphide-based approach is not used to characterize the ML potential of the tailings cyclone sands material, the importance and contribution of each suite of geochemical tests to overall predictions are explained. This report contains the updated results of some work, such as humidity cells, that are ongoing, and the predictions arising from that testwork.

1.0 GENERAL MINERALOGY

The Mount Polley copper-gold ore deposit occurs within the Jurassic-Triassic Polley stocks, which intruded the Nicola Group volcanic rock (Minfile, 1998). Hypogene ore minerals include chalcopyrite (1-3%), magnetite (4-8%), and minor pyrite. Supergene minerals include malachite (copper carbonate), native copper, cuprite (copper oxide), chalcocite, neodiginite, and covellite (copper-sulphide minerals). Thus, copper generally occurs as sulphide minerals ("copper sulphide") and as oxide/carbonate minerals ("copper oxide").

Alteration consists of an outer propylitic zone with calcite, chlorite, epidote, and pyrite and an inner potassic zone with secondary biotite and pink orthoclase (Minfile, 1998). Between these two zones is an intermediate garnet-epidote zone. Zeolites are pervasive through the alteration zones.

Mount Polley Mining Corporation
Mount Polley Mine

2.0 MOUNT POLLEY HUMIDITY-CELL UPDATE – DECEMBER 11, 1999

At this time, there are two humidity cells operating at Chemex Labs in North Vancouver containing tailings material.

The following sections contain updates on the findings from the two cells. Thus, this report builds on the detailed *Tailings Cyclone Sands Geochemical Evaluation* written by Mount Polley staff in 1998.

2.1 Tailings Humidity Cells

2.1.1 MP Tails 98 ("Sorted")

"MP Tails 98" represents relatively coarse cycloned tailings to be placed on the downstream face of the tailings dam starting in 2000. This sample is a sorted composite from approximately five months of tailings grab samples from the on-stream analyzer, as described in previous reports (see *Tailings Cyclone Sands Geochemical Evaluation*).

As explained in *Tailings Cyclone Sands Geochemical Evaluation*, the cell containing MP Tails 98 had an initial SNPR of 21.33 and was thus predicted not to generate net acidity at any time. At the time of that report, the cell had only operated for about six weeks and had not stabilized geochemically. There are now 62 weeks of testing available for more detailed interpretations.

At this time, this cell has generally stabilized geochemically, except for a few parameters like manganese (still decreasing), chromium (decreasing), and zinc (increasing at Week 62). As a result, this cell can now be used for long-term predictions. The weekly pH remains around 8.3 (Figure 2-1) and is expected to remain around this pH until reactive neutralization potential (NP) is depleted.

Sulphate production from MP Tails 98 remains low, around 2 mg SO_4/kg/wk (Figure 2-2). As explained in *Tailings Cyclone Sands Geochemical Evaluation*, this low rate of sulphate production means that the dissolution of NP is driven primarily by the simple addition of water, rather than the generation of acidity by the sulphides. In turn, this means that flow rate will play a major role in NP depletion from cycloned tailings sands.

Because sulphate is decreasing and does not drive NP dissolution, and because the rate of NP dissolution has remained relatively constant, the Carbonate Molar Ratio (Figure 2-3), which is the rate of NP consumption divided by the rate of sulphate production, has climbed to high values around 7-8. These high ratios confirm that NP dissolution is driven by the addition of water, and thus the geochemical mechanism that determines how many mg of NP will dissolve into each liter is important. *Tailings Cyclone Sands Geochemical Evaluation* showed that this mechanism was equilibrium-controlled dissolution of calcite and this continues to be the case. This type of dissolution can be simulated and predicted well with standard equilibrium models like the U.S. EPA MINTEQA2 model and the USGS PHREEQE model.

Based on the 62 weeks of data, the negligible acid-generating sulphide (0.03 %S at the start) will be fully oxidized by Week 337 (6.5 years) at current rates. On the other hand, NP

(20 t $CaCO_3$ equivalent at the start) will be exhausted by Week 1174 (22.6 years), and thus NP will outlast active acid generation in this sample if most of the NP is reactive. Furthermore, even if 70% of the measured NP (of 20 t/1000 t) were unavailable, the prediction for this cell would still be net acid neutralizing. Therefore, no net acidity from this cell is expected at any time.

Weekly aqueous concentrations of many metals are steady in recent weeks. The only metals whose last-five-week-average concentration exceeded 10 μg/L are: aluminum, barium, calcium, copper, iron, potassium, magnesium, sodium, phosphorus (due to higher detection limit), strontium, and, at Week 62, zinc. Of these, copper has been identified as the element with the greatest potential for water quality related impacts at Mount Polley and is discussed in more detail below. Other metals are also considered in terms of potential water-quality concerns at the field scale level.

As discussed in *Tailings Cyclone Sands Geochemical Evaluation*, aqueous copper concentrations from MP Tails 98 in early weeks was apparently controlled by the equilibrium solubility of tenorite (CuO). This caused concentrations to average around 50 μg/L (Figure 2-4). However, in recent weeks, copper has been fluctuating between roughly 20 and 60 μg/L. MINTEQA2 calculations show that these concentrations represent a factor of two undersaturated (log SI = -0.4) to saturation (log SI ~ 0.0), and no other copper minerals were close to equilibrium. As a result, tenorite solubility remains the maximum limit on aqueous concentrations, but the fluctuating weekly concentrations show that tenorite solubility is not consistently attained each week. At current rates, copper will be fully leached from the sample after a few millennia.

2.1.2 98 Tails - Full

"Tails 98 - Full" represents a grab sample of "full" (non-cycloned) tailings. It is a composite of twelve months of tailings grab samples from the on-stream analyzer.

This sample has minor amounts of total sulphur (0.03 %S) and sulphide (0.03 %S), which indicates its Sulphide Acid Potential is 0.9 t $CaCO_3$ equivalent/1000 t. In contrast, its bulk neutralization potential (NP) and carbonate-based NP (CaNP) are 18 and 9 t/1000 t, respectively. As a result, this sample is net acid neutralizing and not predicted to generate net acidity at any time based on its Sulphide Net Potential Ratio (SNPR =NP/SAP) of 20 and its Sulphide Net Neutralization Potential (SNNP =NP-SAP) of +17 t/1000 t. This is very similar to the ABA status of MP Tails 98 above. A major objective of this cell is to determine if there are any major differences in the metal-leaching behavior relative to cycloned tailings.

This sample has similar solid-phase metal levels as MP Tails 98 above. For example, this sample has 2030 ppm copper, compared to 1790 ppm for MP Tails 98. Therefore, there are no major differences in total-metal contents.

Pre-test sieve analyses show that this sample is relatively fine, with 36% passing 270 mesh (roughly 0.05 mm) and approximately 70% passing 100 mesh (roughly 0.15 mm). In contrast, MP Tails 98, which represents the coarser fraction of sorted tailings, has only 14% passing 270 mesh and approximately 75% passing 100 mesh.

At this time, there are 31 weeks of analyses for this cell. The weekly pH from this cell is similar to that from MP Tails 98 (Figure 2-1). However, the rate of sulphate production, while still quite low at about 4 mg SO_4/kg/wk,is roughly twice that of MP Tails 98 in recent weeks (Figure 2-2), indicating equivalent amount of sulphide in this sample is oxidizing twice as fast. This in turn causes the Carbonate Molar Ratio (Figure 2-3) to be roughly one-half that of MP Tails 98, but the Ratio continues to follow the rising trend that MP Tails 98 displays. These results may be a function of the greater proportion of finer grain size material in the bulk tails.

Based on the 31 weeks of data, the negligible acid-generating sulphide (0.03 %S at the start) will be fully oxidized by Week 199 (3.8 years) at current rates. On the other hand, NP (20 t $CaCO_3$ equivalent at the start) will be exhausted by Week 1338 (25.7 years), and thus NP will outlast active acid generation in this sample if most of the NP is reactive. Furthermore, even if 80% of the measured NP (of 18 t/1000 t) were unavailable, the prediction for this cell would still be net acid neutralizing. Therefore, no net acidity from this cell is expected at any time.

Weekly concentrations of many metals are generally steady or increasing, and thus this cell has not fully stabilized geochemically. The metals whose last-five-week-average concentration exceeded 10 µg/L were: aluminum, barium, calcium, copper, iron, potassium, magnesium, manganese, molybdenum, sodium, phosphorus (due to a higher detection limit), selenium, strontium, and titanium. Of these, copper has been identified as the element with the greatest potential for water quality related impacts at Mount Polley and is discussed in more detail below. Other metals are also considered in terms of potential water-quality concerns at the field scale level. This cell was designed for comparison to the [sorted] MP Tails 98 for metal leaching. Results to date indicate unsorted tailings initially allow additional metals to leach at higher concentrations than the cycloned sands. This also may be due to the presence of the smaller grain size fraction.

Aqueous copper from this cell is higher than the other cells (Figure 2-4), with an overall mean of 81 µg/L and a value of 134 µg/L at Week 31. MINTEQA2 calculations for the higher concentrations show that a copper of approximately 150 µg/L represents 1.65 times supersaturation with respect to tenorite ($\log_{10}(SI) = +0.22$). The cause of this supersaturation is not known, but it indicates copper would be around 90 µg/L at saturation.

It is not known at this time whether this represents an initial flushing of available copper and copper levels will fall consistently to, or below, saturation in this cell. Even if this happens, copper from this cell will still be generally higher than the other cells. The only significant difference between this cell and MP Tails 98 is its finer grain size, so at this time the only apparent explanation for the higher copper is the finer size of the copper-bearing minerals.

2.2 Summary

At this time, the two cells are approaching geochemical stability, which will allow long-term predictions, although some concentrations are still showing minor changes. Therefore, the cells should continue in order to provide more reliable predictions of long-term performance.

Neither of the cells are expected to generate net acidity. However, the rate of NP consumption is dependent on the amount of water passing through the cells each week. In turn, this means that the rate of NP consumption, and the potential for net acidity, under on-site conditions depends on flow rates of groundwaters and surface waters. Therefore, predictions from these cells, when stabilized, should be adjusted to on-site conditions for reliable on-site predictions.

Copper leaching is variable, but appears generally controlled by the solubility of tenorite (CuO). When the readily soluble copper oxide is depleted, the rate of copper leaching apparently decreases to a lower level, reflecting the oxidation of copper sulphide. However, when scaled to field conditions, the lower leaching rates from much more material than one kg in each cell will still likely raise concentrations to the solubility limit of tenorite. Available monitoring data from the tailings impoundment should be used to confirm that tenorite and/or other minerals are controlling aqueous concentrations under on-site conditions.

Mount Polley Mining Corporation
Mount Polley Mine

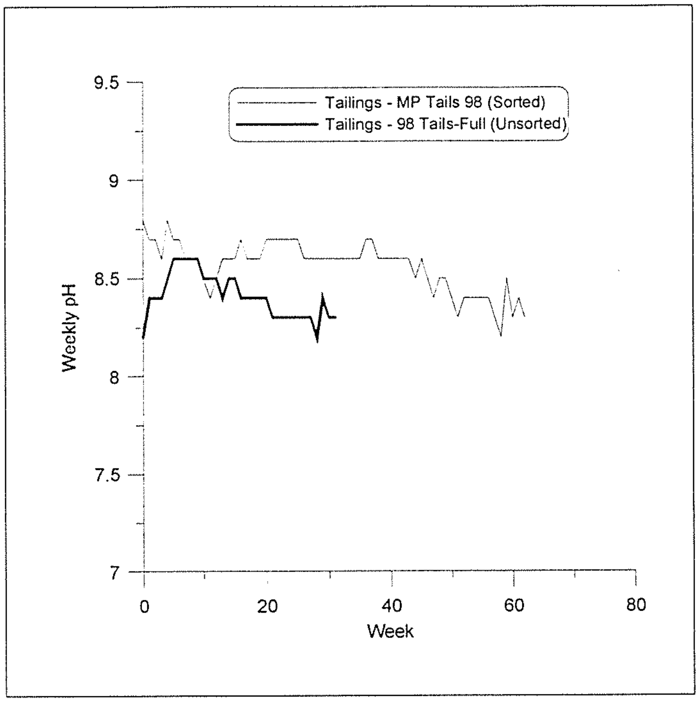


Figure 2-1. Trend of Rinse pH in Mount Polley Humidity Cells.

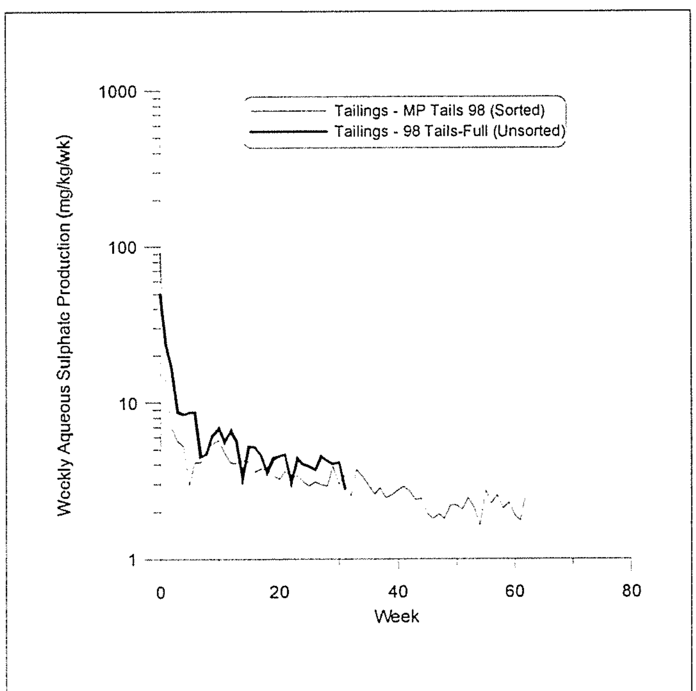


Figure 2-2. Trend of Aqueous Sulphate in Mount Polley Humidity Cells.

Mount Polley Mining Corporation
Mount Polley Mine

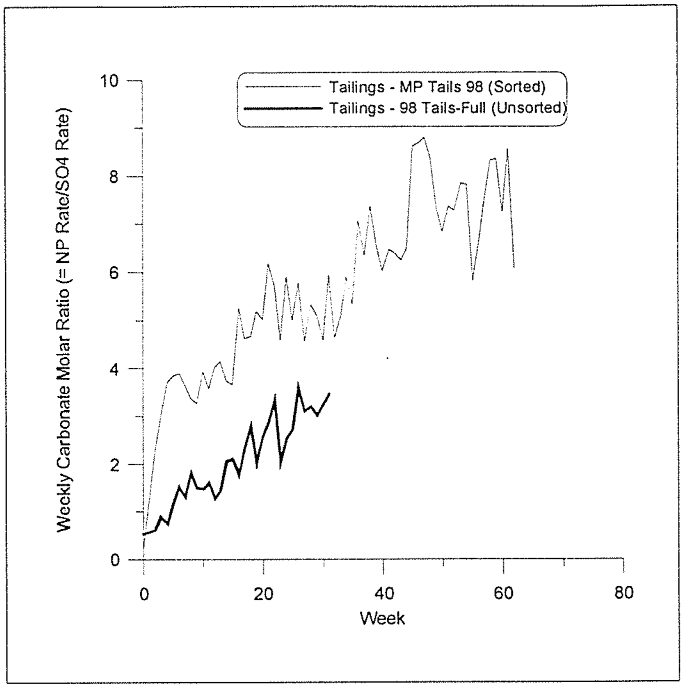


Figure 2-3. Trend of Carbonate Molar Ratio in Mount Polley Humidity Cells.

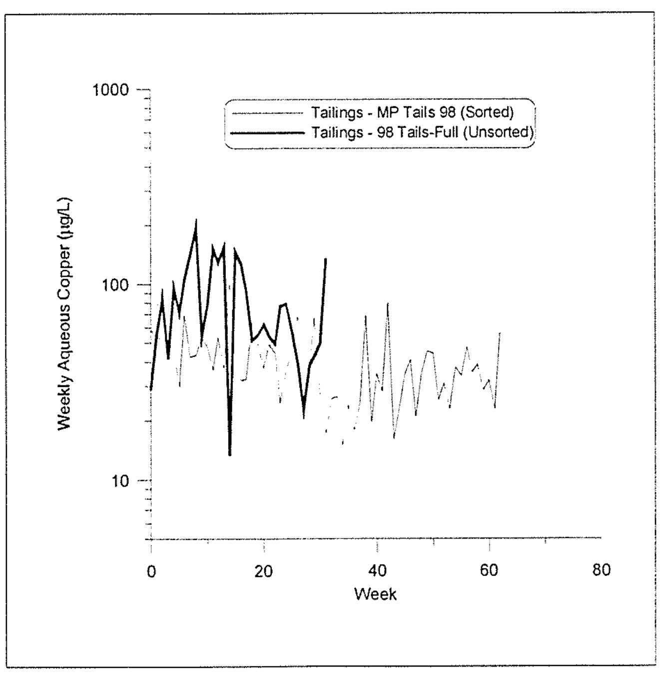


Figure 2-4. Trend of Aqueous Copper in Mount Polley Humidity Cells.

3.0 ENVIRONMENTAL EFFECTS ON RECEIVING WATER QUALITY

3.1 7Q10 Modelling

In order to evaluate water quality impacts on Hazeltine Creek (W7) and NE Edney tributary (W8) from the utilization of tailings cyclone sands, hydraulic modelling of the following creek flow conditions were generated: 7Q10 dry, average, and wet flows.

Appendix C provides the results of the 7Q10 modelling conducted for the Edney-Hazeltine Watershed. It contains a brief background review, a description of the methods used, and the required flow conditions for use in the Impact Model for stations W7 and W8 (Table 4.1.2). The extension of the modelling to the other stations within the watershed was straight forward and was also included in this report.

It was not possible to confidently estimate the 7Q10 flow conditions in the Edney-Hazeltine system based on the data available for that system. Therefore, low flow conditions were estimated for a surrogate watershed (McKinley Creek) and applied to the Edney-Hazeltine system by multiplying the per area flow by the drainage area at any point in the watershed.

This resulted in 7Q10 dry, average, and wet condition estimates for the Edney-Hazeltine system of: 0.0098 m^3/s, 0.052 m^3/s, and 0.097 m^3/s, respectively, for W7, and 0.0003 m^3/s , 0.0017 m^3/s, and 0.0032 m^3/s, respectively, for W8.

3.2 Water Quality Modelling

The conceptual ***Cycloned Sands Construction*** (CSC) design considers that the largest proportion of the tailings sands material will be hydraulically placed directly into the embankment fill slopes. Knight Piesold has submitted a conceptual design report as a separate document. The construction of the downstream slope will be accomplished by discharging the single stage cyclone underflow directly. Process water from the sands will drain and be collected in the existing collection ponds for recovery. The pump-back system will operate in a closed manner.

A seepage flow of 0.0015 l/s from the cyclone placement operation was estimated by Knight Piesold using a typical permeability (Appendix B).

The most efficient means of estimating what the Environmental Effects of the CSC may have on downstream water quality is to examine those periods and conditions when receiving water flows are at their lowest, hence the 7Q10 estimates. These flows are assumed to occur in September.

In summary, the assumptions used in modelling impacts to receiving water quality are as follows:

- The potential seepage reporting to the receiving environment is 0.0015 l/s
- Water quality is typical of that found in the tailings supernatant pond, Site E1.
- Creek flows are based on 7Q10 dry, average and wet estimates
- No attenuation is considered from local till.
- The water quality value for copper is that of MP Tails 98 humidity cell.

3.2.1 Mass Balance Model Inputs

The Environmental Effects model was based on an arithmetic model which superimposed tailings supernatant pond water quality on the baseline receiving water concentrations, which allowed a resulting receiving downstream water quality concentration to be predicted:

$$Rc = \frac{[(Bc \times Bq) + (Ec \times Eq)]}{Rq}$$

Where: Bc = Baseline Concentration (mg/l)
Bq = Background Flow (m^3/s)
Ec = Seepage Concentration (mg/l)
Eq = Seepage Flow (m^3/s)
Rc = Resulting Concentration (mg/l)
Rq = Resulting Flow (Bq + Eq) (m^3/s)

Baseline water quality data (Bc) for both Hazeltine Creek (W7) and Edney Tributary (W8) were collected during the 1989 –1990 sampling campaign and in 1995 and 1996 prior to mine start-up. Tables 4.1.1 and 4.1.2 present the results of the baseline water samples.

A mean Copper value of 0.0041parts per million (ppm) was measured for both sample locations W7 and W8 during baseline study. This value is above the *Approved and Working Criteria for Water Quality (AWCWQ)* and/or *the Canadian Council of Ministers of the Environment Criterias (CCME)*. Baseline iron also exceeded *AWCWQ* and *CCME* at W7.

Tailings cyclone sands drainage water quality was taken from average values collected from site E1 during 1998 and 1999. For values less than the method detection limit, averages were calculated based on half the method detection limit. For copper, the solubility level of tenorite (60 µg/L) was used, based on the MP Tails 98 humidity cells.

3.2.2 Results of the Water Quality Model

The mass balance model illustrates that there would be no environmental effects on the receiving water quality under conditions under a 1 in 10 year average low flow during the month of September when receiving water flows are at their lowest. See Table 4.1.3.

The model is based on a "worst case" flow scenario and therefore should be recognized that there will be no water quality impact on the receiving environment under normal and even extreme operating conditions.

3.3 Closure Considerations

As the cycloned sand fill will be placed in dam construction downstream of an impervious basal till core and perched on top of the pre-existing topography, seepage and/or groundwater flow through the cycloned sand mass will be minimal. Surface water infiltration will be restricted to precipitation falling directly on the sand fill and within the confined catchment area of the dam face. This in turn will be further minimized by reclamation of the dam face which will tie precipitation up in the surficial soils and vegetation. Given the substantial excess of available NP and limited water infiltration expected, it is anticipated that even under field conditions, NP will long outlast sulphide oxidation.

Implementing CSC will result in no fundamental change to the original Reclamation Plan. The downstream slope will be reclaimed with salvaged soil and vegetated to meet stability and esthetic requirements. A cover design will be formulated through the initiation and success of a field test trial research program (2000).

Mount Polley Mining Corporation
Mount Polley Mine

Appendix A - REFERENCES

Allison, J.D., D.S. Brown, and K.J. Novo-Gradac. 1990. MINTEQA2\PRODEFA2. A Geochemical Model for Environmental Systems: Version 3.0 User's Manual. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, Georgia.

Appendix B
Knight Piesold Seepage Estimate

Knight Piésold Ltd.
CONSULTING ENGINEERS

1400 - 750 West Pender St
Vancouver, BC V6C 2T8
CANADA
Tel: +1 (604) 685-0543
Fax: +1 (604) 685-0147
Fax: +1 (604) 687-2203

DATE:	Nov. 23/98	**FILE NO.:**	10162/11.01
TIME:		**REF NO.:**	8/3086
OPERATOR:		**PAGES:**	1 of 2
SENDER:	Ken Embree	**APPROVED:**	

TO:	Mount Polley Mining Corporation	**FAX :**	(250) 790-2268
ATTN:	Ron Martel		
SUBJECT:	Seepage Estimate		

Ron,

Further to my call of Nov. 20/98, the following is a summary of the seepage estimate to groundwater for cyclone sand on the downstream side of the embankment(s).

Seepage was estimated using Darcy's Law;

q=kia, where
q = flow rate
k = permeability
i = hydraulic gradient (h/l)
a = area

The following parameters were used;

k = $1x10^{-8}$ cm/sec (based on typical in-situ field and lab permeability test results (max $1x10^{-6}$ and min $1x10^{-10}$cm/sec were identified)

i = 1 = unit hydraulic gradient (this is conservative for the cyclone sand which will drain and has a drainage layer at the base)

a = 15,000 m^2 (60m wide for full footprint by 250 m long)

Calculations are on the next page.

Seepage Rate:

q = kia

For $k = 1x10^{-8}$ cm/sec **(Typical Permeability)**
$q = 1x10^{-10}$ m/s x 1 x 15,000 m^2 = 1.5 x 10^{-6} m^3/sec = 0.0015 l/sec

For $k = 1x10^{-10}$ cm/sec **(Minimum Permeability)**
$q = 1x10^{-12}$ m/s x 1 x 15,000 m^2 = 1.5 x 10^{-8} m^3/sec = 0.000015 l/sec

For $k = 1x10^{-6}$ cm/sec **(Maximum Permeability)**
$q = 1x10^{-8}$ m/s x 1 x 15,000 m^2 = 1.5 x 10^{-4} m^3/sec = 0.15 l/sec

So, the seepage will be low, with a range from 0.000015 is 0.15 l/sec. This applies only to an area that is in operation, where cycloning is occurring. The flow rate is directly proportional to the area and I have assumed an area which may vary.

The seepage estimate may vary significantly. For instance, seepage may be even lower because much of the Main Embankment foundation has artesian pore pressures that will prevent seepage from entering the groundwater. Artesian pore pressures exist in piezometers at Plane A (4 of 5 foundation piezometers A2-PE2-01, 06, 07, 08), Plane B (2 of 3 foundation piezometers AB-PE2-01, 02, 06) and Plane C (3 of 5 foundation piezometers C2-PE2-01, 02, 06). On the other hand, seepage may be higher if near surface higher permeability zones are covered. (We have seen from construction of the Stage 2B haul road that the near surface till is quite extensive, however.)

Also, as we discussed, this seepage rate applies only to an active area and will drop to zero after deposition has stopped and the sand has drained.

I hope this helps.

Regards,

Ken Embree

Appendix C
7Q10 Modelling of Edney - Hazeltine Watershed

23 February, 2000

Mr. Greg Smyth
Environmental Coordinator
Mount Polley Mining Corporation
Box 14, Likely, B.C.
V0L 1N0

Reference: 7Q10 Modelling of Edney-Hazeltine Watershed
21671.1

Dear Greg,

This letter report provides the results of the 7Q10 modelling conducted for the Edney-Hazeltine Watershed. This report contains a brief background review, a description of the methods used, and the required flow conditions for use in your Impact Model for stations W7 and W8. The extension of the modelling to the other stations within the watershed was straight forward and has also been included into this report.

Watershed Description – Edney-Hazeltine Creeks

The Mount Polley Minesite is drained primarily by two watersheds. The Edney-Hazeltine drains the south and east portions of the mine. The remainder of the undisturbed minesite drains into the Morehead Creek watershed. Figure 1 shows the Edney-Hazeltine Watershed, sub-watersheds and monitoring stations used in the remainder of this report.

The total drainage area of the Edney-Hazeltine watershed is approximately 115 km². Both Polley Lake and Edney Lake are contained within the watershed. Polley Lake is approximately 5 km² in size while Edney Lake is less than 1 km² in size. Originally, Bootjack Lake also drained into this watershed via Bootjack Creek but was diverted into the Morehead system around 1913 to supply water for the now abandoned gold mine near Likely. At the discharge to Quesnel Lake, the elevation of Edney Creek is approximately 730 m. The highest points in the watershed are Mount Polley, Bootjack Mountain and Mount Jacobie which are all approximately 1200 m at their peaks.

The tailings disposal area, which is approximately 4 km² in size is also contained within this watershed. The tailings area occupies the upper portion of the area drained by the NE Tributary of Edney Creek. Runoff from the tailings area is diverted away from the Edney Creek watershed and is not included in this analysis.

Table 1 provides a summary of the sub-watershed areas within the Edney-Hazeltine Creek system.

Table 1 – Edney-Hazeltine Sub-Watershed Areas

Sub-Watershed	Drainage Area (km^2)
Polley Lake (W6)	22
Bootjack Creek (W5)	1
Hazeltine Creek (W7)	30
Hazeltine Creek at Edney Creek	39
Edney Ck above SW Tributary (W9)	42
Edney Creek SW Tributary	13
Edney Creek NE Tributary (W8)	1
Edney Ck NE Tributary at Edney Ck	3
Edney Creek SE Tributary	14
Edney Ck above Hazeltine Ck (W10)	76
Edney Creek at Quesnel Lake (W11)	115

Available Flow Data – Previous Studies

During the 1995 and 1996 no-snow period, Hallam Knight Piésold Ltd. conducted field studies into the surface water hydrology of the two watersheds draining the Mount Polley minesite as part of the baseline studies. Recording water level gauges were installed at eight locations in the Edney-Hazeltine system.

Stage discharge curves were produced for W5, W7,W8, W8A, and W9. In general, these curves had a high degree of scatter, especially at the lower flow levels. At stations W10 and W11, beaver activity changed the relationship during the 1996 study period. No curve was provided for station W6.

The 1996 Baseline study also states that the lowest summer flow recorded was 0.13 m^3/s which is one or two orders of magnitude different from the summer low flows provided by the mine or the Water Survey of Canada (see next section).

With only two partial years available from this data set, it was not possible to confidently estimate the 7Q10 flow conditions in the Edney-Hazeltine system. A more rigorous analysis of the data collected in 1995 and 1996 could provide more insight into the surface water hydrology of the watershed. The 1996 Baseline Study does suggest that the hydrologic conditions at W9 and W7 are similar meaning that pro-rating flow on a drainage area basis is a reasonable approach to determine the low flow conditions within the system.

Available Flow Data – Hazeltine Creek

Only limited data are available for the Edney–Hazeltine Creek watershed. A number of stations have records for 1995 and 1997 but for the summer months only. The Water Survey of Canada (WSC) also operated a recording gauge at W7 (08KH027) for one year in 1995. Mine flow data at W7 were also available for the summer months of 1997, 1998, and 1999. Figure 2 shows the flow data collected in 1995 at W7 by the WSC and the mine.

The flow at W7 is based on a stage measurement at a weir. The mine and the WSC both used a different rating curve resulting in a lower estimate by the mine. In general, the WSC estimate is 33% higher than the mine estimate.

Based on the mine data, the flow at W7 ranged from 0.005 m^3/s to 2.27 m^3/s with an average value of 0.241 m^3/s over the four years of data. Please note that these data did not include the winter months. The peak flow typically occurs during the spring melt which occurs around April and May. The low-flow period usually occurs in late summer or during the winter months (i.e. period of no snow melt). A summary of all the data are provided in Table 2 along with the seven day average low flow for each of the years available.

Table 2 – Summary of Flow Data for Hazeltine Creek (W7)

Year	Average Flow (m^3/s)	Lowest Flow (m^3/s)	Highest Flow (m^3/s)	7 Day Average Low Flow (m^3/s)
Water Survey of Canada				
1995	0.268	0.064	1.260	0.069
Mine Data				
1995	0.221	0.005	0.890	0.050
1997	0.281	0.005	2.270	0.005
1998	0.081	0.005	0.540	0.005
1999	0.501	0.035	1.582	0.038
Combined	0.241	0.005	2.270	----

With only four partial years available, it is very difficult to estimate a flow for a 10 year return period. While it is possible to extrapolate these data to a 10-year return period, the associated error on the predictions can be substantial. In turn, the estimate of the 7Q10 flow is unreliable. In cases such as this, it is generally preferable to estimate the low flow condition based on a surrogate watershed.

Procedure for Estimating Flows Based on a Surrogate Watershed

In order to estimate the low-flow condition in the Edney-Hazeltine Creek watershed, the following steps are followed:

1. Determine the watershed areas of the study area;
2. Identify a surrogate watershed which is similar in size to the study location and is reasonably close to study location so that it experiences similar weather patterns, has similar topography to the study area, and has sufficient flow data;
3. Determine the flow conditions (i.e. 7Q10 flow, extreme events, etc.) for the surrogate watershed; and,
4. Pro-rate the flow conditions of the surrogate watershed to the study area on a drainage area basis.

Surrogate Watershed – McKinley Creek

The Water Survey of Canada Gauge Station on McKinley Creek (08KH020) is located approximately 45 km south-east of the Mount Polley Mine. McKinley Creek has a drainage area of 430 km^2 and flows into the Horsefly River which also drains into Quesnel Lake.

Daily flow data were available for the period 1965 through 1995. In that period, the maximum daily flow was 50.5 m^3/s, the minimum flow was 0.037 m^3/s and the average flow was 4.962 m^3/s.

There are three yearly seven day average low-flows that are of interest for this analysis:

1. the average seven day average low-flow (i.e. 'average' year);
2. the lowest yearly seven day average low-flow that occurs once every ten years (i.e. 'dry' year); and,
3. the highest yearly seven day average low-flow event that occurs once every ten years (i.e. 'wet' year).

The yearly seven day average low-flows are determined by finding the lowest seven day average flow that occurs in each of the 31 years in the record period. For the 'dry' year, the yearly flows are then ranked in order from largest to smallest and the return period is calculated using:

$$t_r = \frac{N+1}{m}$$

where: tr recurrence interval (yrs);
N total number of years; and,
m rank of individual record.

The individual flows are then plotted against the recurrence interval (return period) as shown on Figure 2. The flow corresponding to the ten-year return period can then be determined from the best fit line. For the 'wet' year, the flows are ranked in order from smallest to largest and the same approach is used as for the 'dry' year. The results of the analysis are presented in Table 3.

Table 3 – Results of Flow Analysis of McKinley Creek

	Flow in McKinley Creek (m^3/s)	($m^3/s/km^2$)
Annual 7 Day Average Low Flow		
Lowest Recorded	0.040	0.000093
'Dry" Year	0.140	0.000326
'Average' Year	0.750	0.00174
'Wet' Year	1.389	0.00323
Highest Recorded	1.700	0.00395
Daily Flows		
Minimum Recorded	0.037	0.000086
Average Recorded	4.962	0.0115
Maximum Recorded	50.5	0.117

Application of Surrogate Flows to Edney-Hazeltine System

The estimated flow in the Edney-Hazeltine system is calculated by multiplying the per area flow from Table 3 by the drainage area at any point in the watershed. The estimates for average, 'wet' and 'dry' years are provided for several points in the watershed in Table 4.

Table 4 – Estimated Flows in Edney-Hazeltine System

Sub-Watershed	Type of Year 'Dry' (m^3/s)	Average (m^3/s)	'Wet' (m^3/s)
Polley Lake (W6)	0.0072	0.038	0.071
Bootjack Creek (W5)	0.0003	0.0017	0.0032
Hazeltine Creek (W7)	**0.0098**	**0.052**	**0.097**
Hazeltine Creek at Edney Creek	0.013	0.068	0.17
Edney Ck above SW Tributary (W9)	0.014	0.073	0.14
Edney Creek SW Tributary	0.0042	0.023	0.042
Edney Creek NE Tributary (W8)	**0.0003**	**0.0017**	**0.0032**
Edney Ck NE Tributary at Edney Ck	0.0010	0.0052	0.0097
Edney Creek SE Tributary	0.0046	0.024	0.045
Edney Ck above Hazeltine Ck (W10)	0.025	0.13	0.25
Edney Creek at Quesnel Lake (W11)	0.037	0.20	0.37

Given the absence of any long term flow records within the Edney-Hazeltine system, the application of drainage area pro-rated flows was the only reasonable method to determine the one in ten year low flow conditions within the system. All applicable flows for your Impact Model have been highlighted in Table 4.

If you have any questions or comments, please feel free to contact me at any time by phone at (905)-794-2325 x218 or by email at gvanarkel@beak.com. Also, if you require electronic copies of this report, please let me know.

Yours truly,

BEAK INTERNATIONAL INCORPORATED

Gerard van Arkel, M.Eng, P.Eng
Environmental Engineer

Figure 2: Flow Measurements at W7

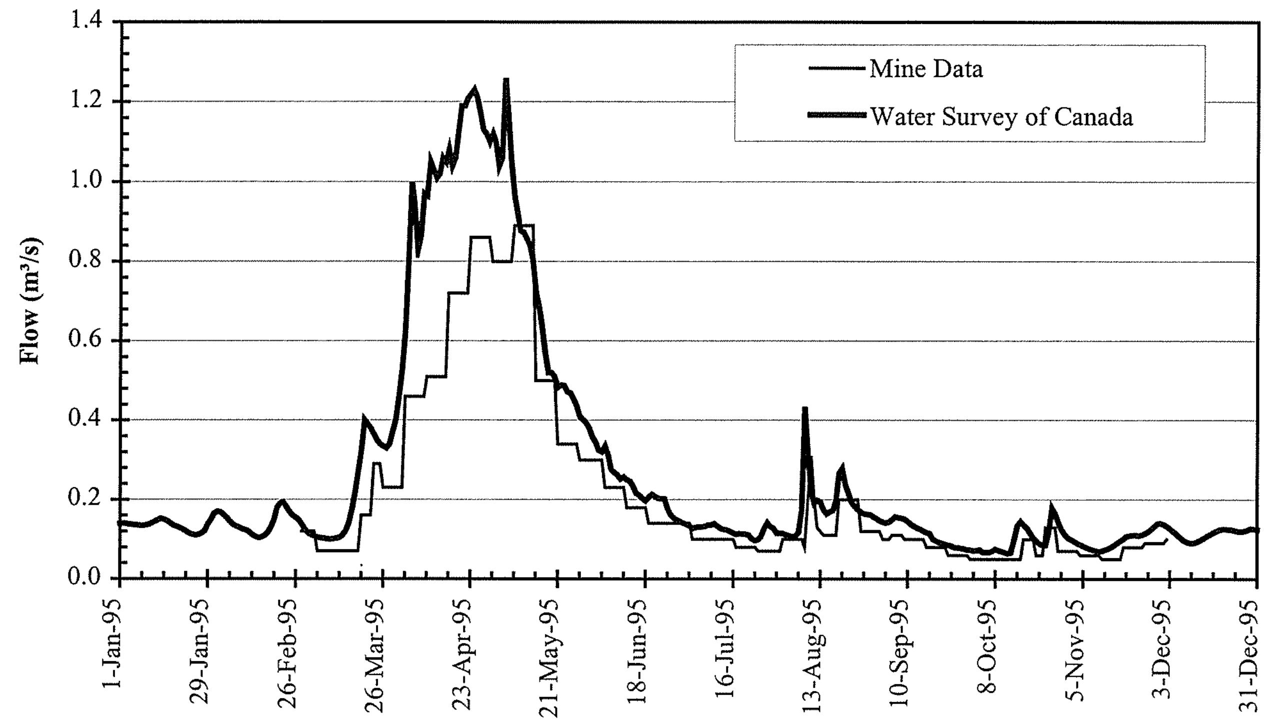
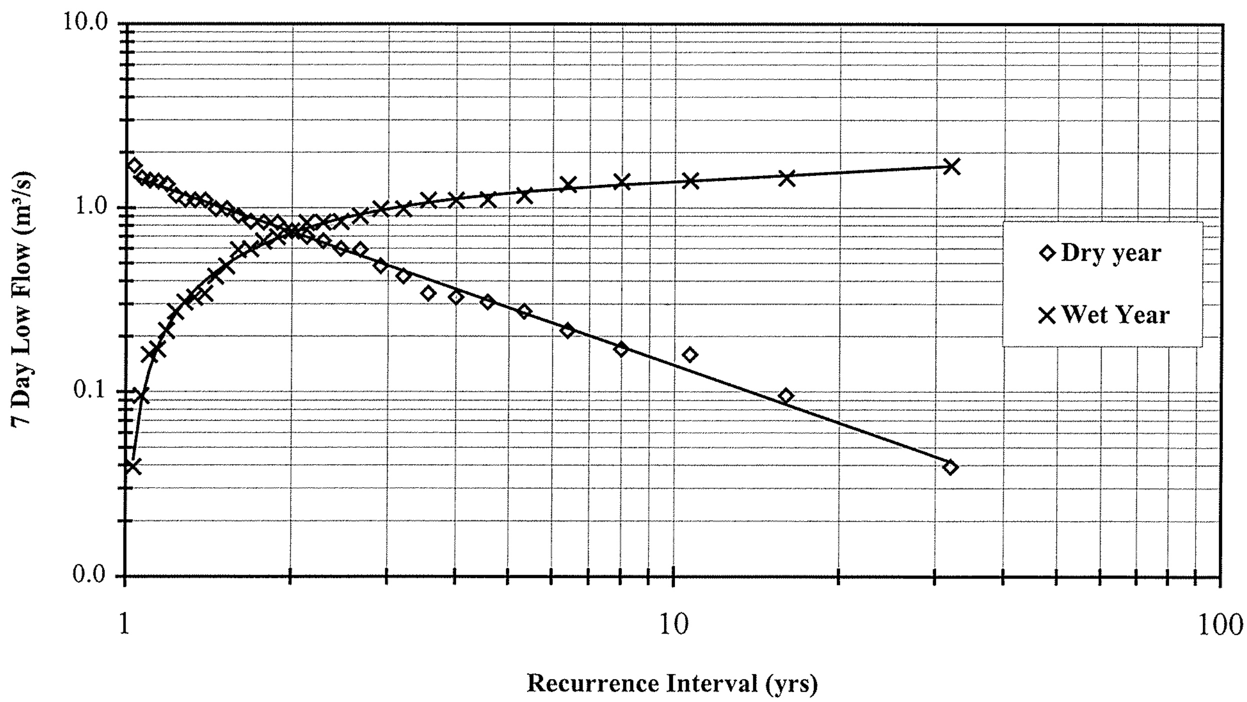
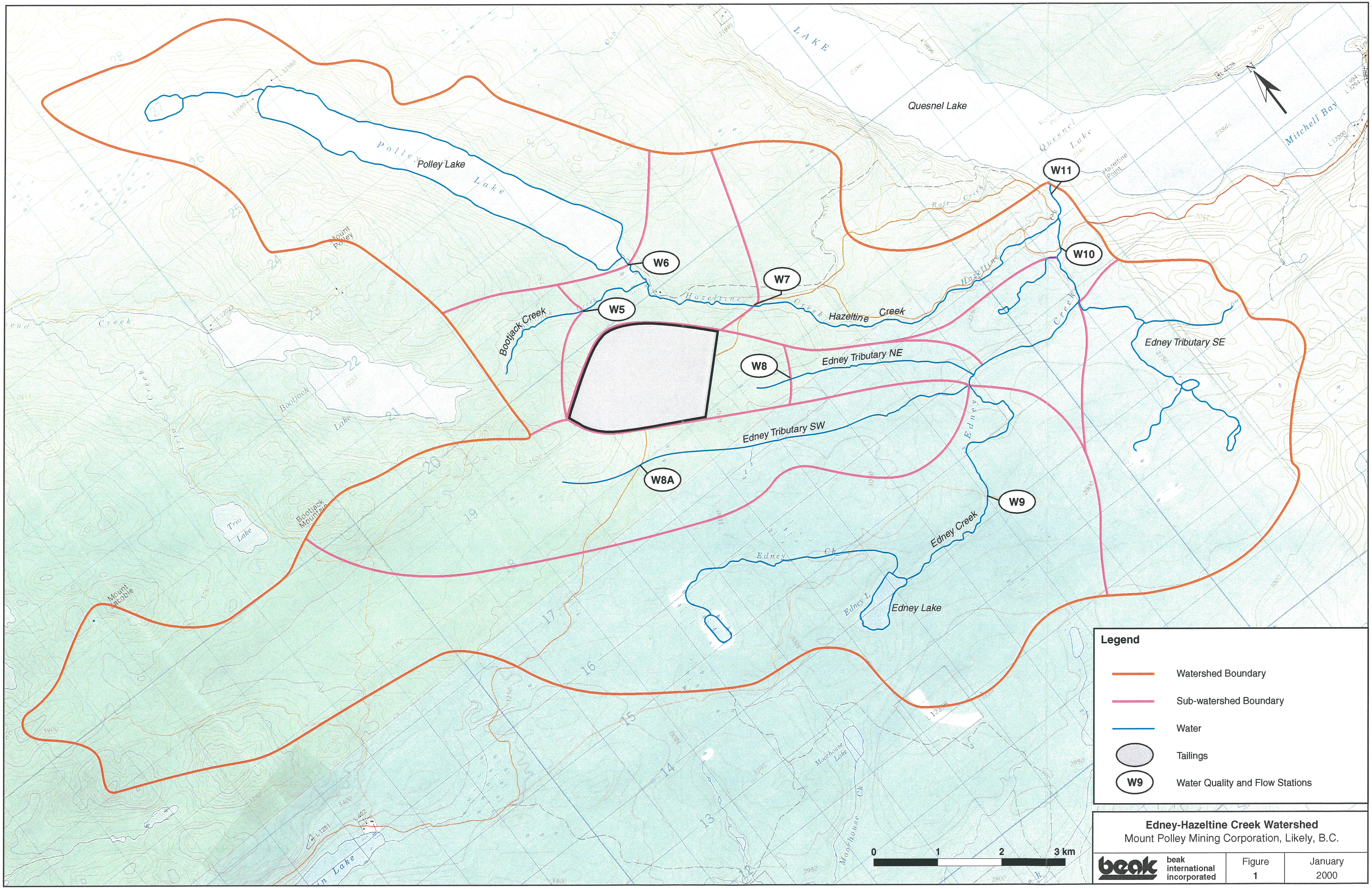


Figure 3: Recurrence Interval for Seven Day Average Low Flow in McKinley Creek





Edney-Hazeltine Creek Watershed

Mount Polley Mining Corporation, Likely, B.C.

beak international incorporated | Figure 1 | January 2000

Appendix D
Response to MELP letter dated February 12, 1999
Re: Report on Tailings Sands Geochemical Evaluation

MINESITE DRAINAGE ASSESSMENT (MOR WIJK ENTERPRISES LTD.)

MEMORANDUM

DEC. 10 1999 03:12PM **P3**

TO: Ron Martel, Mount Polley

FROM: Kevin Morin

DATE : February 18,1999:
MDAG FILE: 2012-1

RE: Mount Polley - Comments on Beak Draft Report and NIELP Geochemical Review - BY FAX AND MAIL

We have read the letter from Doug Hill (MELP) regarding the geochemical evaluation. We thus offer the following observations on each of his comments,

"The method of washing tailings sample through a 200 mesh should be compared with actual cycloned tailings to determine if the screened sample accurately simulates the separation that occurs with the cyclone."

During the cyclone trials, the cyclones were fine tuned, yielding material that varied somewhat at any particular moment in time but which eventually achieved the average separation necessary for dam construction and stability. The "screened sample" was prepared to simulate this average achievable separation for cycloned tailings produced in the field. Thus the sample was representative of the actual cycloned tailings that meet design objectives. However, numerical "accuracy" as requested by MELP is not definable when minute-to-minute variability is involved, as explained in more detail below. Nevertheless, the geochemical evaluation explained that the geochemical results and predictions can be adjusted for other splits, although these other splits would not likely be used in the dam for stability reasons.

"The term SNPR is used on page 3, presumably to mean sulfide NPR, this should be clarified and an explanation provided as to why this is specified. "

SNPR is the standard acronym for Sulphide Net Potential Ratio (dimensionless value from dividing Neutralization Potential by Sulphide Acid Potential). The draft provincial ML/ARD Prediction Manual requires that the type of NPR used in a report must be specified and thus the geochemical evaluation uses SNPR. The reason why SNPR was used is because SNPR must be used in all cases for accuracy, unless other relationships are established. For example, if all measured sulphur is sulphide, then total sulphur can be substituted for sulphide, but this is not the case for Mount Polley.

"Results for ICP scans in appendix A indicate microsplitting as a sample preparation step for some samples, what this is and how might it affect the results should be explained in section 2.4. "

Microsplitting is a standard laboratory technique through which relatively small samples are properly split with a small splitter (a "microsplitter"). A larger, standard-sized splitter would not perform properly with such small samples. The laboratory (Chemex Labs in North Vancouver) has indicated about microsplitting that "this splitting process would not have any effect on the analytical results".

"Particle size analysis is based on a single sample. Additional samples are needed to generate a statistically meaningful result. Section 3.2.2 indicates that the PSA completed compared well with "material that was produced in the field". If this indicates materials analyzed from trial cyclone runs, comparison of data between the simulated cycloned sands and actual cycloned sands. I " [sic]

The particle size of the actual cycloned tailings will vary minute-to-minute, but will provide the averaged result to meet design specifications and dam stability. The objective of the geochemical evaluation was to test a sample, derived from a five-month tailings composite, that was similar to the designed and required cycloned tailings. This was achieved. In any case, the geochemical evaluation shows that this is not relevant to the geochemical predictions, but they can be scaled if there is a significant deviation from design (although the cycloned tailings would then not likely be used in the dam for stability reasons).

Furthermore, the one particle-size analysis in Chapter 3 was not intended to be statistically compared to the trial cyclone tailings, because statistical tests among minute-by-minute variations during fine tuning, which cannot be fully defined, are invalid. Instead, the purpose of the single particle-size analysis was (1) to show that the sample size approximates the anticipated average size of the designed and required cycloned tailings and (2) to estimate particle-surface area as required by the ML/ARD Prediction Manual with the elm recognition that particle-surface area is only a rough indicator of actual surface area. Statistical comparisons in these matters would not be meaningful.

"An explanation of the rationale for changing the digestion for MP-98 from that used for the monthly composites is needed in section 3.2. "

The initial digestion method was aqua regia (a strong, dual-acid solution) which typically dissolves most solid-phase amounts of several metals like copper. It does **not** fully dissolve other metals like aluminum. By accident, the laboratory used triple-acid digestion on MP-98, which subsequently showed that the standard aqua regia was not fully dissolving all relevant metals. We now realize that triple-acid digestion is required for Mount Polley tailings samples. This apparently rare case may be included in the next version of the province's ML/ARD Prediction Manual.

"The prediction manual noted on page 8 is an MEM document not a joint MEM/MELP document (only the ARD policy is a joint document) "

This is incorrect. MELP staff in Smithers and Victoria have been heavily and repeatedly involved in revisions and expansions to this manual with the intent of both ministries issuing it. This may change if MELP withdraws, but the manual still reflects heavy involvement by MELP.

"The result in table 3.2.4for silicon in the MP tails is significantly lower than the average crustal range to which the table compares it to. Unless this is an error, some explanation should be provided explaining why the result is significantly lower. "

The value for the tailings is provided as percent rather than as ppm. The value in the table should be 262,000 ppm. Thus it is within the range of average crustal abundance.

"The comment on page 8 that NP is outlasting AP requires more explanation as fig. Cell-S and NP- remaining seems only to show that to date there has been no change in either parameter. "

Because the potential for ARD is so low at Mount Polley and because the humidity cell shows that the low amount of sulphide oxidizes so slowly, the graphs do not show the negligible change in the values. Instead, the spreadsheets containing the data were used to estimate the long depletion times for sulphur and NP in the report. Nevertheless, the cell is still in the early stages of testing so results cannot yet be considered reliable. Over the next few months, the reliability of the data will be clearer, although we expect the minor changes in sulphur and NP will still not be visible on the diagrams.

"The MINTEQA2 user's manual indicates that the first step in applying the program model is the formulation of 'relevant chemical questions'. The questions that the model is supposed to answer are not discussed. The report should present these questions in an explicit fashion ".

The report states that the purpose of the MINTEQ evaluations was to search for equilibrium conditions with known minerals. However, it would be wasteful and of little value to explicitly present the questions for each metal and mineral. For each of the dozens of metals and nonmetals, and for each of the hundreds of minerals, in MINTFQA2, we would have to explicitly add to the report:

> Is element X in equilibrium?
> Is element X at saturation with mineral Y in MfNTEQA2?
> Is element X close to saturation with mineral Y in MINTBQA2?
> Could the saturation limit, if not at zero, reflect site-specific conditions as reflected in the MINTEQA2 runs with other samples?

This would result in hundreds to thousands of lines repeating these questions over and over again. Instead, it is sufficient to say, as in the report, that the purpose of the MINTEQ evaluations was to search for equilibrium conditions with known minerals.

"The charge balance for the results in table 5-1 exceed the IO% maximum guideline in 6 of the 13 samples that are shown. The impact on these imbalances should be discussed for the examples shown. "

The value of 10% is only a guideline and thus exceeding this value does not mean there are errors in the data. In fact, such discrepancies may mean that a particular metal like strontium may not have been measured. The impact of these imbalances were not discussed because there are no significant impacts. For example, a large imbalance of 50% indicates the reported concentration of the major cation or anion could be incorrect by up to a factor of 2. If it is incorrect by a factor of 2, then this would change the associated mineral-saturation indices by only 0.3 units, which is insignificant to the Mount Polley interpretations. As explained in the geochemical evaluation, site- specific factors (not errors) can actually after saturation indices by 1.0 unit or more, so any MINTEQA2 assessment requires care in interpretation rather than strict application of rules and guidelines. We see no reason to greatly expand the report to discuss all issues that are not significant.

Mount Polley response to comments on Section 6.

A reference for the equations for calculating the runoff coefficient and for calculating the 1 in 20 year formula should be provided

The equations for calculating the runoff coefficient and the 1 in 20 year formula were from the Knight Piesold Field Manual (unpublished) provided to Mount Polley Mining Corporation.

used in the report was based on the equation used by Knight Piesold for the Mount Polley Water Balance.

In Section 6.1.2 a seepage rate is quoted from Knight Piesold. A report should be referenced in support of this number.

The seepage rate calculation has been added into the previous report and is provided as an addendum to this update.

MELP policy for determining water quality impacts is to ensure that BCWQC are met for conditions up to a 1 in 10 year 7-day average low flow.

The 7Q10 was used in this Update to determine water quality impacts.