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Technical Memorandum

DATE: June 12, 2002

TO: Brent Murphy, EBA Engineering Consultants Ltd.

FROM: Shannon Shaw, Robertson GeoConsultants Inc.

RE: Technical review of CanZinco Ltd's Nanisivik Mine Closure and Reclamation Plan, RGC Project No. 089005/1

Robertson GeoConsultants Inc. (RGC) has been contracted by EBA Engineering Consultants Ltd. (EBA) for the technical review and assessment of the acid generating potential issues related to the *Nanisivik Mine Closure and Reclamation Plan,* dated February 2002. The results of that review are provided herein and are organized into the specific items outlined in the scope of work for ease of integration into your final report. The specific reports and supporting documents reviewed for this evaluation are listed in a reference section at the end of this memo.

The deposit is a Mississippi-Valley Type, carbonate (dolostone) hosted Zn, Pb mine. The area is one of significant mineralization with the predominant sulphides being pyrite, sphalerite and galena. Pre-mining elevated concentrations in the area, in particular for Zn, have been documented and a water treatment facility on site currently treats ARD via lime neutralization. While evidence of acid generation and metal leaching through a range of pH conditions exists at the site, the mine is located in an area in which climate will be extremely beneficial in minimizing long term sulphide oxidation and metal leaching, and therefore potential water quality impacts. It is clear that utilizing permafrost development is paramount to CanZinco's closure and remediation plan, therefore the primary comments raised in this review pertain to the geochemical processes that may affect permafrost development, and where permafrost development is questionable, what affect the geochemical processes may have on the localized areas.

A. The capping of tailings disposal areas and associated long term stability issues

The acid base accounting results and water quality results (sample location 159-1) suggest the tailings are currently buffered, however are considered potentially acid generating with very high sulfur contents. The pH has been maintained alkaline due to process waters and tailings disposal, however concentrations of those parameters reported (Cd, Pb and Zn) are high and consistently above the water quality standards outlined in the Water License (see Figures 1 to 3 below). While attenuation mechanisms and precipitation along the seepage flowpath may reduce the concentrations, Zn in particular may remain relatively mobile at near neutral pH conditions and pose water quality concerns regardless of whether or not acidic conditions prevail in the seepage quality. There was no discussion of metal leaching potential at near neutral conditions found in the documents reviewed. However, if the tailings pore waters freeze completely as is anticipated by CanZinco and their consultants for the sub-aerial tailings, seepage of metal rich waters will likely not result.

This is to be accomplished with a layered shale and gravel cover of 1.25m thickness to permit permafrost aggradation and maintain the active zone within the cover itself. We are of the understanding that others are reviewing the effectiveness of this cover for permafrost development. However, there are two geochemical processes that may affect the development of permafrost that should be mentioned, one of which has been identified in volume 2 of the Closure and Reclamation Plan. Specifically, that is the effect of heat from the exothermic reaction of pyrite oxidation on the formation of permafrost. This issue was also identified by Gartner Lee and proposed for assessment in the Phase 2 ESA. The results of this evaluation were not reviewed, it is recommended that this be evaluated relatively soon with the objective of determining the adequacy of cover depth.

Another issue related to permafrost development that has not been identified in the information reviewed relates to the potential of freezing point depression in pore waters with elevated conductivities. The Nanasivik tailings consist of approximately 48% total sulphur, an extremely sulphur-rich material. While there was no information reviewed that related to pore water chemistry (such as kinetic tests, leach extraction tests, pore water sampling etc.), it would be expected that pore waters associated with such high sulphur tailings would have elevated conductivities. The tailings process waters, represented by sampling location 159-1 have electrical conductivities in the range of 5000 to 8000 μS/cm. If localized sulphide oxidation has time to occur within the upper layer of the tailings prior to freezing, these conductivity values could increase. There was reference to humidity cell testing, however there was no report provided for this review, therefore the site specific kinetics of sulphide oxidation, or the potential 'lag' period before sulphide oxidation becomes apparent has not been reviewed.

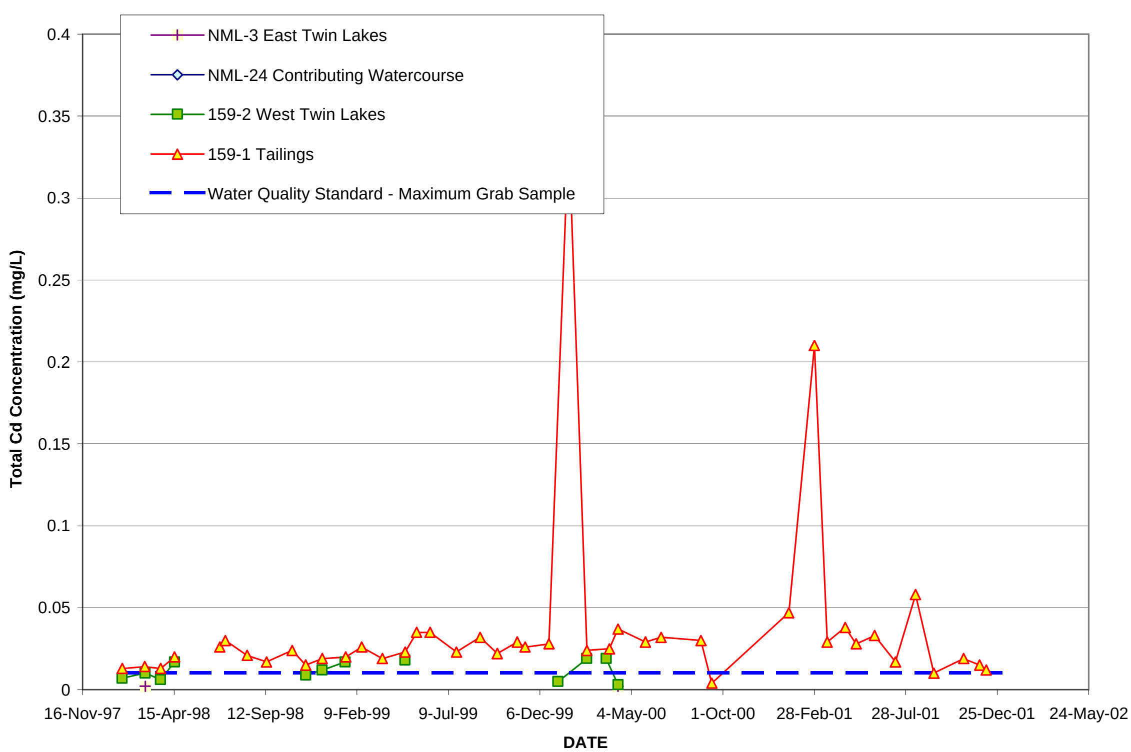

Figure 1. Total Cd Concentrations at Select Monitoring Locations

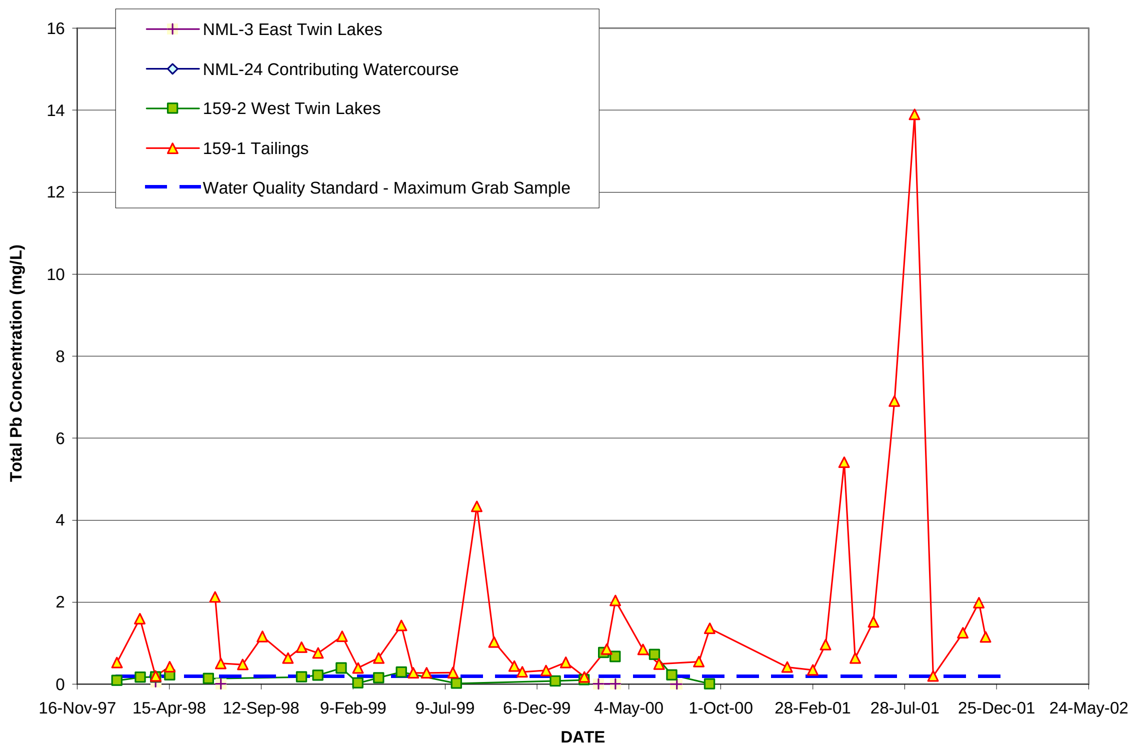

Figure 2. Total Pb Concentrations at Select Monitoring Locations

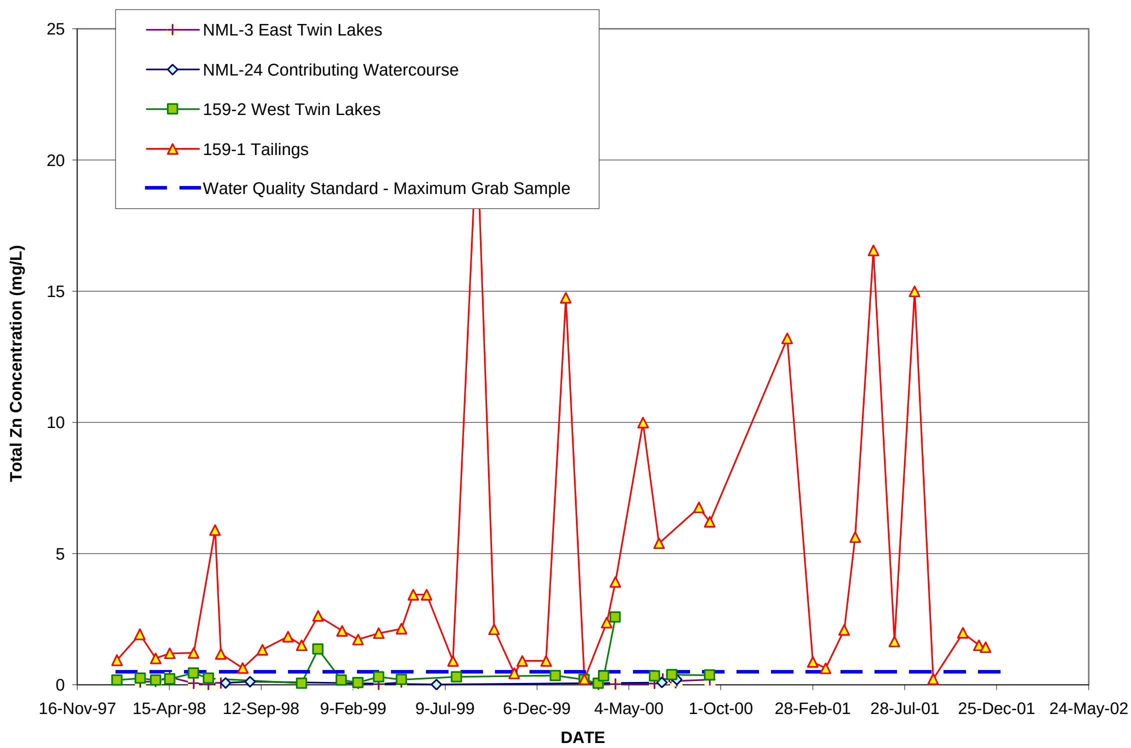

Figure 3. Total Zn Concentrations at Select Monitoring Locations

The geochemical characteristics of the shale identified as cover material indicate that the shale is acid consuming. It will not generate acid itself and does contain excess buffering capacity, however it should be noted that it will not be an effective buffering source for acid generating material underlying it, but will only provide neutralization for acidic waters in direct contact with the shale (i.e. seepage migrating through it) as the acidic solutions dissolve the carbonate buffering minerals. In this case, it would be anticipated that significant secondary mineral formation, such as gypsum ($CaSO_4.2H_2O$, a white ‘salt’), would be evident due to anticipated high SO_4 in acidic waters and Ca from the shale itself. This mineral formation has been noted in the dyke shale during geotechnical inspections in a number of the documents reviewed, suggesting SO_4-rich seepage through the dyke is or has occurred.

The sub-aqueous tailings cell will rely on oxygen limitation for the reduction of sulphide oxidation in the submerged tailings. This type of ARD control is often used for sulphidic and uranium tailings, in particular in Canada. The water depth planned for the Nanisivik tailings cell is 1m. There have been significant studies completed and referenced in the literature on the ‘appropriate’ water cover depth and the potential for water quality degredation as a result of resuspension of tailings due to wind-induced wave action and/or long term drought effects. Resuspension of tailings under water cover could result in impacted water quality of the cover and downstream environment. While the appropriate water cover depth is a site specific parameter, a recent paper by Yanful et al. (2002) references minimum depths of 1.2 to 1.4 m for wind speeds on the order of 10 to 18 m/s, for numerous sites in order to minimize tailings resuspension. Their field measurements at the Heath Steele Mine indicated that resuspension and transportation of tailings within the pond occurred when the water cover was 1m deep or less. There was no reference found in the documents reviewed to studies at Nanisivik looking at either wind-induced wave effects or potential drought effects on the water cover and water quality. It is recommended that these issues be addressed in order to evaluate the appropriateness of a 1m cover to ensure sulphide oxidation of the underlying tailings is minimized.

B. The disposal of sulphide-bearing rock and the restoration of waste rock disposal sites

Waste rock piles on the surface, are predominantly from earlier operations. Waste rock that is currently produced is used underground for pillar support and backfill. There are essentially three surface dumps, the West Adit Area, the East Adit Area and Area-14. It has been assumed that any waste rock at the Ocean View and K-Baseline zones are included in the general Area-14 description. It is our understanding that some, but not all of the surface waste rock will be placed underground. That material left on the surface will either be utilized as backfill in the open pits or remain in place with most areas, but not all, being covered.

Gartner Lee proposed in the 2002 ESA to estimate the disposal volumes and schedules for waste rock to assess what is going to fit U/G and what will stay above ground. We'd suggest that the geochemistry of various piles be considered in the scheduling if possible so that a 'mapping' of material characteristics can be created and priority can be given to the placing the ‘higher risk’ material underground with respect to acid generation. It is likely that additional sampling and testing may be needed to adequately ‘map’ the waste rock material for these purposes.

In addition, a QA/QC program for material left on surface is recommended. Ideally this program would be significantly conservative as we would expect that even in a net neutralizing waste dump, localized ‘hot spots’ where massive sulphide rock exists will develop. It is often seen in waste rock dumps that carbonate rocks will ‘blind’ over time with secondary mineral precipitates such as iron oxy-hydroxides becoming less effective at neutralization over time; whereas massive sulphide rocks will break apart with weathering providing greater surface area thereby increasing the rate of sulphide oxidation over time. The two processes together can result in acid generation in piles that had been characterized as net neutral.

These processes will be negligible if the waste rock is encapsulated by permafrost. It is not clear from the material reviewed however if the hydrologic regime of backfilled pits is such that some seepage, even seasonally, can be anticipated from these areas. Similarly, the waste rock covered in-place or those dumps that will not receive a cover may develop localized seeps. It is a possibility that some of these seeps would be acidic, or may be 'buffered' but still have elevated levels of certain metals, in particular Zn. The metal loading study indicated that these processes and seepage conditions currently exist in the dumps along Twin Lakes Creek. The information reviewed does not confidently indicate that these processes will not continue in some areas, at least on a local scale.

C. The filling and capping of open pits and associated long term stability issues.

It has been assumed that the sulphide-bearing pit walls will be covered with backfilled material so as to minimize the potential sulphide oxidation and acid generation from the exposed, in-situ pit wall rock. It is not clear how this will be performed or monitored. There has been no discussion of an evaluation program to identify sulphidic pit wall material, nor a discussion of the criteria to be utilized to ascertain 'sulphidic' from 'non-sulphidic' wall rock. It would be recommended that a 'mapping and sampling program' for design and a QA/QC program during reclamation be completed to ensure that any potentially acid generating pit walls are not left exposed.

D. The disposal and remediation of the municipal infrastructure, including solid waste disposal site.

Not reviewed for ARD issues.

E. The sealing of portals.

Not reviewed for ARD issues.

F. The restoration of water management structures (dams, diversion channels, intake, liming and dump ponds) and associated long term stability issues.

The water treatment facility sludge has been planned for disposal underground. It is not clear whether or not this sludge will need physical or chemical stabilization for disposal (e.g. cement addition) or whether the potential for metal re-mobilization exists. It would be recommended that these issues be addressed in greater detail.

G. The remediation of roads and ore stockpile pads.

It would appear, based on the results provided in the Lorax Report (2001), that the main road material was largely constructed of waste rock with variable geochemical characteristics. The majority of those samples tested by Lorax would be considered non acid generating, however some samples would classify as potentially acid generating. Assuming the 12 samples reported are representative, it might suggest that localized areas of acid generation may result along the road. The Closure and Remediation Plan alluded to additional sampling and assessment of road material scheduled for this year, which we agree should definitely be carried out. Based on these forthcoming results, the closure plan includes the excavation and removal of any potentially acid generating material for disposal underground and contouring of non-acid generating areas. It is not certain what QA/QC program or classification criteria will be utilized to ensure complete removal of potentially acid generating material. It is suggested that a conservative criteria be selected to minimize surface oxidation and the potential development of acidic seeps.

There was no reference found in the documents reviewed to the closure measures related to the roads associated with pipeline right-of-ways. It is anticipated that areas along these roads, in particular areas that have been subjected to occasional tailings spills, may be of concern with respect to ARD issues and should therefore be assessed for this potential. Similarly, sampling and evaluation of the geochemical characteristics of the two dump ponds areas should be included in the reclamation program.

The ore stockpile pads are reportedly comprised of dolostone and shale and the closure measure consists of removing any remaining sulphidic material underground for disposal. Again, a QA/QC program should be defined to ensure all sulphidic material is removed.

H. The filling and/or contouring of quarries.

While previous testing indicates that the quarried shale is likely non-acid generating, it would be recommended that a QA/QC program or inspection program be integrated into the filling and contouring of quarries to ensure no localized sulphide oxidation potential on the final surfaces.

I. The dismantling of surface structures (process plant, concentrate storage building, and associated structures).

Not reviewed for ARD issues.

J. The dismantling and remediation of petroleum and chemical reagent storage areas.

Not reviewed for ARD issues.

K. Underground workings of the mine.

Not reviewed for ARD issues.

L. Determination of the extent of contamination beyond the tailings disposal area.

It has been acknowledged in the closure and remediation plan that there are areas that have been affected by wind blown tailings. Currently there are no closure measures or remediation programs defined for these areas, but an assessment as part of an ESA in 2002 was referenced. It would be anticipated that a field and laboratory based sampling program would be developed for such an assessment.

A hydraulic confinement study was undertaken to assess the potential for seepage from the WTDA towards the East Twin Lake. Figure 4 is the same plot as shown in Figure 3 with a smaller Y-axis scale to look more closely at the results from those locations with smaller Zn concentrations.

No definitive increase in Zn concentrations is seen in East Twin Lakes since early 1998. It would be expected that Zn would be an early indication of contamination as concentrations in the tailings process waters are elevated. Typically SO_4 concentrations are also tracked in this manner as an early ARD indicator. Adding SO_4 to the parameter list for routine analyses at the locations included in the reclamation and closure monitoring programs would be recommended for these purposes.

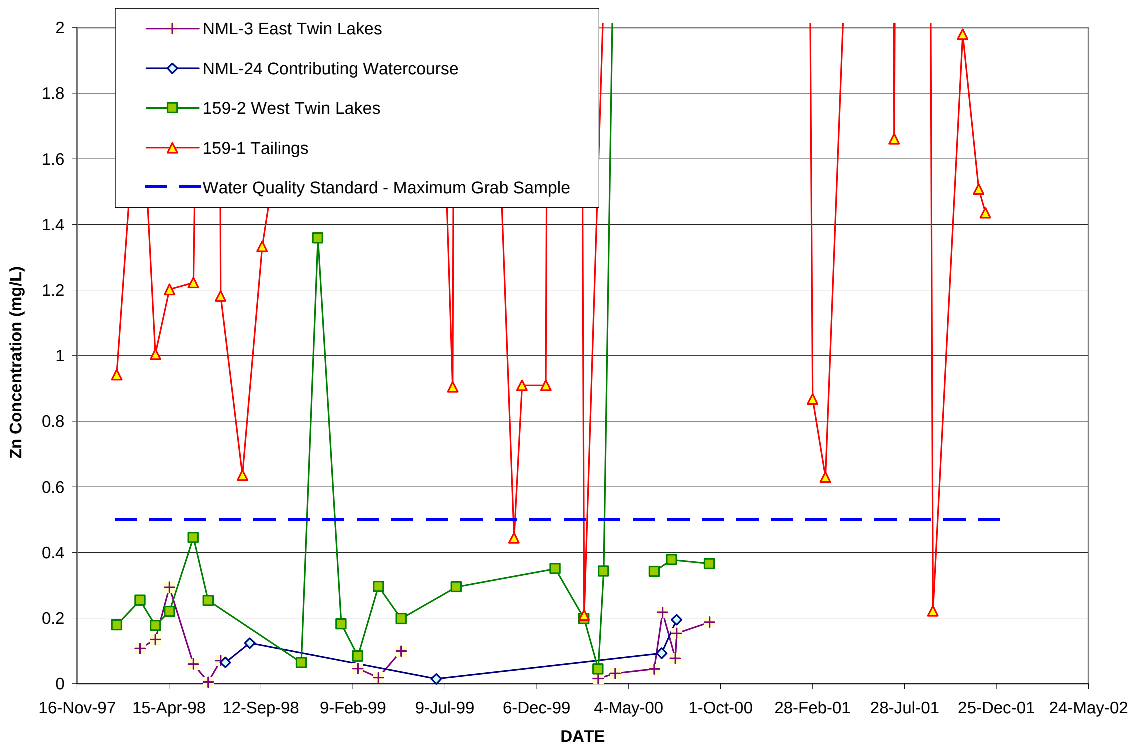

Figure 4. Total Zinc Concentration for Select Monitoring Stations (smaller Y axis scale).

The water elevation in the two lakes as reported in the Hydraulic Confinement study indicate that surface water flow would be from East Twin to West Twin Lakes thereby indicating no surface water connection from West Twin Lake to East Twin Lake. It is our understanding that, if conditions were such that sulphide oxidation/metal leaching resulted in the tailings, any consequential surface water contamination from West Twin Lakes would report to Twin Lakes Creek and the current monitoring stations would detect such a trend. Again it would be our recommendation that SO_4 be added to the analysis program as an early indication of potential sulphide oxidation within the tailings area.

There may also exist a potential for shallow groundwater movement down gradient from West Twin Lakes. It would be of benefit to conduct a seep survey and perhaps install a few monitoring wells in the down gradient areas most susceptible to groundwater impact to define whether or not a plume currently exists, or may potentially develop in this area and if so, what areas are potentially susceptible to impact (e.g. Twin Lakes Creek). There was no discussion reviewed in the material provided whether or not this type of assessment is planned.

M. Remediation of possible contamination within the townsite.

The closure and remediation plan does not discuss a program to determine the extent or remediation of possible contamination within the townsite. It would be assumed that areas of potential contamination would be roads, parking lots etc. and that a QA/QC program with excavation and disposal of any contaminated areas could be implemented in a similar manner to that for the main roads (see item G above).

N. Other issues

The reclamation monitoring period of 2 years and a closure monitoring period of 5 years may not be sufficient to satisfy regulators that conditions are such that final closure can be achieved, in particular due to the slower kinetics (temperature related) and likely slower 'lag' time to acid generation as a result of significant amount of neutralization available. It would be anticipated that a time frame on the order of 10 years may be more appropriate, or that wording be added such that monitoring will continue until such time that it can be demonstrated that acid generation has been minimized and permafrost conditions have been soundly established.

There are fewer monitoring sites included in the closure monitoring plan than in the reclamation monitoring program as is typically the case. However, it is assumed that if areas are identified as potential problems during the reclamation period, that these areas will be included in the closure monitoring program (e.g. areas where covers will not be applied to waste rock, Ocean View drainage area etc.) In order to demonstrate the existence or lack of potential problem areas, it is also recommended that any seeps from backfilled areas and covered waste rock piles identified during reclamation and/or closure be sampled and tested and that SO_4 be added to the routine analysis within the existing monitoring program as an early indicator of potential acid generating locations.

Conclusions

I trust that the information provided herein fulfills your current needs and if there are any questions or concerns regarding the discussion provided in this memo that you will not hesitate to contact me.

Sincerely,
Robertson GeoConsultants,

Ms. Shannon Shaw, M.Sc.
Geochemist/Mineralogist

References

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Yanful, E.K. and Catalan, L.J.J. (2002). Predicted and Field-Measured Resuspension of Flooded Mine Tailings. Journal of Environmental Engineering, April 2002, pp. 341-351.