October 31, 2001 EBA File: 0701-01-15302

Echo Bay Mines Ltd.
Lupin Operation
9818 Edmonton International Airport
Edmonton, Alberta
T5J 2T2

Attention: Mr. Hugh Ducasse, CMSP
Manager, Loss Control and Environmental Affairs

Dear Mr. Ducasse:

Subject: Technical Review, Abandonment and Restoration Plan, Lupin Mine, Contwoyto Lake, Nunavut

We are pleased to present three copies of the above report for your review and comment. The report presents the results of our review which were initiated in late August 2001, at your mine site, and is a the result of a team effort by representatives of EBA Engineering Consultants Ltd. of Yellowknife, NWT and Edmonton Alberta., and Robinson GeoConsultants of Vancouver, B.C.

We trust that the information meets with your requirements at this time. Please do not hesitate to contact us should there be questions or should you require additional information.

Yours truly,
EBA ENGINEERING CONSULTANTS LTD.

R. B. Murphy, M.Sc., P. Geol.
Project Director, NWT/Nunavut

RBM/…
cc: Mr. Dave Hohnstein, Echo Bay Mines Ltd.
Ms. Shannon Shaw, Robertson GeoConsultants Inc.

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TECHNICAL REVIEW
ABANDONMENT AND RESTORATION PLAN, LUPIN MINE
CONTWOYTO LAKE, NUNAVUT

Project No. 0701-01-15302

October, 2001

TECHNICAL REVIEW
ABANDONMENT AND RESTORATION PLAN
LUPIN MINE, CONTWOYTO LAKE, NUNAVUT

Prepared by:

EBA ENGINEERING CONSULTANTS LTD.
YELLOWKNIFE, NORTHWEST TERRITORIES

Submitted To:

ECHO BAY MINES LTD
EDMONTON, ALBERTA

Project No. 0701-01-15302

October, 2001

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1.0 INTRODUCTION

EBA Engineering Consultants Ltd. (EBA) was retained by Echo Bay Mines Ltd. (Echo Bay) to initiate a technical review of proposed restoration activities at the Lupin Mine site. This review is the first step in a proposed multi-phased program designed to provide a detailed evaluation of the overall reclamation approach for the mine site. This evaluation was requested to clarify the technical feasibility of the existing restoration plan for the mine site (especially within the Tailings Containment Area (TCA)) and to initiate the process of determining the potential technical viability of potential alternative methods for restoration/reclamation of the site.

Previous studies have predicted that the tailings are potentially acid generating. The current Interim Abandonment and Restoration Plan (Echo Bay, 2001c) involves consideration of two primary physical methods for the remediation and control of contaminants (i.e., dissolved metals) originating from the waste material (i.e., tailing solids) that is currently located within the confines of the TCA. These methods include:

- Flooding of the areas that are currently used for water retention and low elevation tailings deposition (maximum water level elevation of 484.5 m); and
- Mechanical covering with up to 1.75 m of esker material on top of the higher elevation cells containing tailings to promote the establishment of permafrost within the tailings or to contain the tailings and minimize oxidation to acceptable criteria.

This review was conducted on reports gathered and collected from Echo Bay files during EBA's visit to the Lupin Mine site on August 27 to 29, 2001. The reports included the results from the following:

- geotechnical design of earthfill dams and dykes;
- thermal monitoring of earthfill dams and dykes, active and inactive tailings cells, and a natural esker;
- geochemical evaluation of tailings materials, esker sand and gravel, and quarry rock;
- chemical analysis of TCA Facility discharge; and
- baseline reports describing the baseline environmental and physiographic conditions at the Lupin site prior to mine development.

Robertson GeoConsultants Inc. of Vancouver, B.C. was sub-contracted by EBA to evaluate the available information regarding the discharge water chemistry and the geochemistry of the tailings material.

2.0 REVIEW OF GEOTHERMAL DATA

2.1 General

The tailings and process waters are impounded through natural topographic relief and a series of engineered retaining structures.

The current closure concept, consisting of the frozen tailings concept, proposed by Echo Bay, may be geotechnicaly feasible provided that over the long term:

- The perimeter water retention dams will continue to contain the water in the flooded areas;
- The thickness of esker sand and gravel cover over the tailings will be sufficient to maintain the majority of the deposited tailings column in a frozen condition; and,
- The lower flooded areas will not thaw the frozen tailings in the adjacent cells.

These considerations require knowledge of the geothermal regime of the TCA, which is influenced by climatic conditions, size of the ponds, and thermal properties of the permafrost foundation, dam fill, tailings, and cover materials.

This section provides a general summary of the available information on the climate and permafrost conditions of the Lupin mine site in addition to a brief discussion on the geotechnical and thermal properties of the TCA materials.

2.2 Climate at Contwoyto Lake/Lupin Mine Site

The climate at the Lupin Mine site is subarctic and semi-arid with an average annual rainfall of 129 mm, an average annual snowfall of 118 cm and total precipitation of 247 mm (Environment Canada, 1993).

Environment Canada has monitored air temperatures in the Lupin area since 1959. The meteorological station was initially located on the west shore of an island in Contwoyto Lake and was referred to as the Contwoyto Lake station. In 1982, this station was replaced

as the monitoring site for the area with one at Lupin, which is located further north on the west side of Contwoyto Lake. The mean annual air temperature for the recorded period is -11.5^{o}C and the mean freezing index and thaw index are 4990 ^{o}C-days and 820 ^{o}C-days, respectively.

The estimated annual total precipitation for the mine site is estimated to be 247 mm. The mean annual lake evaporation at Lupin is estimated to be 275 mm.

2.3 Permafrost Conditions at Lupin Mine Site

The Lupin mine site is located in continuous permafrost and is underlain by several hundred metres of permafrost; over 500 m of frozen ground was intersected in the development of the mine shaft (Lafleche et al., 1988). The area is north of the northern limit of tree growth and is typical of barren grounds. Vegetation is sparse, consisting mainly of moss, lichens, and a few small grass patches (tundra) (Geocon, 1980b).

Mean ground temperatures are approximately -6^{o}C to -8^{o}C. The active layer thickness (maximum depth of annual thaw) at the Lupin mine varies from approximately 1.0 m in undisturbed terrain with organic cover to up to 4.0 m in exposed bedrock outcrops (Geocon, 1990).

2.4 Active And Reclaimed Tailings Cells Temperatures

Based on the review of the available geotechnical and geothermal data available from within the Echo Bay database, detailed, extensive and high quality data exists which provides a thorough history of the thermal regime of the active and inactive tailings cells.

The temperature history has shown that where reclaimed tailings were covered with varying thickness of esker sand and gravel cover (0.5 m to 1.5 m in thickness), the tailings were frozen year round, except for seasonal thaw during the summer, with the active layer ranging in depth from 1.5 m to 2.0 m. This typically penetrated 1.0 m into the underlying tailings, which has been deposited up to 10.0 m in thickness in each cell. Temperatures in the inactive tailings cells below 10 m depth ranged from -3.5^{o}C to -7.5^{o}C (Klohn-Crippen, 1997, Geocon 1990).

3.0 GEOCHEMICAL REVIEW

3.1 General

The feasibility of the current closure concept proposed by Echo Bay and any other future or alternative concept requires knowledge of the geochemical behaviour of the tailings materials and the resultant potential contaminant loading into groundwater and surface water.

This section summarizes the available information on water quality and the geochemical characteristics of materials in the TCA, including the tailings solids, and the esker cover with particular emphasis on the acid generating potential of these materials. A preliminary assessment of the acid generating potential of the tailings, particularly in relation to the currently proposed abandonment and restoration plan for the TCA, is presented.

3.2 Preliminary Assessment of ARD Potential in the Tailings (And Potential Cover Materials)

This review was undertaken to re-assess the proposed measures included for the TCA Abandonment and Restoration Plan. The assessment provided will pertain to the current and future acid generating characteristics of the tailings and related water quality impacts/risks and in particular how the predicted geochemical characteristics could be impacted by saturation, freezing or continued exposure to oxygen and water.

ARD is a result of the oxidation of sulphide minerals and the subsequent neutralization of acid produced by buffering minerals present in the tailings or alkalinity in the pore water. The sulphide minerals present in Lupin tailings include arsenopyrite (FeAsS), pyrrhotite ($Fe_{1-x}S$), pyrite (FeS_2), and chalcopyrite ($CuFeS_2$). Sulphide sulphur contents between approximately 3 and 4 percent were reported in the various documents. Given this relatively high sulphide content, and the low neutralization capacities reported (<50 kg $CaCO_3$/t equiv.), it would be expected that, given time, the majority of the tailings would become acid generating and metals likely to be a concern include As, Fe, and potentially Cu and Zn.

From a geochemical perspective, the two main questions that cannot be answered with the existing data are:

(1) Assuming a seasonally active layer in the upper tailings profile of up to 1.5m (plus 1.75m esker on top), what is the current and likely future pore water associated with the tailings in the active zone?

(2) Given this, what current and future impact does the pore water have on receiving waters (Pond 1, Pond 2 and ultimately at the discharge point)?

4.0 DISCUSSION OF RECLAMATION OPTIONS

The current closure concept -- flooding areas that are currently retaining water and placing an esker cover over the higher elevation tailings to encourage permafrost aggradation within the tailings -- are consistent with industry-accepted practice to minimize the potential for acid generation of the tailings by limiting the availability of oxygen and the sulphide oxidation rate within sulphidic mine waste (Geocon, 1993; Payant and Yanful, 1995; Dawson and Morin, 1996).

The proposed esker cover option will limit, but not entirely prevent the ingress of oxygen to the underlying potentially reactive tailings. Studies have shown that near $0^{o}C$, the chemical oxidation rate is about 15 percent of its value at $25^{o}C$ (Knapp, 1987). Laboratory studies by Meldrum et al. (2001) showed no measurable oxidation of tailings samples at temperatures of $-10^{o}C$ and a reduced but measurable oxidation at $-2^{o}C$; the latter observation was attributed to the high unfrozen water content of the tailings samples due to freezing point depression of the porewater from seawater salts and dissolved solids. Other studies on acid mine drainage in permafrost environments have also indicated that permafrost will not provide an absolute control on ARD production (Dave et al., 1996; Dawson and Morin, 1996). Furthermore, sulphide oxidation can still occur with unfrozen water at sub-zero temperatures, and the process chemicals contained in the tailings porewater can lead to high levels of unfrozen water (Dawson and Morin, 1996).

The proposed esker cover option will not entirely prevent thaw penetration into the underlying tailings. It is estimated that under the proposed 1.75 m esker cover, the active layer in the underlying tailings may be approximately 0.5 to 1.5 m thick. Alternatively, a cover of lesser thickness could be placed over the tailings material with a resultant increase in active layer. It is estimated that a cover thickness of 1.0 m would result in an active layer of approximately 2.0 to 2.5 metres thick.

The geochemical impacts of seasonal freeze-thaw cycles and of the on-going sulphide oxidation in the active layer and the resultant impact on increased metal mobility are not well known based on the existing database for the site. Any selected reclamation option

utilising an esker cover will need evaluation of these impacts on the water chemistry within the TCA and the resultant discharge chemistry into the receiving water environment prior to implementation. The current esker cover thickness of 1.75 metres was an arbitrary number based on what was estimated in order to implement total permafrost encapsulation of the tailings materials.

A tailings cover, comprised of esker borrow material of 1.0 m thickness or less may be an viable reclamation option for the Lupin Mine site, dependent upon the pore water geochemistry within the active layer of the frozen tailings and its subsequent potential impact on the receiving water environment.

Total encapsulation of the tailings material within permafrost is possible but not technically feasible for the following reasons;

- the thickness of the cover material required for total encapsulation. Geocon (1993) suggested that 3 m or greater of esker material would be required to maintain the tailings in a "permanently" frozen condition;
- this option is only feasible if the tailings are fully frozen, including those within the active tailings deposition cells. If these tailings are not fully frozen, the time required for permafrost to naturally aggrade into the tailings may negate any benefits associated with permafrost encapsulation;
- the presence of solutes may depress the freezing point of the porewater, therefore subzero temperatures may be required to ensure that the tailings are fully frozen;
- the long-term thermal regime of the permafrost encapsulated tailings may be affected by global warming.

5.0 CONCLUSIONS AND RECOMMENDATIONS

A technical review of the existing thermal and geochemical database at the Lupin Tailings Containment Area was conducted based on reports gathered and collected from Echo Bay Mines. Based on a review of the available reports, there is sufficient existing information with regards to the thermal regime of the TCA, in addition to the geochemical characterization of the Lupin tailings, to conclude that;

- There is an excellent database of geotechnical and geochemical information at the Lupin Mine site to allow a thorough review of the existing proposed reclamation option;

- The reclaimed tailings areas are frozen the majority of the year with a thin active layer ranging from 1.5 to 2.0 metres with cover thicknesses ranging from 0.5 to 1.5 metres;
- A cover of esker borrow material assists in limiting, but not preventing, the ingress of oxygen to the underlying potentially reactive tailings material;
- The cover concept assists with maintaining the tailings in a frozen condition within the reclaimed tailings deposition cells (Cells 1 and 2);
- The current reclamation option of 1.75 provides insufficient cover material to fully encapsulate the tailings material within permafrost;
- Total encapsulation of the tailings material with-in permafrost may not be technically feasible;
- Covers of 1.0 m or less thickness may be a viable reclamation option dependent upon the geochemical characteristics of the porewater within the active layer in the tailings;
- There are gaps in the data set that need to be addressed before a final reclamation and closure plan can be determined.

The data gaps have been identified and are summarized below.

- The current geochemical characteristics of the tailings (and predictions of the future characteristics) should be completed;
- The water quality of the current and likely future pore water should be characterized;
- The buffering capacity of pond waters to handle the seepage of potentially acidic waters from adjacent tailings cells should be evaluated.

It is proposed that the next phase of studies focus on collecting information that would help evaluate the feasibility of the current proposed closure plan.

A geochemical field study is recommended in Cells 1, 2 and 5. This would provide data to show whether or not the esker-covered tailings, given time, generate acid. The data will be used in geochemical modelling to determine whether or not Ponds 1 and 2 have the buffering capacity to handle seepage of acidic (or buffered, arsenic-rich) waters from the higher elevation tailings.

With the results of the geochemical data, a water/load balance and sensitivity analyses of the TCA could be completed. The sensitivity analyses will consider the geochemical loads from various active layer thicknesses within the tailings cells. If the ultimate discharge point from the TCA could still meet discharge water qualities, then no additional closure measures are required.

6.0 CLOSURE

We trust that the preceding report meets with your requirements at this time. Should there be any questions, please do not hesitate to contact us.

Yours truly,
EBA Engineering Consultants Ltd.,

R. Brent Murphy, P. Geol.
Senior Environmental Geologist, Arctic Division

RBM/…

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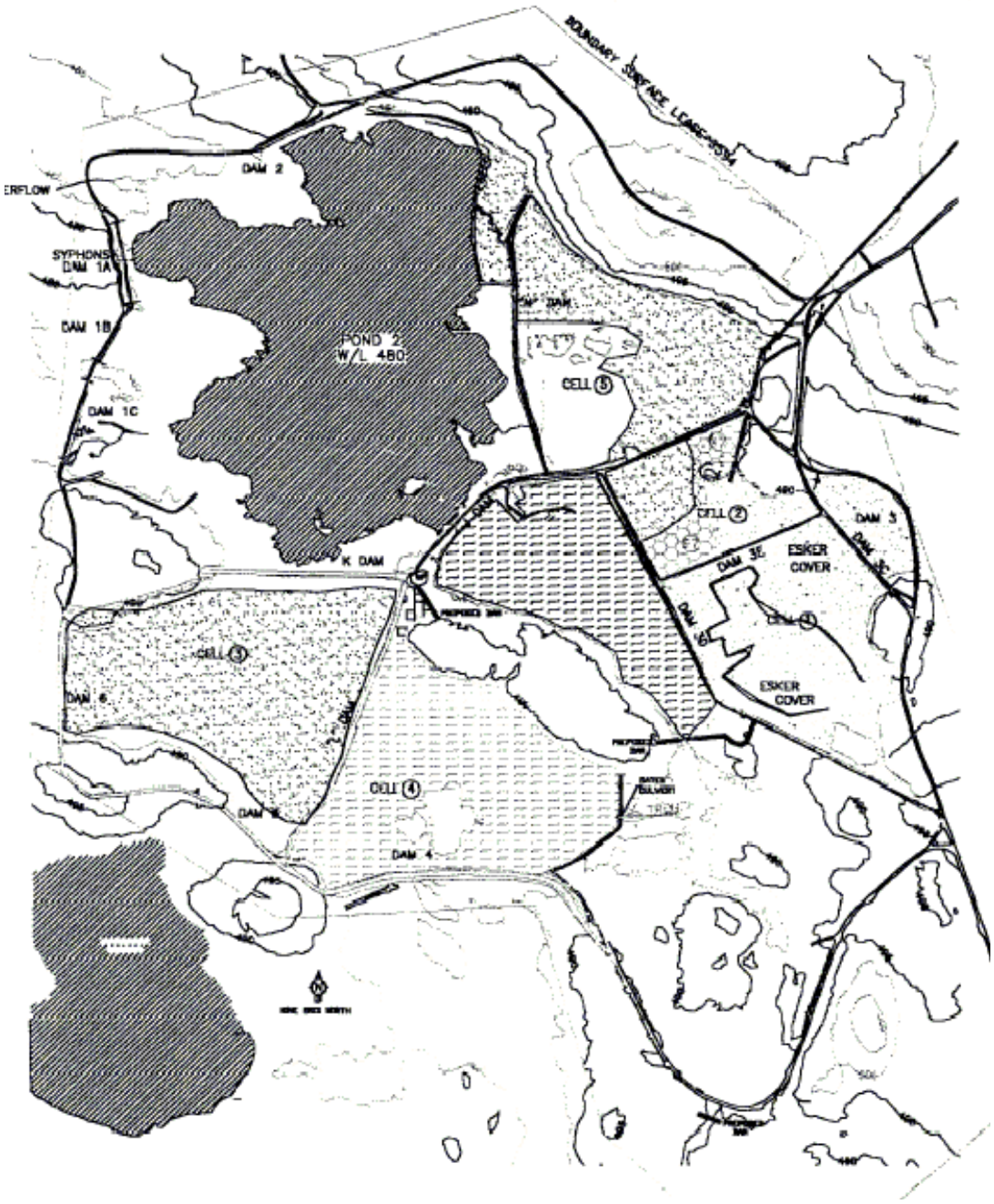

Figure 1 Lupin Mine Tailings Containment Area - 2001