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5 September 2000

Mr. Louie Azzolini
Environmental Assessment Officer
Mackenzie Valley Environmental Impact Review Board
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Re: Technical Comments on BHP's Environmental Assessment (EA) Report for the Sable, Pigeon and Beartooth Kimberlite Pipes – Northwest Territories

As requested, Natural Resources Canada (NRCan) has reviewed BHP's Environmental Assessment Report of the Sable, Pigeon and Beartooth Kimberlite Pipes. Our reviews have concentrated on those aspects of the EA relevant to the following disciplines: groundwater quality, seismicity, permafrost, geomorphology and surficial materials, acid mine drainage and treatment, and explosives. A discussion of our specific findings may be found in the Attachment to this letter.

Our overall opinion of the document is that it is well organized and comprehensive. Concerns are focused primarily on groundwater quality in the pits and the seismicity parameters used in modeling. Although the project is in a region of very low seismicity, it is recommended that the developer use an updated model for designing containment structures.

In addition to our specific technical review comments, we have included a response to the Board's Information Request (IR) of July 20, 2000 on "Assessment Methodology". There is also a discussion regarding BHP's response (ref. July 24, 2000 letter from L. Azzolini to Tina Markovic) to the Department's June 30, 2000 IRs on water quality and subaqueous disposal of tailings and waste rock.

If you have any questions, please contact me at (613) 947- 1591.

Yours truly,

Rennie Tupper

for John Ramsey
Senior EA Officer
Office of Environmental Affairs
Natural Resources Canada

Canada

CANADA REMEMBERS
LE CANADA SE SOUVIENT

cc: P. Henderson
C. Hogan
J. Kasemets
N. Leanage
M. Bourgon

ATTACHMENT

Natural Resources Canada's comments are based on a review of the following documents:

1) Environmental Assessment Report for Sable, Pigeon and Beartooth Kimberlite Pipes (BHP, July 2000); and

2) Preliminary Design of Water Control Structures for Sable, Pigeon and Beartooth Pit Developments (EBA Engineering Consultants, April 2000).

Note: Unless otherwise indicated, comments are based on a review of the first document

A. Water Quality (Groundwater)

Section 2.2.3 Scope of Development: Waste

Kimberlite contains a certain amount of apatite which, under certain conditions, can be a source of phosphorus. In this section, the proponent should discuss the possibility of phosphorus being leached from processed kimberlite, processed coarse ore, or in-situ from pit walls. The issue of phosphorus derived from kimberlite was discussed in the Diavik EA report and should be discussed here also. It is relevant to the management of processed kimberlite, pit discharge waters, and the chemistry of groundwaters.

Section 4.4.1.2 Environmental Effects Assessment: Groundwater

It is unclear from the EA report whether a talik currently exists beneath Sable Lake. However, because of the depth of the Sable pit, a talik will certainly be created once it is flooded. Therefore, the flooded Sable pit will become part of the deep regional groundwater flow regime, possibly altering it significantly. The proponent's claims (page 4-46; section 4.4.1.2.4) that effects on the groundwater flow regime will be negligible and reversible (last paragraph) are puzzling if a talik is created where none existed before.

While such effects would not necessarily be negative, they should be documented and quantified (in terms of steady-state groundwater inflow or outflow rates from the pit lake) using results from the modeling study. The consequences of significant groundwater inflow to the lake on lake water chemistry should also be discussed. A similar study was presented in the Diavik EA report.

Section 4.5 Environmental Effects Assessment : Water

In subsection 4.5.1.2 : Pit Water Discharge (EAR page 4-71) and in later subsections for individual pits, there is no discussion of the possibility that discharge waters may contain phosphorus derived from kimberlite in the pit walls. This should be addressed.

B. Seismic Hazard

General

1) The project is in a region of very low seismicity.

2) The chief risk from the seismic viewpoint is a catastrophic failure of the water-retaining structures ("dams" henceforth) around the Beartooth and Panda pipes to be mined as open pits. These dams will hold back small lakes from flooding the 135-155 m deep pits. While a seepage failure would probably cause a slow failure of one part of the dams, permitting a rapid (but not catastrophic) filling of the open pit, earthquake failure would affect the entire length of every dam at the same time, with the risk of multiple failures.

Section 4.4.2.3 Environmental Effects Assessment: Earthquake Hazard

The probabilistic design levels proposed are very low (less than 2% g and 0.05 m/s for the 1/1000 year event from Table 4.4-3), suggesting a very low level hazard. The stresses on the dams due to blasting probably come closer to causing a risk of failure, but they are not explicitly compared with the earthquake motions. In any event, the shaking from earthquakes is likely to have longer periods and longer durations than the shock from a blast, so the effects may be qualitatively different.

The seismic hazard calculations (Table 4.4-3) from PGC are those that the GSC calculates as being equivalent to the 1995 (and 1985) National Building Code of Canada and are based on GSC's 1982 seismic source zones. As such they are more useful for screening projects like Ekati than for design. A specific point is that the seismic sources used in 1982 totally neglect all earthquakes within about 400 km of the Ekati site, and so the seismic hazard is computed only from distant sources in Boothia-Ungava and the Nahanni and Mackenzie mountains. Furthermore, the Nahanni earthquakes - earthquakes far larger than any considered by the 1982 model that are relevant to the site - were not included since they happened after the calculations were finalized.

The dam design is intended to follow the Canadian Dam Safety Guidelines. Those guidelines specify an evaluation for the "high consequence" category adopted using a low annual exceedence probability 1/1000 p.a. or lower. The consultants use the GSC's 0.001 p.a. hazard computations for the 1995 National Building Code (rather inappropriate, see below) to conclude that the overall effect is negligible.

Our 1995 "4th generation" seismic hazard model (details available on the WWW at www.seismo.nrcan.gc.ca) has two probabilistic models that include the consequences of the Nahanni earthquakes and updates other parameters in the hazard model. We ran a computation for the site at the 0.0001 p.a. probability level and found the hazard from this part of the model to be negligible.

The remainder of the model includes a background event for the shield, as discussed below.

As said above, both the 1982 and 1995 seismic hazard models neglect all seismicity near Lac de Gras. A better representation of seismic hazard at the site, more in keeping with the Canadian Dam Safety Guidelines, is to consider instead the occurrence of large earthquakes in the Canadian Shield as a whole, or in worldwide shields of similar age. We have been involved in such an analysis for a nuclear fuel waste repository, and reached the following conclusions:

- The maximum earthquake credible would have magnitude 6 3/4.
- Current knowledge does not permit the screening out of shield areas that could have earthquakes of this size, so they should be considered as low probability events anywhere on the Canadian Shield.
- A reasonable design earthquake for the shield would be magnitude 6.0.
- The rate of magnitude 6.0 or greater is estimated to be 0.004 p.a. per 1,000,000 square kilometres (Adams and Fenton, abstract for Geol. Soc. Am. 1996 Annual Meeting).

For the probability level of 0.001 p.a., the earthquake could be expected to occur within an area of 250,000 km*km, equivalent to a circle of radius 280 km about the site. For the probability level of 0.0001 p.a., the earthquake could be expected to occur within an area of 25,000 km*km, equivalent to a circle of radius 90 km about the site. Thus by this analysis, the design should cope with a magnitude 6 earthquake at a distance of 280 km (estimated Peak Ground Acceleration of about 1% g and PGV of 0.01 m/s) or possibly 90 km (Peak Ground Acceleration of about 5% g and PGV of 0.004 m/s) depending on assessed "consequences". For comparison, we compute the largest Nahanni earthquake (M6.9 at about 600 km distance) might have produced a little less than 0.3% g.

I conclude that satisfying CDA guidelines would include checking the design against the hazard from these rare large shield earthquakes which may occur close to the site.

Note: the aforementioned comments on earthquake effects were generated in conjunction with a review of Section 5.0 Final Design, of the report entitled: Preliminary Design of Water Control Structures for Sable, Pigeon and Beartooth Pit developments, EBA Engineering Consultants Ltd., April 2000.

C. Geomorphology and Surficial Materials

Section 3.2.1 Description of Existing Environment: Regional Terrain Conditions

The Dredge *et al.* (1994)'s GSC reference is incomplete (page R-8) and outdated, but remains essentially correct. Newer GSC A-series maps and reports exist.

The Ward (1992) reference is incorrect: scale of mapping was 1: 125,000 not 1:25,000

Typographical errors exist with respect to Dyke and Dredge (1989) reference.

Section 3.2.2.2 Description of Existing Environment: Glaciofluvial Deposits

Although it is stated in the report that "good drainage limits annual ground ice-formation", considerable amounts of buried ice may exist in some of these deposits. However, this is noted in section 3.2.3.2 (Local Permafrost).

The description of Surficial Materials in section 3.2.2 does not correspond exactly to the description of surfical deposits listed in Table 3.2-1.

D. Permafrost

No concerns were raised regarding the understanding of the distribution of permafrost or the implications of permafrost for safeguarding the environment or safely carrying out the proposed operation.

E. Waste Rock, Mitigation Strategies for Acid Generation and Pits

Acid Generation/Metal Leaching Studies

Prediction studies of the waste rock and processed kimberlite should be performed to determine the acid generating/metal leaching potential. Static tests were performed by the proponent to address this issue. Acid Base Accounting (ABA) analysis, using a modified Sobek method, and paste pH were determined for a number of samples taken from waste rock and processed kimberlite.

Sulphide sulphur was used in the calculation for AP, which is the recommended procedure (method used is not referenced so unable to comment in detail). The amount of sulphur capable of generating acid is very low for the majority of waste rock samples taken, <0.01, and would be considered as non-acid generating. However, some samples had a sulphide sulphur content between 0.1 – 0.3%, with corresponding NP/AP ratios between 0 and 3.0. Although these values indicate acid-consuming material, it may be advisable to conduct kinetic test on samples with a relatively high sulphide sulphur content (>0.1%) in combination with a high metal content ($\geq$1000 ppm Ni and/or $\geq$300 ppm Zn). This combination is indicative of nickel sulphides and/or zinc sulphides.

These tests should be conducted, regardless of NP/AP, to evaluate potential metal leachings as Ni and Zn will remain largely mobile in near-neutral environment once they are released into solution. Only low concentration of other metals, such as Pb, As, Cu, Cd, are present in the rock and, as such, are unlikely to be problematic. Quantification of the rock types and kimberlite ore with high metal content (Zn and/or Ni) in combination with high sulphide sulphur is

recommended to determine amount of potential metal leaching material. The proponent plans to carry out kinetic tests – but did not provide specific information on the intended methodologies or geochemical characterization.

Plan for Waste Rock Runoff Management and Processed Kimberlite Disposal

Waste disposal plans should be based on the results of the kinetic studies. Material that has potential for metal leaching should be identified and specially handled for disposal.

The proponent plans to characterize the waste rock from all three pits (Pigeon, Sable and Beartooth) and specially handle any material that has ARD/metal leaching potential. BHP intends to place PAG (potentially ARD generating) material (if any) in the centre of the waste rock storage pile. The intent is to form a permafrost core so that any acidic drainage/metal leaching that occurs will be trapped in the voids of the pile and be permanently frozen. This technology has been established, however, periodic monitoring of the pile is recommended to ensure that runoff is minimized and meets Water Licence requirements.

NP/AP ratios for the kimberlite samples indicate the majority of the material is highly acid-consuming. Overall, the potential for ARD is low. Disposal of non-PAG processed kimberlite in the Long Lake containment facility, or in Beartooth pit, when exhausted, is suitable. However, if large volumes of kimberlite ore with metal leaching potential are found (via kinetic testing) alternate methods for disposal of the processed kimberlite should be used to prevent metal leaching.

Mitigation Strategies for Pits

The issue of acid generation from diabase and schist left on the pit walls for Sable and Pigeon pits is discussed in the October, 1999 Project Description. The proponent proposes: geochemical characterization to define the magnitude of the problem; and finalization of pit design and determination of rock types in final walls. Good information on the metal content, as determined by ICP, and rock types for the pits is given in the EA. Further information on the quantity of each type of waste rock should be provided to determine the amount of PAG material – which the proponent intends to do. However, since flooding of the open pits will proceed over 10 – 20 years after closure, BHP should address the issue of long-term monitoring to ensure water quality is maintained.

F. Explosives

It is the departments understanding that there will be no requirement for an explosives factor licence. The proponent has indicated that they plan to use packaged explosives stored in magazines licenced by the Territory. Therefore there is no *Explosives Act* trigger under Section 5 (1)(d) of the *CEAA*.

G. Comments on BHP's Responses to NRCan's Information Requests of June 30, 2000

G.1 Three requests for further information on "Water Quality" were submitted:

Terms of Reference Line #s 181, 400-401 Request: Please indicate (and provide supportive documentation) whether groundwater inflows are likely to affect water quality in pits once they are reclaimed? Some indication of pit discharge water quality based on mining experience thus far would be useful.

In response to this request, BHP supplied a table describing the quality of seepage water from the sump in Panda Pit. This information was requested because there was no detailed indication of anticipated water quality for seepage into the pits of the proposed expansion.

Although the Panda Pit has not progressed to the base of permafrost, total dissolved solids (TDS) have reached 1780 mg/L according to the Jan. 31, 2000 analysis. It is known that deeper groundwater in the Canadian Shield can be much higher in TDS than this most recent finding, however, there is no indication in the Environmental Assessment Report of the water quality to be expected in the proposed pits once the base of permafrost is reached in the Sable Pit. The progression of TDS given in the sump water quality table for Panda Pit suggests that TDS will continue to increase as the mine deepens. It seems possible that groundwater encountered beneath permafrost could have TDS much higher than the highest level reported in the table. As Sable Pit is expected to reach a depth below permafrost, pit seepage water similarly high in TDS can also be expected.

If seepage waters high in TDS are encountered, this reviewer is concerned about the disposal of such water should TDS continue to increase. It is understood that seepage waters will be used for mining purposes within the pits but that any excess will be transported to adjacent disposal facilities. In describing the operation of these facilities, it is stated that poor quality water will be dealt with by retention and filtration (Section 4.5.1.2 - Pit Water drainage). However, this treatment is with respect to suspended solids. Is poor quality water on the basis of dissolved solids expected in any disposal facilities and if so how will it be treated before release?

Terms of Reference line #s 177, 331-334, 348-349 Preamble: With reference to Terms of Reference Line #s .....there is no mention of freeze-back performance of the Long Lake Containment Facility.

Request: Please indicate (and provide supportive documentation) whether this is progressing as expected? Please provide any data on pore water quality in the tailings deposited in the facility to date; and please indicate (and provide supportive documentation) whether there is any likelihood of expulsion of residual pore water during freeze-back.

BHP responded that a university-operated research program to assess the performance of the Long Lake Facility is underway. This is regarded as a satisfactory answer to these questions.

Terms of Reference line # 355 Request: Please indicate whether any monitoring of waste rock runoff water quality has been carried out. If "Yes", please provide details. If "No", please specify if you intend to monitor runoff water quality as mining.

BHP responded that slightly acid seepage from waste rock areas has been detected and that further studies are underway to better define the origin of this acidity. This is considered to be a satisfactory answer.

G.2 A request for information on subaqueous disposal of tailings and waste rock was submitted.

Terms of Reference line #s 353-354 - X and 390-391 - X Request: Please provide the chapter/section or appendix that covers alternate disposal options for kimberlite tailings and waste rock in: BHP Diamonds, Inc., 1995. NWT Diamonds Project EIS.

BHP responded by indicating where the appropriate references could be found. The issue of subaqueous disposal of tailings and waste rock has been dealt with satisfactorily by the proponent.

H. The Mackenzie Valley Environmental Impact Review Board's Information Request of July 20, 2000

Preamble: The Mackenzie Valley Environmental Impact Review Board is considering the adequacy of BHP's assessment methodology and the conclusions reached regarding the effects of the proposed development on the physical, biological, social, cultural and economic environment.

Request: Please provide for those areas where expertise is provided:
(a) General comment and advise regarding the assessment methodology reported.

(b) Specific comments and advise regarding the appropriateness of the spatial and temporal boundaries.

(c) Specific comments and advise regarding the methods and criteria used to determine significance.

Response:
(a) With reference to Section 4.2.1 Assessment Methodology, the changes to the valued ecosystem components (VEC) associated with the biophysical environment are reasonable.

(b) With reference to Section 4.2.1.3 Spatial Boundaries, the redefinition of spatial boundaries for groundwater, permafrost and the physical/terrestrial environment is reasonable. Table 4.2-2 is presumably designed to summarize the significance of any residual effects on these three

VEC's by developmental activity. It is unclear, however, and the associated explanation provided in sections 4.2.2.2, 4.2.2.3, 4.2.2.4 does not help. Should these three components be grouped together in this table? Why do the potential effects increase with geographic area? How is developmental activity related to the temporal parameters given?

(c) Table 4.4-4 provides a good summary. It separates the VEC's and assesses the effects for each type of development. It is a reasonable assessment.