DE BEERS
CANADA
GAHCHO KUÉ PROJECT

April 6, 2012 File: S110-01-08

Chuck Hubert
Environmental Assessment Officer
Mackenzie Valley Environmental Impact Review Board
P.O. Box 938
Yellowknife NT X1A 2N7

Dear Mr. Hubert:

Aboriginal Affairs & Northern Development Canada - Information Request Responses - Gahcho Kue Project Environmental Impact Review

De Beers is pleased to provide the Mackenzie Valley Environmental Impact Review Board with responses to Information Requests submitted by Aboriginal Affairs and Northern Development Canada.

Sincerely,

Veronica Chisholm

Veronica Chisholm
Permitting Manager

Attachment
c: T. Joudrie, Director, Renewable Resources & Environment, NT Region, AANDC

A DIVISION OF DE BEERS CANADA INC.
SUITE 300, 5102 – 50th AVENUE, YELLOWKNIFE, NT X1A 3S8
TEL: 1 (867) 766-7350 FAX: 1 (867) 766-7351
www.debeerscanada.com

Information Request Number: AANDC_1

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: Water Quality Objectives for Kennady Lake and the Downstream Receiving Environment

EIS Section: Section 8: KLOI Water Quality and Fish in Kennady Lake; Section 9: KLOI Downstream Water Effects

Preamble:

Water Quality Objectives (WQOs) are determined to ensure that the aquatic environment will not be significantly impacted by the project (terms used to describe WQOs in other Northern projects include EA Threshold and Water Quality Benchmarks).

AANDC notes that if the project impairs water quality to a point that it exceeds WQOs, the project is considered to have the potential to cause significant long-term impacts to the environment.

WQOs can be established based on local environmental sensitivities, generic water quality guidelines and background conditions. AANDC notes that DeBeers Canada Inc. (DCI) has compared water quality in Kennady Lake and the downstream environment to baseline conditions, water quality guidelines (CCME Water Quality Guidelines for the Protection of Aquatic Life) and Chronic Effects Benchmarks in Section 8.4.

The Gahcho Kue project is unique as it utilizes an existing waterbody (Kennady Lake) as a Water Management Pond and it requires that the waterbody be reopened at the end of operations. Consequently, the conditions within the Water Management Pond during operation are key to having the pond reopened at the end of mine.

The EIS document outlines changes/impacts from the project on Kennady Lake and the downstream receiving environment including: a change in trophic status within Kennady Lake, temporary or long term increases in metal and ion parameters in Kennady Lake and the downstream receiving environment, changes in species distributions within Kennady Lake and the downstream receiving environment. DCI concludes that the predicted effects are not significant and/or mitigable.

Request

1. Please propose water quality objectives for Kennady Lake during operations and post-closure.
2. Please propose water quality objectives for the downstream receiving environment (e.g. N11) during operations and post-closure.
3. Relate the proposed post-closure Kennady Lake objectives and downstream water quality objectives to long-term chronic toxicity benchmarks to support acceptability.

Response

De Beers would like to clarify with the comment in the preamble that exceedance of WQOs indicates the potential to cause significant long-term impacts to the environment. Assuming that WQOs represent generally applicable water quality guidelines, such as the CCME water quality guidelines (CCME 1999), the approach to developing guidelines and the intent of the guidelines must be considered when evaluating the implications of exceedances. CCME water quality guidelines are intended to protect all forms of aquatic life, including the most sensitive life stage of the most sensitive species, over the long term. Guidelines are based on the Lowest Observed Effects Level for the most sensitive life stage of the most sensitive organism, usually based on a chronic endpoint. In addition, a safety factor (typically 0.1) is applied to derive the guideline to account for uncertainty. Concentrations above guidelines are commonly observed in natural waters without adverse effects on aquatic life, and are thus not interpreted as causing significant effects on aquatic live. The length of the period with effects on aquatic life depends on the length of the exposure and the subsequent recovery period; an exceedance of a guideline by itself cannot provide an indication of the temporal characteristics of an effect.

The development of water quality objectives for the Project was not a requirement of the Terms of Reference (Gahcho Kué Panel 2007), and is typically addressed as part of the Water License Application and Approval Process. However, De Beers acknowledges the importance and benefit of setting water quality benchmarks, which will be used for the effects level evaluation for the receiving aquatic environment. There is also added benefit to undergo this process early in the Project review phase, and De Beers is currently developing these benchmarks for Kennady Lake (closure and post-closure) and downstream lakes (e.g., Lake N11). .

De Beers is currently developing a Environmental Monitoring Framework for the Project, which will include the Aquatic Effects Monitoring Plan (AEMP). The framework provides a conceptual structure for site-specific monitoring and mitigation plans, and the approach and criteria for monitoring the aquatic disciplines, including hydrology, water quality, lower trophic organisms (e.g., plankton). The initial phase of the Framework is to provide the basis for De Beers to engage and elicit feedback from government and communities, which will be an important element of completing the Framework, and developing the AEMP during the licensing phase of the Project.

References

CCME (Canadian Council of Ministers of the Environment). 1999 with updates to 2012. Canadian Environmental Quality Guidelines. Winnipeg, MB.

Gahcho Kué Panel. 2007. Terms of Reference for the Gahcho Kué Environmental Impact Statement. Mackenzie Valley Environmental Impact Review Board. Yellowknife, N.W.T.

GAHCHO KUÉ PROJECT ENVIRONMENTAL IMPACT STATEMENT
INFORMATION REQUEST RESPONSES

Information Request Number: AANDC_2

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: Acceptable Levels of Change for Kennady Lake and the Downstream Receiving Environment

EIS Section: Section 8: KLOI Water Quality and Fish in Kennady Lake; Section 9: KLOI Downstream Water Effects

Preamble:

Sections 8 and 9 of the EIR predict a range of effects from the project. DCI concludes that the predicted effects are not significant and/or mitigable.

AANDC recognizes that the EA prediction and effects/impacts discussed in the EIR are predictions. Once the project is in operation, the extent of the effects may be greater or less than predicted. Understanding the level of change in the receiving environment that would be considered unacceptable is valuable when assessing potential impacts from a project, given that there is always a level of uncertainty inherent in EA predictions and effects assessments. Furthermore, understanding the acceptable/unacceptable level of change directly contributes to the development of; i) an appropriate and focused Aquatic Effects Monitoring Plan; ii) appropriate Effects Levels that 'trigger' Adaptive Management; and, iii) appropriate management response actions within an Adaptive Management Plan.

These plans rely on outcomes of the EA even though they are ultimately required of the project in the regulatory phase. As such, the EA and regulatory phase of the process are directly linked. Consequently, an incomplete EA can lead to complications in the regulatory process during initial water licence issuance, as well as, during operations and closure (i.e. unanticipated changes to the project, mining conditions or effluent quality).

Request

1. Please describe levels of change (Early Warning Low, Moderate and High) within the aquatic receiving environment that would be considered unacceptable/significantly adverse (e.g. water quality, sediment, benthic and aquatic community, fish, etc.).

2. Describe how these Effect Levels would 'trigger' adaptive management for the project.

Response

Consistent with the response provided to AANDC IR #1, De Beers acknowledges the importance and benefit of setting water quality benchmarks, which will be used for the effects level evaluation in the receiving aquatic environment and to develop adaptive management and mitigation plans. There is also added benefit to undergo this process early in the Project review phase, and De Beers is currently developing these benchmarks for Kennady Lake (closure and post-closure) and downstream lakes (operations, closure and post-closure). It is planned that an initial iteration of the proposed benchmarks and rationale will be prepared as part of the Project Monitoring and Adaptive Management Framework for the Project that is being developed and which will form the basis for detailed consultation with government agencies and communities.

GAHCHO KUÉ PROJECT ENVIRONMENTAL IMPACT STATEMENT
INFORMATION REQUEST RESPONSES

Information Request Number: AANDC_3

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: Aquatic Effects Monitoring Plan, Adaptive Management Plan

EIS Section: Section 8: KLOI Water Quality and Fish in Kennady Lake; Section 9: KLOI Downstream Water Effects; Section 10: KLOI: Long-term Biophysical Effects, Closure and Reclamation; Terms of Reference

Preamble:

Section 3.2.7 of the ToR for the EIS requires that the:

> "EIS must include a description of any follow up programs, contingency plans, or adaptive management programs the developer proposes to employ before, during, and after the proposed development, for the purpose of recognizing and managing unpredicted problems."

DCI requested clarification on the intent of this requirement to the MVEIRB, and the MVEIRB responded in a January 24, 2008 letter that

> "The intention of this section in the ToR was 1) to ensure that impact prediction and mitigation is undertaken in an adaptive management context and 2) that a comprehensive description of the monitoring process be provided with emphasis on follow up programs. These programs will assist in future critical evaluation of both specific and cumulative impact predictions made for Gahcho Kue Project."

The MVEIRB recognized that comments from the regulators, once the EIS was reviewed, would be used to refine the content of the EIS with respect to monitoring programs.

AANDC has developed the "Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories, 2009" which outline the requirements for an Aquatic Effects Monitoring Program (AEMP). AEMP design should be initiated during the Environmental Impact Review of a project.

Section 10.10 of the EIS briefly describes follow-up monitoring that will be conducted, but little detail is provided.

Request

1. Please provide a draft AEMP Framework.
2. Please include consideration of Adaptive Management in the AEMP, with reference to levels of acceptable change per AANDC IR #2.

Response

De Beers is developing a conceptual AEMP as a component of a Monitoring and Adaptive Management Framework for the Gahcho Kué Project, which will include the conceptual structure and approach of site-specific monitoring and mitigation plans associated with aquatics effects monitoring. A key objective of the Framework is to provide a basis for De Beers to engage and elicit feedback from government and communities, which will be an important element of completing the Framework, and developing the associated AEMP during the licensing phase of the Project.

De Beers is aware of the "*Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories*, 2009" (INAC 2009) as mentioned by the author in the preamble, and these guidelines will be referenced in the development of the Project`s AEMP.

Reference

INAC (Indian and Northern Affairs). 2009. Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories. Recommended Procedures for Developing Detailed Designs for Aquatic Effects Monitoring Programs. AEMP Technical Guidance Document, Volume 4. June 2009 Version

Information Request Number: AANDC_4

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: Water Quality

EIS Section: EIS and Conformity Responses

Terms of Reference Section:

Preamble:

The water quality of the area in both the short and long term is an important part of understanding the effect of the project. In addition to the current and predicted water quality, mitigation strategies need to anticipate a range of assumptions and predictions.

Request

1. What is the capacity of the partially dewatered Kennedy Lake?
2. What is the anticipated short and long term water quality of PK, Areas 2, WMP, off of the rock piles and Hearne Pit. How were the effect levels determined? What are the parameters of concern?
3. The western edge of the coarse PK waste rock pile will likely be in contact with water. This will prevent ARD if the material is underwater but what is preventing ML? What are the effects in association with annual fluctuating water levels -"rinsing".
4. What is the water quality of the water above the PK in the Hearne Pit? What is the water quality of the Tuzo Pit? What is the expected schedule of water quality over the life of the mine and variations seasonally, how will DCI deal with it over the mine life and into the closure period?
5. What are the plans if the groundwater conditions and water quality conditions are not favourable for discharge?
6. What is the anticipated water treatment option for the water that does not meet objectives for TSS and TDS?
7. For Dyke A, how will the water in this area be handled if it does not meet discharge criteria to allow dyke to be breached?

8. What is the anticipated effect of the phosphorous (groundwater) on the environment?

Response

1. What is the capacity of the partially dewatered Kennedy Lake?

De Beers understands this information request relates to the volume of the partially dewatered Kennady Lake and not the storage capacity. To access the open pits, water will be pumped from Areas 3 and 5 and 7 to Lake N11 and Area 8, respectively. The Project water balance (EBA 2011) indicates partial dewatering of Areas 3 and 5 will occur during two years of construction and during three years of operation. Water will only be pumped from Area 7 to Area 8 during the first year of construction, while water meets discharge criteria, and subsequently to Lake N11 from Area 3 and 5. At the start of the no discharge period (i.e. once partial dewatering of Kennady Lake is completed), Area 6 will be completely drawn down to the lakebed elevation to provide access to the 5034 pit. The water level will be drawn down to the maximum extent possible, e.g., Area 2 will be drawn down approximately two metres, three metres in Areas 3 and 5 and Area 4, and six metres in Area 7, retaining a cumulative volume of approximately 13.8 Mm^3 in the partially dewatered Kennady Lake. The initial volume of Kennady Lake is approximately 35 Mm^3 (EBA 2011).

2. What is the anticipated short and long term water quality of PK, Areas 2, WMP, off of the rock piles and Hearne Pit. How were the effect levels determined? What are the parameters of concern?

In the 2011 EIS Update (De Beers 2011), the water chemistry of runoff and seepage from the processed kimberlite (PK) and mine rock storage facilities was based on a source term water chemistry assigned to drainage from these materials and scaled to the field condition by prorating the unit mass/volume of water to the simulated drainage volumes (EBA 2011). These source terms were updated in the 2012 EIS Supplement (De Beers 2012) based on ongoing and supplemental geochemical testing. A description of the most recent selected source term water chemistry for coarse and fine PK and mine rock is provided in the modelling report provided in Appendix 8.II of the 2012 EIS Supplement (De Beers 2012).

The simulated water quality in Area 2, the water management pond, and the Hearne pit will be variable and a function of the various source waters reporting to each area. To illustrate this, simulated TDS concentrations in each of these areas is provided in Figure AANDC_4-1. Simulated concentrations of other specific parameters can be made available to AANDC upon request. It is important to note that hydrodynamic modelling of the Hearne Pit for the 2012 EIS Supplement indicates meromixis will occur in the pit. As such, the concentrations provided in Figure AANDC_4-1 represent the water quality below the pycnocline (or chemocline). This water is isolated and does not mix with the overlying Kennady Lake in the water quality assessment. The water above the pycnocline is assumed to be fully mixed in Area 6 of Kennady Lake. The simulated TDS concentrations for this area are also provided in Figure AANDC_4-1. Additional details related to the hydrodynamic modelling are provided in Section 8 of the 2012 EIS Supplement (De Beers 2012).

In the 2012 EIS Supplement (De Beers 2012), effects to aquatic health from changes to water quality were evaluated by comparing simulated results to aquatic species Chronic Effects Benchmarks (CEB) once Kennady Lake has been refilled and reconnection to Area 8 has been established. Based on comparisons to baseline concentrations and federal water quality guidelines for the protection of aquatic life, 12 substances of potential concern (SOPCs) were selected to further evaluate the potential for aquatic health effects due to direct waterborne exposure. Maximum water concentrations of total antimony, barium, beryllium, cadmium, chromium, cobalt, manganese, strontium, vanadium, fluoride, and total dissolved solids are predicted to remain below the CEB identified for each substance. Thus, the predicted increases in the concentrations of these 11 SOPCs are expected to have a negligible effect on aquatic health in Kennady Lake under closure and post-closure conditions. The maximum concentration of total copper is projected to be above respective CEBs at one or more points during closure and post-closure. However, based on a review of the CEBs and the concentrations predicted, the potential for adverse effects to aquatic organisms in Kennady Lake from copper is considered to be low, and residual effects to aquatic communities are expected to be negligible; follow-up monitoring will be undertaken to confirm this evaluation.

Predicted metal concentrations in fish tissue are predicted to be above tissue-based toxicological benchmarks for aluminum, nickel, and silver under closure conditions, and silver under post-closure conditions in Kennady Lake. However, based on a review of the benchmarks and the concentrations predicted, the potential for adverse effects to fish tissue quality is predicted to be low; follow-up monitoring will be undertaken to confirm this evaluation. Details of this assessment are provided in Section 8 (Kennady Lake and Area 8) of the 2012 EIS Supplement. Derivation of the CEBs is provided in Appendix 8.VI of the 2012 EIS Supplement (De Beers 2012).

In the 2011 EIS Update (De Beers 2011), total phosphorus (TP) was predicted to increase in Kennady Lake during the post-closure period to a long-term maximum steady state concentration of 0.018 mg/L, which would change the lake trophic status to mesotrophic. It was identified during a detailed review of the geochemical source terms that the saturated fine PK was the main contributor of phosphorus loadings to Kennady Lake during the post-closure period. To mitigate these loadings to Kennady Lake, De Beers updated the mine plan to reduce the footprint of the Fine PKC Facility and use the 5034 and Hearne pits to store additional fine PK. An evaluation of the water quality in Kennady Lake for this supplemental mitigation, incorporating the most recent results from ongoing and supplemental geochemical testing, indicates TP levels to be less than presented in the 2011 EIS Update following refilling of Kennady Lake (long-term maximum steady state concentration of 0.009 mg/L, with the lake remaining oligotrophic). Details of this assessment are provided in the 2012 EIS Supplement (De Beers 2012).

3. The western edge of the coarse PK waste rock pile will likely be in contact with water. This will prevent ARD if the material is underwater but what is preventing ML? What are the effects in association with annual fluctuating water levels -“rinsing”.

A component of coarse PK is expected to be submerged in Kennady Lake along the western edge of the Coarse PK Pile. Flushing of these materials as a result of annual lake level fluctuations was not considered in the water quality assessment since loadings from this process are considered to be negligible in comparison to loads generated from runoff and seepage through the pile. Loading from these runoff and seepage sources were calculated by assigning the simulated runoff source term water chemistry from the geochemical testing program (see Appendix 8.III, Section 8 of the 2012 EIS Supplement, De Beers 2012).

4. What is the water quality of the water above the PK in the Hearne Pit? What is the water quality of the Tuzo Pit? What is the expected schedule of water quality over the life of the mine and variations seasonally, how will DBCI deal with it over the mine life and into the closure period?

In the 2011 EIS Update (De Beers 2011), the water quality in Hearne pit above the fine PK was assumed to be fully mixed. As such, the water quality above the fine PK was considered to be similar to the mixed concentrations presented in Figure AANDC_4-1. As indicated in Part 2 of this response, the water quality is dependent on several input sources and the quality will vary throughout the life of the mine. To illustrate this, simulated TDS concentrations in each of these areas is provided in Figure AANDC_4-1. Simulated concentrations of other specific parameters can be made available to AANDC upon request. Hydrodynamic modelling of Hearne pit completed for the 2012 EIS Supplement indicates that meromixis will develop in the Hearne pit, which will isolate the deeper, higher TDS water lying over the fine PK, and the concentrations presented in Figure AANDC_4-1 represent the water chemistry below the pycnocline.

The water quality of the Tuzo pit will also be a function of several input sources and will be variable throughout the life of mine. Simulated TDS concentrations for this facility are provided in Figure AANDC_4-1. Simulated results of other parameters can be made available to AANDC upon their request. Similar to the Hearne pit, hydrodynamic modelling of this pit also indicates meromixis will develop and the concentrations presented in Figure AANDC_4-1 represent the water chemistry below the pycnocline. The water above this elevation is considered to be fully mixed with Kennady Lake in the water quality assessment.

As indicated in Section 8.I.2.3 of the 2012 EIS Supplement, the water quality model simulated concentrations monthly based on average annual precipitation. Water quality in Kennady is not expected to vary significantly on a seasonal basis for two reasons. First, as a lake-dominated system, water quality is less susceptible to inter-annual fluctuations in precipitation and temperature. Second, the majority of changes in water quality parameter concentrations due to the Project are large in terms of relative change compared to baseline conditions (see Section 8.8.4.1 of the EIS Update), so natural variability would be a relatively small contributor to overall change.

A detailed description of the water management plan is provided in Section 3.9 of the 2012 EIS Supplement. In general, all pit inflows are managed through the water management pond until Year 8 of operations when Tuzo pit inflows are reclaimed to the process plant. At this stage of operations, mining in the Hearne pit is completed and fine PK is deposited in the mined out Hearne pit. At closure, a large proportion of site waters will be directed to the Tuzo pit to expedite flooding of the facility and to segregate high total dissolved solids (TDS) water from mixing with the overlying water in Kennady Lake.

The water management strategy has been designed to minimize discharges to the receiving environment. In addition, opportunities exist in the water management plan to minimize the effects to water quality. For example, at closure, high TDS water will be pumped to the Tuzo pit, which based on hydrodynamic modelling, becomes isolated from the overlying Kennady Lake.

5. What are the plans if the groundwater conditions and water quality conditions are not favourable for discharge?

As described in Section 3.9.3 of the 2012 EIS Supplement, (De Beers 2012) dewatering discharge will be sampled regularly to monitor for compliance with discharge criteria (e.g., TSS) to be specified by the Mackenzie Valley Land and Water Board in the water license, which will be required before the Project can operate. Any water not meeting the discharge limits will be stored within the controlled area boundary of the Kennady Lake watershed.

Section 3.9.6.3 of the EIS Supplement describes the plan for managing the groundwater flowing into the open pits. During the operational period, groundwater flowing into the open pits will be pumped to the water management pond. Water in the water management pond that meets water quality discharge criteria will be pumped to Lake N11. Water quality modelling indicates that the water quality in the water management pond during the first four years of operation will be suitable for discharge and not result in any effects to aquatic health in the downstream watershed. Any water not meeting discharge criteria will be stored within the controlled area boundary of the Kennady Lake watershed.

In addition, the water quality model also indicates that the Kennady Lake water quality will be suitable for discharge following refilling (i.e., removal of Dyke A and reconnection of Kennady Lake to downstream waters). De Beers will monitor the water quality during operations, and if required, develop an appropriate adaptive management strategy that can be implemented prior to closure to ensure the quality of the water in Kennady Lake is acceptable for reconnection with downstream lakes following refilling.

6. What is the anticipated water treatment option for the water that does not meet objectives for TSS and TDS?

Based on the water quality assessment for the Project, water quality treatment is not required for TDS as the projected concentrations are not expected to result in residual effects to aquatic life. However, De Beers will continue to monitor the water quality during operations to confirm the predictions of the water quality evaluation. If concentrations become higher than projected, adaptive management will be implemented to minimize the TDS concentrations during operations and refilling.

As described in the Water Management Plan (Section 3.9 of the EIS Supplement), it is anticipated that more than half the water in Kennady Lake (about 17 Mm^3) can be pumped out without water treatment. However, as the lake level is drawn down and shoreline areas exposed, TSS concentrations will increase. To manage water that has higher levels of TSS, flocculants may be added through an in-line treatment process; for example, water that can no longer be pumped from Area 7 to Area 8 will be pumped to Areas 3 and 5 through a pumped system with in-line flocculation to minimize TSS in Areas 3 and 5 to allow for dewatering of this area to the maximum extent possible. Dewatering details are provided in Section 3.9 of the 2012 EIS Supplement.

7. For Dyke A, how will the water in this area be handled if it does not meet discharge criteria to allow dyke to be breached?

As indicated in Part 5 of this response, based on the water quality assessment for the Project, it is expected that Kennady Lake will be able to be reconnected to the downstream watersheds following refilling. De Beers will monitor the water quality during operations and develop adaptive water management strategies if, and as, required. This may include consideration of slowing down the refilling process or raising the dykes to contain more water until monitoring data indicates the water quality in Kennady Lake is suitable for discharge.

8. What is the anticipated effect of the phosphorous (groundwater) on the environment?

The water quality modelling includes source term inputs from a number of sources associated with the Project, including groundwater inflows, for use in the assessment of effects to Kennady Lake during closure and post-closure. During closure, groundwater contributions to Kennady Lake are considered small in comparison to the loading from the Fine PKC Facility, which was identified as the primary source of phosphorus to Kennady Lake. Groundwater contributes some phosphorus load to the water management pond during operations. However projected concentrations within the water management pond do not result in downstream concentrations that would result in a trophic level change in Lake N11 during the dewatering phase of the Project.

At closure, a large volume of the water management pond is transferred to Tuzo pit, along with a large proportion of parameter loading derived from the pumped groundwater inflows collected over the life of the mine, including phosphorus. Updated water quality modelling for the 2012 EIS Supplement based on the reduced size of the PKC Facility, revised source term inputs of TP from the on-going geochemical testing, and pit hydrodynamic modelling projected the long-term steady state TP concentrations to be less than that reported in the July 2011 EIS Update, with Kennady Lake projected to remain oligotrophic in the long-term.

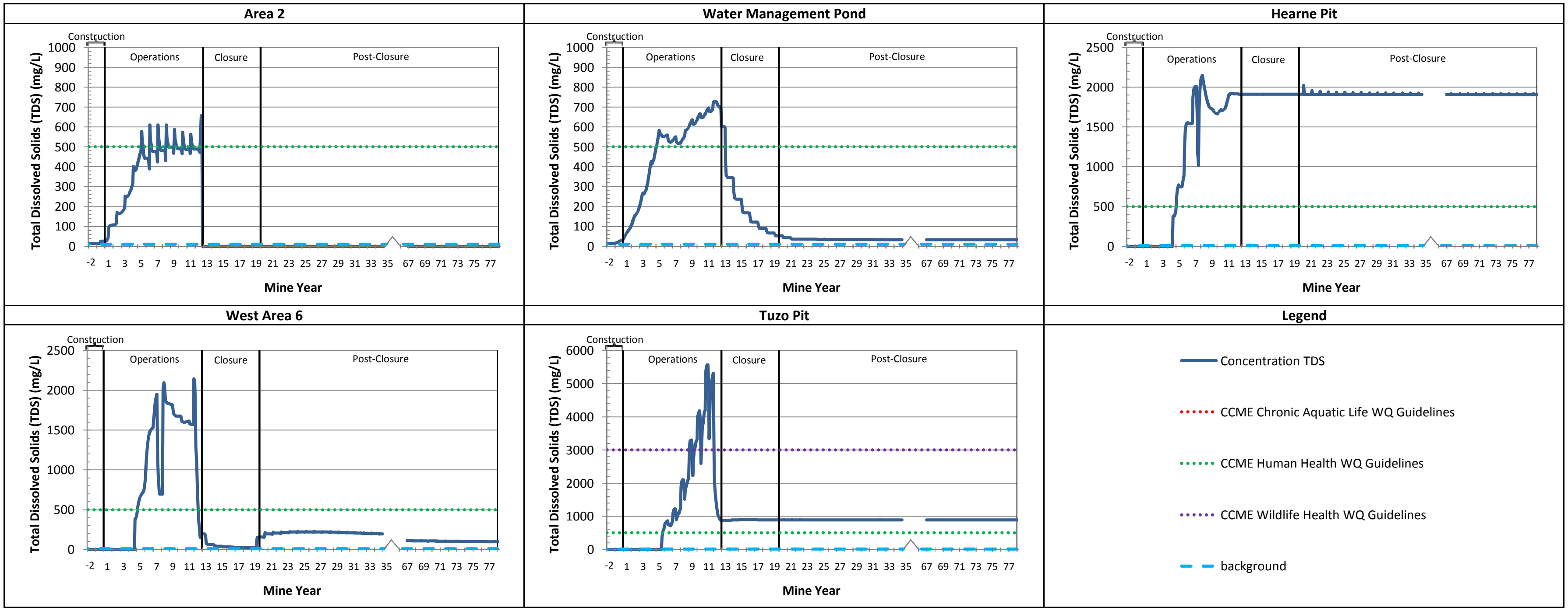
References

EBA 2011. Updated Summary of Water Management and Balance during Mine Operation, Gahcho Kué, NT (for updated fine PK disposal plan – Option 2). EBA File: E14101143.

De Beers (De Beers Canada Inc.). 2011. *Environmental Impact Statement for the Gahcho Kué Project. Volumes 3a Revision 2, 3b Revision 2, 4 Revision 2, and 5 Revision 2.* Submitted to the Mackenzie Valley Environmental Impact Review Board in Response to the Environmental Impact Statement Conformity Review. July 2011.

De Beers. 2012. *Environmental Impact Statement Supplemental Information Submission for the Gahcho Kué Project*. Submitted to the Mackenzie Valley Environmental Impact Review Board. April 2012.

Figure AANDC 4-1: Predicted Total Dissolved Solids (TDS) concentrations in Kennady Lake areas



GAHCHO KUÉ PROJECT ENVIRONMENTAL IMPACT STATEMENT
INFORMATION REQUEST RESPONSES

Information Request Number: AANDC_5

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: Reclamation and Closure

EIS Section: Section 3: Project Description, Section 8: KLOI: Water Quality and Fish in Kennady Lake, Section 10: KLOI Long-term Biophysical Effects, Closure and Reclamation

Terms of Reference Section:

Preamble:

In order to adequately close a site, a clear understanding of the issues is required. Once the solutions have been determined adequate support infrastructure needs to be available. The solutions have to sufficiently cover a range of conditions and be viable options.

Request

1. The surface inflow into the pits - Is this volume of water to be pumped to the partially dewatered Kennedy Lake? What is the volume of water expected and the quality of it?
2. Is the drainage directly to the environment from the waste rock piles and PKC during operation and into closure? What are the contingencies to intercept seepage prior to going into the NW portion of Kennedy Lake?
3. Is the outflow from Area 8 directly to the environment?
4. What is the strategy if the long term water quality of the partially dewatered Kennedy Lake does not permit discharge to Lake N11?
5. What is the level of permafrost in the waste rock piles? At what elevations within the waste rock piles is the PAG rock and when is it in permafrost conditions? There is no detailed information or evaluation of the reclamation cover and rate of convection. What consideration was given to heat input from lake water on permafrost development?
6. Is the unfrozen area near the filter dyke L a concern for the PK facility? Should something be done to mitigate this unfrozen area?

7. The coarse PK will have 1 m cover. Is this sufficient to ensure permafrost conditions and what are the performance expectations of this cover long term (i.e. post-closure)?

8. Has the thermal evolution of the fine or coarse PK been evaluated?

Response

1. The surface inflow into the pits - Is this volume of water to be pumped to the partially dewatered Kennedy Lake? What is the volume of water expected and the quality of it?

   Surface inflows will be collected in the pits and pumped to the water management pond. The surface inflows were calculated as part of the EBA water balance (EBA 2011), based on the surface area of the pit footprint, which will expand as mining expands. At the maximum footprint, the following approximate surface flow volumes are expected to report to the pits on an annual basis until closure, when the pits are flooded:

   5034 Pit: 130,000 m^3

   Hearne Pit: 70,000 m^3

   Tuzo Pit: 91,500 m^3

   This water will mainly flow over exposed wall rock, which is expected to be predominantly composed of granite. In the water quality model, these flows were assigned the source term water quality designated to mine rock. These are presented in Table 8.I-4 of the 2012 EIS Supplement (De Beers 2012).

2. Is the drainage directly to the environment from the waste rock piles and PKC during operation and into closure? What are the contingencies to intercept seepage prior to going into the NW portion of Kennedy Lake?

   The West Mine Rock Pile will drain directly into the water management pond (Areas 3 and 5). During operations this area is isolated from the downstream environment by dyke B. At closure the dykes will be breached, and drainage from this facility will continue to report to Areas 3 and 5, then flow through Kennady Lake and enter the downstream environment through Area 7.

The Coarse PK Pile will drain into Kennady Lake Area 4. While mining is active in the Tuzo pit this area will remain dewatered. The runoff from the Coarse PK pile will be collected and pumped to the water management pond during mining of the Tuzo pit. Similarly, the South Mine Rock Pile drains to Area 6, which is pumped to the water management pond during mining of the 5034 Pit. At closure these drainages will flow to Kennady Lake in Areas 4 and 6, respectively.

3. Is the outflow from Area 8 directly to the environment?

   Area 8 drains into the downstream environment, through the interlakes (i.e., the L and M watersheds) and then into Lake 410. Area 8 will be hydraulically isolated from the rest of Kennady Lake during construction, operations, and closure phases of the project, although it will receive diverted flows from the A watershed during operations (De Beers 2012). After the refilling of Kennady Lake and water quality meets discharge criteria, Dyke A will be breached reconnecting Area 7 with Area 8 and the downstream environment.

4. What is the strategy if the long term water quality of the partially dewatered Kennedy Lake does not permit discharge to Lake N11?

   The water management plan (Section 3.9, 2012 EIS Supplement) plans for operational discharge from the water management pond to Lake N11 in the first four years of operation. Water quality modeling indicates that the water in the water management pond will be acceptable for discharge during this period. De Beers will monitor the water quality of the water management pond during operations and if required develop an adaptive management strategy that can be implemented to ensure the quality of the water in Kennady Lake is acceptable for discharge following refilling.

5. What is the level of permafrost in the waste rock piles? At what elevations within the waste rock piles is the PAG rock and when is it in permafrost

conditions? There is no detailed information or evaluation of the reclamation cover and rate of convection. What consideration was given to heat input from lake water on permafrost development?

To provide a conservative estimate of the Kennady Lake water quality, permafrost conditions were not considered to develop in the mine rock piles, Coarse PK Pile, and Fine PKC Facility. As mentioned in Section 11.6 of the EIS (De Beers 2010): “The development of permafrost in the mine rock piles, Coarse PK Pile and the Fine PKC Facility will limit seepage rates from these structures to Kennady Lake. However, the assessment of potential effects to water quality and fish in Kennady Lake was complete without taking this beneficial effect into account. In other words, the assessment was completed assuming no permafrost was present within the aforementioned structures. As such, further analysis of this pathway was not required to support the assessment of potential effects to values components.”

6. Is the unfrozen area near the filter dyke L a concern for the PK facility? Should something be done to mitigate this unfrozen area?

   The site water quality model assumes no permafrost development in the Fine PKC Facility. Therefore, all areas around the facility, including the area near Dyke L, would also be assumed free of permafrost. This provides a conservative estimate of water quality based on the increased seepage through these areas under no-permafrost conditions. Permafrost development, or freezing of the area near Dyke L, lead to limited seepage rates from these structures and would provide a beneficial effect to the water quality predictions.

7. The coarse PK will have 1 m cover. Is this sufficient to ensure permafrost conditions and what are the performance expectations of this cover long term (i.e. post-closure)?

   Section 3.7.4.2 of the 2011 EIS Update (De Beers 2011) provides the design details. The facility will be built entirely on land in 5 to 10 m lifts to a maximum height of 30 m. Once the facility has reached its design storage capacity, it will be covered with a 1 m layer of waste rock.

As indicated in Section 11.6.3.1.2 (Subject of Note: Permafrost, Groundwater and Hydrogeology) of the EIS Update (De Beers 2011), permafrost is expected to affect local permafrost conditions. This will result in taliks of varying depths forming beneath the facility. However, as the warm coarse PK cools, permafrost is expected to re-establish within the Coarse PK Pile by the end of operations and lake refilling.

In the long-term, the permafrost could disappear from the coarse PK as a result of climate-change. As such, to evaluate the effects of the project on the site water quality, no permafrost was considered for this facility.

The purpose of the mine rock cover on the Coarse PK Facility is to prevent erosion of the underlying coarse PK. The cover will consist of granite rock which, owing to the hardness of this lithology, is not expected to weather significantly.

8. Has the thermal evolution of the fine or coarse PK been evaluated?

The thermal evolution of the fine PK has been modelled as described in the AANDC-15 information response request. The thermal evolution of the coarse PK has not been modelled as the coarse PK pile performance is not a function of permafrost in the pile.

References

EBA 2011. Updated Summary of Water Management and Balance during Mine Operation, Gahcho Kué, NT (for updated fine PK disposal plan – Option 2). EBA File: E14101143.

EBA. 2012. Seepage Analysis for Fine PK in Area 2 (Updated Fine PK Management Plan – Option 2) Gahcho Kué Diamond Project. EBA File: E14101143.

De Beers (De Beers Canada Inc.). 2010. Environmental Impact Statement for the Gahcho Kué Project. Volumes 1, 2, 3a, 3b, 4, 5, 6a, 6b, 7 and Annexes A through N. Submitted to Mackenzie Valley Environmental Impact Review Board. December 2010.

De Beers. 2012. Environmental Impact Statement Supplemental Information Submission for the Gahcho Kué Project. Submitted to the Mackenzie Valley Environmental Impact Review Board. April 2012.

Information Request Number: AANDC_6

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: General Mining Plan

EIS Section: EIS and Conformity Responses

Preamble

The proposed mine development plan generally follows standard mining practices. The large number of dykes and the amount of water required to be moved to access the mineralized zones is definitely atypical of most mines in Northern Canada.

Request

1. Why has DCI limited the footprint to a single watershed?

2. Can DCI outline all potential impacts (physical controls such as Till Cover, Permafrost and Rock/Water interface and their linkage to effects to local surface water) from the Waste Rock and PKC storage?

3. Please provide contingencies for closure if aspects of the mine do not perform adequately or the mine does not develop according to plan (i.e. technical, operational or practical/feasible complications)?

Response

1. De Beers has limited the footprint of the mining operation to a single watershed to minimize environmental impacts. Restricting the development footprint to a single watershed represents sound engineering and environmental design practice. By containing all waste streams in a single watershed, any associated runoff from disturbed areas will flow naturally to the isolated watershed (i.e., the controlled area), allowing for the monitoring and testing of water quality prior to any discharge to the environment. Using natural topography also eliminates the need for problematic ditching networks to collect and redirect flows.

   The kimberlite deposits are located under the lake surface and as a result of dewatering the lake to safely access the deposits, other project facilities are designed to fall within the affected watershed. The dykes and dams planned for the development are either for internal water management within the controlled area or to prevent water from flowing into the controlled area. The design uses the natural topography and relief of the isolated Kennady Lake (Areas 2 to 7) to prevent water from flowing out of the controlled area.

2. The potential effects associated with the storage of mine rock, coarse PK, and fine PK on surface water (quantity and quality) are assessed in Sections 8 (Fish and Water Quality in Kennady Lake) and Section 9 (Downstream Water Effects). The potential effects to water quantity and water quality are outlined in Sections 8.6 and 9.6, and the assessment of effects to water quantity quality provided in Sections 8.7 and 9.7, and Sections 8.8 and 9.8, respectively.

   As stated in Section 8 of the 2011 EIS Update (De Beers 2011), the assessment of effects to water quality in Kennady Lake and to downstream waters did not include the development and persistence of permafrost conditions within the Mine Rock piles, the Coarse PK pile, and the Fine PKC Facility. It was assumed that seepage quantities from these facilities would be representative of no permafrost conditions, and provide seasonal geochemical loading to Kennady Lake after closure. It is recognized that frozen layers may establish during the development of these facilities and that permafrost will likely continue to develop following closure, which will result in lower rates of seepage through the facilities and geochemical loading to Kennady Lake than simulated in the EIS assessment. However, as the assessment of impacts to the suitability of the water quality to support aquatic life includes time periods that extend into the long-term (i.e., 200 years), the assessment was designed to represent potential future climatic conditions where no permafrost may exist depending on the climate change scenario considered.

3. The conceptual mine closure plan is provided in Section 10 of the 2011 EIS Update (De Beers 2011), which outlines adaptability to potential variations in the mine performance during operations.

   Mine development plans can change due to a variety of factors, which can include: variations in the reserve estimates including grade, tonnage and realized diamond prices; metallurgical changes in processing; added kimberlite discoveries; extension (deeper) of mining known resources; mine operating costs structure; as well as other potential unforeseen factors not predicted at the time of the EIS. The Project Description as provided in the EIS (Section 3), and including the associated conceptual closure plan, provides sufficient flexibility for unpredicted changes to occur and still close the mine in an environmentally sound fashion in line with the predicted impacts provided in the EIS.

References

De Beers (De Beers Canada Inc.). 2011. Environmental Impact Statement Conformity Response. Submitted to the Mackenzie Valley Environmental Impact Review Board in Response to the Environmental Impact Statement Conformity Review, July 2011.

De Beers. 2012. Environmental Impact Statement Supplemental Information Submission for the Gahcho Kué Project. Submitted to the Mackenzie Valley Environmental Impact Review Board. April 2012.

Information Request Number: AANDC_7

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: Water Quality – toxicity testing

EIS Section: Section 8: KLOI Water Quality and Fish in Kennady Lake

Preamble

The EIS provided predicted water chemistry for both water pumped into Lake N11 during operations, and within Kennady Lake post-closure. The predicted water chemistry indicated that concentrations of several substances of potential concern may exceed the CCME and/or the derived Chronic Effects Benchmarks.

Discussion in the EIS has argued that the concentrations are unlikely to result in chronic effects to aquatic organisms. A short-coming of comparing measured (or predicted) water chemistry against toxicity-based numeric benchmarks is that there is no consideration of the following: (1) the potential for additive or synergistic effects arising from the combined exposure of more than one substance of potential concern; and (2) that there may be chemical entities that are not accounted for in standard chemical analysis. Examples of the latter can include process/treatment chemicals, or minor/secondary natural substances in the rock being processed.

Consequently, at this time, there is insufficient information to assess the potential for chronic/sub acute toxicity to resident aquatic organisms. One way to assess a complex water sample for potential effects is to subject the sample to toxicity testing. This testing should be done with representative species of different kingdoms (i.e., fish, invertebrate, plant). The testing should also favor chronic or sub-lethal tests as these are more sensitive, and representative of possible effects within the receiving environment.

If toxicity is observed at concentrations expected to be either pumped to Lake N11 during operations or found within Kennady Lake post-closure, then a toxicity identification evaluation (TIE) would be appropriate. A TIE would help De Beers identify the contaminant most likely resulting in the toxicity. De Beers could then consider mitigative approaches.

Request

1. Please provide the results of sub-lethal and chronic toxicity tests on simulated water samples as outlined above. If this is not practical, please provide a reason why toxicity testing should not be done.

Response

Toxicity tests (acute or chronic) have not been conducted on simulated water samples. In the 2011 EIS Update (De Beers 2011) reliance has been placed initially on comparisons to toxicity-based benchmarks, which are discussed below.

Carrying out toxicity testing on simulated water samples was considered for the 2010 EIS (De Beers 2010), but discarded not only because the approach used is considered adequately protective (Section 8.9; De Beers 2011), but also because of the disadvantages of testing simulated water samples. In particular, simulated water samples cannot fully mimic the receiving environment once operations commence and could produce both false positives and false negatives, making interpretation of the results problematic at best.

Comparing predicted water quality to toxicity-based benchmarks is standard practice in environmental impact reviews. Literature-based toxicity benchmarks, such as those used in the 2011 EIS Update (De Beers 2011) (i.e., chronic effects benchmarks and tissue benchmarks) are designed to be conservative (i.e., protective) and thus tend to overestimate toxicity. Choice of literature-based toxicity benchmarks followed CCME (2007), specifically the following order of preference for chronic endpoints:

- No-Effects Threshold EC_x>EC_{10}>$EC_{11\text{-}25}$>MATC>NOEC>LOEC>$EC_{26\text{-}49}$>Nonlethal EC_{50}

Where: EC_x = effects concentration affecting x% of the organisms tested;

NOEC = no observed effect concentration;

LOEC = lowest observed effect concentration; and

MATC = maximum acceptable toxicant concentration (the geometric mean of the NOEC and LOEC)]

Note further that exposure toxicity modifying factors (ETMFs), which can reduce toxicity (*c.f.* CCME 2007) were not considered. Laboratory toxicity studies are typically carried out in water absent of ETMFs such as hardness and dissolved organic carbon.

The advantage of using such conservative benchmarks in the 2011 EIS Update (De Beers 2011) is that if exceedences do occur it does not necessarily imply toxicity will occur, only that effects may potentially occur. As discussed in the 2011 EIS Update, follow-up monitoring will be used when operations commence in order to assess whether effects are occurring and to track the uncertainties of predictions (De Beers 2011, Section 8.16). Note further that combinations of toxicants need not only result in more toxicity than individual toxicants but can in fact result in less than additive (antagonistic) toxicity.

De Beers is committed to undertaking regular monitoring and follow-up testing of water quality and aquatic health during the Project (De Beers 2011, Section 8.16). Sub-lethal toxicity testing will be undertaken during operations to assess predictions in the 2011 EIS Update that effects from water quality to aquatic communities will be negligible (De Beers 2011, Section 8.13.3). Toxicity testing with sensitive, native organisms (i.e., not previously exposed to chemicals) will be conducted to provide conservative toxicity responses. Such responses will serve as an indicator to further investigate any potential effects, but will not necessarily indicate that population-level effects are occurring in the receiving environment. Where necessary, adaptive management will implemented. Such management could include investigations of causation such as a TIE, but only where such investigation would be useful. For example, a TIE is only useful and feasible if there is a consistent, relatively high level of toxicity.

References

CCME (Canadian Council of Ministers of the Environment). 2007. A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life. Winnipeg, MB, Canada.

De Beers (De Beers Canada Inc.). 2010. Environmental Impact Statement for the Gahcho Kué Project. Volumes 1, 2, 3a, 3b, 4, 5, 6a, 6b, 7 and Annexes A through N. Submitted to Mackenzie Valley Environmental Impact Review Board. December 2010.

De Beers. 2011. Environmental Impact Statement for the Gahcho Kué Project. Volumes 3a Revision 2, 3b Revision 2, 4 Revision 2, and 5 Revision 2. Submitted to the Mackenzie Valley Environmental Impact Review Board in Response to the Environmental Impact Statement Conformity Review. July 2011.

GAHCHO KUÉ PROJECT ENVIRONMENTAL IMPACT STATEMENT
INFORMATION REQUEST RESPONSES

Information Request Number: AANDC_8

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: Water Quality – P and potential enrichment

EIS Section: Section 8: KLOI Water Quality and Fish in Kennady Lake;
Section 9: KLOI Downstream Water Effects

Preamble

Sections 8 and 9 of the EIS discuss potential effects to Kennady Lake and downstream water bodies as a result of increased P loading to Kennady Lake during operations and post closure. The EIS indicates that these water bodies will likely shift from being oligotrophic to becoming mesotrophic. Furthermore, a number of changes (both potentially beneficial and negative) were outlined. One of the negative changes was a likely reduction in overwintering dissolved oxygen concentration in Kennady Lake post–closure. And consequently "over wintering habitat in Kennady Lake at post-closure may become more limited for cold-water fish species, such as lake trout and round whitefish than under baseline conditions" (Bottom P8-503). A concern is that periodic dissolved oxygen concentrations in Kennady Lake (and lakes downstream that currently provide over-wintering habitat [M2, M3 and M4]) may not be sufficient to support any large bodied fish.

Request

1. Discuss the potential for periodic die-offs of non-cold-water fish species (including forage fish) in Kennady Lake and downstream lakes post closure. If possible please put this discussion in context with existing mesotrophic lakes nearby to the Gahcho Kue site.

2. Please also discuss the likelihood that a maximum total P concentration (18mg/L) in Kennady Lake post-closure (proposed by De Beers as a possible commitment) would avoid the periodic die-off of large non-coldwater fish species (P8-494).

Response

1. As described in Section 9.10.4.3.2 of 2011 Environmental Impact Statement (EIS) Update (De Beers 2011), the L and M lakes downstream of Kennady Lake are predicted to have increased nutrient levels during post-closure compared to baseline. As the lakes in the L watershed currently provide nil or limited overwintering habitat, the increased nutrient levels would not be expected to change the overwintering capability or suitability of these small lakes. In the M watershed lakes, it was predicted that there may be some small reductions in overwintering habitat availability or suitability at post-closure for fish species remaining in these lakes throughout the winter; however, it is expected that the lakes would continue to support the same fish species over the winter period as under pre-development conditions.

   However, based on the supplemental mitigation associated with the Fine Processed Kimberlite Containment (PKC) Facility presented in the 2012 EIS Supplement (De Beers 2012), the lakes in the L and M watersheds are predicted to remain oligotrophic, and not mesotrophic as presented in the 2011 EIS Update. As a result, changes to overwintering habitat would be less than presented in the 2011 EIS Update. Although the lakes would likely be more productive compared to existing conditions, any changes to overwintering habitat in these lakes would be expected to be not measurable. As a result, no periodic die-offs of fish species (including cold-water and warm-water species) would be expected to occur in these lakes resulting from the small change in nutrients.

   The updated water quality projections, and effects to fish and fish habitat will be provided in Section 9 of the 2012 EIS Supplement, which will be submitted to the Mackenzie Valley Environmental Impact Review Board (MVEIRB) in 2012.

2. Based on the supplemental mitigation associated with the Fine PKC Facility presented in the 2012 EIS Supplement, the predicted long-term steady state phosphorus concentration is projected to be 0.009 milligrams per liter (mg/L), which indicates that long-term trophic status in Kennady Lake will remain oligotrophic (i.e., less than 0.010 mg/L); this level is less than that presented in the 2011 EIS Update (De Beers 2011). The dissolved oxygen modelling associated with the updated phosphorus projection, conducted as part of the

2012 EIS Supplement, predicts that overwintering habitat conditions will be suitable to support fish populations, including the more sensitive, cold-water fish species, such as lake trout and round whitefish. As a result, no periodic die-offs of fish species (including cold-water and warm-water species) would be expected to occur in the refilled Kennady Lake resulting from the change in nutrients.

The updated water quality projections, and effects to fish and fish habitat will be provided in Section 8 of the 2012 EIS Supplement, which will be submitted to the MVEIRB in 2012.

References

De Beers. 2011. Environmental Impact Statement for the Gahcho Kué Project. Volumes 3a Revision 2, 3b Revision 2, 4 Revision 2, and 5 Revision 2. Submitted to the Mackenzie Valley Environmental Impact Review Board in Response to the Environmental Impact Statement Conformity Review. July 2011.

De Beers. 2012. Environmental Impact Statement Supplemental Information Submission for the Gahcho Kué Project. Submitted to the Mackenzie Valley Environmental Impact Review Board. April 2012.

Information Request Number: AANDC_9

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: Water Quality – Copper

EIS Section: Section 8: KLOI Water Quality and Fish in Kennady Lake

Preamble

The EIS indicates that possible effects of copper in water may be mitigated by a predicted increase of dissolved organic carbon (page 8-496). A biotic ligand model provided by USEPA (USEPA 2003) provides a convenient way to assess copper toxicity in the context of hardness, alkalinity and dissolved organic carbon.

Request

1. Please test this hypothesis using a biotic ligand model or similar approach. If this is not practical, please provide a compelling reason why a biotic ligand model (or similar) could not be used.

Response

As requested, this hypothesis has been tested using the biotic ligand model (BLM). We provide the following below as part of our response:

- information regarding the BLM;
- inputs to the model and the assumptions used when conducting this assessment;
- the results;
- the model sensitivity; and,
- sources of uncertainty.

In summary, the model clearly shows that copper bioavailability and toxicity in Kennady Lake will be ameliorated by increasing concentrations of dissolved organic carbon (DOC). This finding is not surprising, given the abundance of literature substantiating this relationship (see summary/synthesis of copper toxicology in Grosell 2012). However, as is explained in this response, DOC is not the only factor to consider when using the BLM, and input to the BLM does not always result in higher toxicity benchmarks than those that currently exist (e.g., than the CCME 2011 water quality guideline of 2 micrograms per litre [µg/L] referenced in the 2011 EIS Update [De Beers 2011]).

The Biotic Ligand Model

The Biotic Ligand Model (BLM; USEPA 2009) is used in this response to develop scenario-specific chronic effects benchmarks (CEBs; hereafter refered to as BLM-derived CEBs) for the various waterbodies and predicted scenarios. These BLM-derived CEBs for copper incorporate DOC as the primary, but not the only, exposure and toxicity-modifying factor (ETMF; CCME 2007).

The BLM predicts copper toxicity by simulating the accumulation of copper at the “biotic ligand”, which represents the site of toxic action in biota (HydroQual 2007a). Based on water chemistry, the concentration of copper in water that will cause toxicity can vary. The BLM uses an equilibrium approach that includes the dominant parameters that affect the free ion concentration, which has been shown to be responsible for metal toxicity (HydroQual 2007a). The BLM generates acute toxicity criteria that are converted by the model to chronic criteria by applying an acute to chronic ratio determined by the model (ACR, [USEPA 2009]).

The BLM Windows User Interface, Version 2.2.3 (HydroQual 2007b) was used to derive site/scenario-specific CEBs for copper. The water quality parameters (i.e., ETMFs) necessary to run the BLM are:

- physical parameters (water temperature and pH);
- dissolved organic carbon (and proportion of humic acid);
- major cations (calcium, magnesium, sodium, and potassium);
- major anions (sulphate and chloride);
- alkalinity; and,
- sulphide.

Hardness is calculated from calcium and magnesium concentrations. Sulphide concentrations are listed as an input parameter, but currently do not affect the BLM, as research is needed to better characterize its effects on metal-sulphide interactions. Metal-sulphide interactions can occur, and will likely be incorporated into the BLM's equilibrium in the future (HydroQual 2007a; Grosell 2012).

Inputs and Assumptions

Site/scenario-specific BLM-derived CEBs were derived for eight scenarios described below:

- Kennady Lake measured average baseline - average parameter concentrations in water samples collected from Kennady Lake between 1995 and 2011;
- Downstream Watersheds measured average baseline - average parameter concentrations in water samples collected from lakes in the L, M, and N basins, and Lake 410 between 1995 and 2011;
- Kennady Lake predicted maximum concentrations after refilling - maximum concentrations in Kennady Lake predicted by modelling after Kennady Lake is refilled with water from Lake N11;
- Kennady Lake predicted maximum long-term steady state concentrations - maximum concentrations in Kennady Lake predicted by modelling 100 years into post-closure;
- Lake N11 predicted maximum concentrations during Kennady Lake dewatering - maximum concentrations in Lake N11 predicted by modelling during the period of construction and operations, when water from Kennady Lake and the water management pond is being pumped to Lake N11;
- Lake N11 predicted maximum concentrations during Kennady lake closure flooding - maximum concentrations in Lake N11 predicted by modelling during closure, while water is drawn from Lake N11 to refill Kennady Lake;

- Area 8 predicted maximum concentrations during post-closure - maximum concentrations in Area 8 predicted by modelling after Area 7 of Kennady Lake is reconnected to Area 8, during post-closure; and,
- Lake 410 predicted maximum concentrations - maximum concentrations in Lake 410 predicted by modelling during construction, operations, closure, and post-closure.

Measured average baseline and predicted maximum concentrations were used as inputs for the BLM (Table AANDC_9-1; Appendix 8.2.4; De Beers 2012). Measured baseline data were collected from Kennady Lake and lakes in the downstream watersheds (L,M, and M watersheds, and Lake 410) between 1995 and 2011. Predicted concentrations were derived from a flow and mass-balance water quality model, developed in GoldSim™, for a range of water quality parameters in various waterbodies for specific scenarios (Sections 8.2.5 and 9.2.5; De Beers 2012). Other assumptions were:

- Parameters that were not predicted (i.e., water temperature, total alkalinity and DOC) in the 2012 EIS Supplement (Sections 8.2.5 and 9.2.5; De Beers 2010) were set to the Kennady Lake or downstream watersheds average baseline concentration (Section 8.2.6 and 9.2.6; De Beers 2012).
- Concentrations below the analytical detection limit were set to the method detection limit.
- The pH values of Kennady Lake and of the lakes downstream were not modelled, but are expected to be within the CCME guideline range (6.5 to 9.0). As such, the lowest pH (6.5) was selected to be conservative.
- Humic acid proportion of dissolved organic carbon was assumed to be 10%, based on the BLM User Guide’s suggestion (HydroQual 2007a).
- A conversion factor of 1.04 (1/0.96) was used to convert predicted copper concentrations from dissolved to total concentrations (USEPA 2007).

Results

Based on the inputs and assumptions presented above, the BLM yielded Criterion Continuous Concentrations (CCCs) for dissolved and total copper for each scenario (Table AANDC_9-2). These CCCs were adopted as scenario-specific BLM-derived CEBs. The dissolved and total copper BLM-derived CEBs ranged from 1.63 to 2.30 µg/L. These BLM-derived CEBs are similar to the CCME water quality guideline for copper (2 µg/L). The range in BLM-derived CEBs were mainly due to the range in pH among the scenarios. For example, the scenario with the highest BLM-derived CEB for total copper (2.30 µg/L) used an input pH of 6.5, while the scenario with the lowest BLM-derived CEB for total copper (1.69 µg/L) used the lowest pH (6.39) of all scenarios. The model is also sensitive to changes in DOC (Table AANDC_9-4), however, the DOC concentrations among the scenarios only ranged from 4.0 to 4.04 mg/L.

Total copper concentrations for Kennady Lake during the predicted maximum concentrations after refilling and predicted maximum long-term scenarios exceed the corresponding BLM-derived CEBs (Table AANDC_9-3). The predicted total and dissolved copper concentrations for all other scenarios were below the corresponding BLM-derived CEBs.

The BLM-derived CEB exceedences (Table AANDC_9-3) are based on predicted maximum copper concentrations, which are expected to decrease over time, but remain above BLM-derived CEBs in Kennady Lake into the post-closure period. Time series plots of predicted copper concentrations in Kennady Lake are presented in Appendix 8.V of the 2012 EIS Supplement (De Beers 2012).

Table AANDC_9-1 Water Quality Input Parameters for the Copper Biotic Ligand Model

Waterbody	Scenario	Temperature (°C)[(a)]	pH	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	SO_4 (mg/L)	Cl (mg/L)	Alkalinity (mg/L $CaCO_3$)
Kennady Lake	measured average baseline	15	6.39	4.0	1.2	0.52	0.71	0.48	0.83	0.55	6.51
Downstream Watersheds	measured average baseline	15	6.47	4.04	1.1	0.43	0.78	0.39	0.88	0.49	5.64
Kennady Lake	predicted maximum concentrations after refilling	15	6.5	4.0	27	4.6	15	2.8	20	64	6.51
Kennady Lake	predicted maximum long-term steady state water quality	15	6.5	4.0	5	1.6	2.4	1.9	10	3	6.51
Lake N11	predicted maximum concentrations during Kennady Lake dewatering	15	6.5	4.04	9.6	1.8	5.4	1.03	5.7	22	5.64
Lake N11	predicted maximum concentrations during Kennady Lake closure flooding	15	6.5	4.04	1.1	0.43	0.8	0.39	0.9	1	5.64
Area 8	predicted maximum concentrations post-closure	15	6.5	4.0	17	3.1	9.9	2.0	13.2	39	6.51
Lake 410	predicted maximum concentrations during construction, operations, closure, and post-closure	15	6.5	4.04	4.1	0.94	2.4	0.63	2.7	7.9	5.64

Notes: Water quality data for baseline scenarios and for parameters not predicted during simulated scenarios in the 2012 EIS Supplement update (De Beers 2012; Sections 8.2.5 and 9.2.5) are the average concentrations in either Kennady Lake (Kennady Lake and Area 8 scenarios) or the Downstream Watersheds (Lake N11 and Lake 410) as in Tables 8.2-3 and 9.2-3, respectively De Beers 2012) . Concentrations below the analytical detection limit were set to the method detection limit. Sulphide is not reported as it is not taken into account by the Biotic Ligand Model. The pH values of Kennady lake and the lakes downstream of Kennady Lake are expected to be within the CCME guideline range (6.5 to 9.0).The proportion of humic acid was assumed to be 10%, based on the Biotic Ligand Model, Windows Interface, Version 2.2.3, User's Guide and Reference Manual (HydroQual 2007a).

(a) Water temperature was assumed to be 15 °C. Because water temperature varies depending on the season, using an average value would inaccurate.

(b) The average baseline value from Kennady Lake or the downsteam watersheds and Lake 410 was assumed, as this parameter was not simulated.

°C = degrees Celsius; DOC = dissolved organic carbon; mg/L = milligrams per litre; HA = humic acid; % = percent; Ca = calcium; Mg = magnesium; Na = sodium; K = potassium; SO_4 = sulphate; Cl = chlorine; mg/L $CaCO_3$ = milligrams per litre calcium carbonate.

Table AANDC_9-2 Predictions of the Copper Biotic Ligand Model for each Scenario

Waterbody	Scenario	Final Acute Value (µg/L)	Criterion Maximum Concentration (µg/L)[a]	Criterion Continuous Concentration for Dissolved Copper (µg/L)[a]	Criterion Continuous Concentration for Total Copper (µg/L)[b]
Kennady Lake	measured average baseline	5.24	2.62	1.63	1.69
Downstream Watersheds	measured average baseline	6.65	3.33	2.07	2.15
Kennady Lake	predicted maximum concentrations after refilling	6.89	3.44	2.14	2.22
Kennady Lake	predicted maximum long-term steady state water quality	5.77	2.89	1.79	1.86
Lake N11	predicted maximum concentrations during Kennady Lake dewatering	5.99	2.99	1.86	1.93
Lake N11	predicted maximum concentrations during Kennady Lake closure flooding	7.14	3.57	2.22	2.30
Area 8	predicted maximum concentrations post-closure	6.35	3.17	1.97	2.05
Lake 410	predicted maximum concentrations during construction, operations, closure, and post-closure	5.99	2.99	1.86	1.93

Note: The BLM-derived CEB is equal to the criterion continuous concentration.

(a) The criterion maximum concentration and criterion continuous concentration are based on dissolved copper concentration. A conversion factor of 1.04 (1/0.96) was used to convert from a dissolved to a total basis (USEPA 2007).

(b) The criterion continuous concentration based on dissolved copper converted to total copper concentration.

µg/L = micrograms per litre.

Table AANDC_9-3 Comparison of the Biotic Ligand Model-Derived Chronic Effects Benchmarks for Copper to Measured and Predicted Copper Concentrations for each Scenario

Waterbody	Scenario	Copper Fraction	Copper BLM-derived CEB (µg/L)	Measured or Predicted Copper Concentration (µg/L)[a]
Kennady Lake	measured baseline	Dissolved	1.63	0.7
		Total	1.69	1.2
Downstream Watersheds	measured baseline	Dissolved	2.07	0.99
		Total	2.15	1.28
Kennady Lake	predicted maximum concentrations after refilling	Dissolved	2.14	1.7
		Total	2.22	**<u>2.3</u>**
Kennady Lake	predicted maximum long-term steady state water quality	Dissolved	1.79	1.5
		Total	1.86	**<u>2.0</u>**
Lake N11	predicted maximum concentrations during Kennady Lake dewatering	Dissolved	1.86	1.12
		Total	1.93	1.5
Lake N11	predicted maximum concentrations during Kennady Lake closure flooding	Dissolved	2.22	1.0
		Total	2.30	1.3
Area 8	predicted maximum concentrations post-closure	Dissolved	1.97	1.4
		Total	2.05	2.0
Lake 410	predicted maximum concentrations during construction, operations, closure, and post-closure	Dissolved	1.86	1.09
		Total	1.93	1.4

Note: Bold underlined values indicate the copper concentration exceeds the corresponding BLM-derived CEB.

[a] Copper concentrations were measured for the baseline scenarios, and predicted from modeling for the other scenarios.

µg/L = micrograms per litre; CEB = chronic effects benchmark; BLM = Biotic Ligand Model.

Limitations

As with all models, the BLM has limitations based on its assumptions and data inputs. Model limitations are:

- Not all parameters were measured or predicted such as humic acid content, pH and sulphide. To run the model, average baseline concentrations were used, which may not be representative of concentrations during operations and closure.

- Seasonal variation of water quality is not taken into account by the BLM, as modelled water quality was not predicted for each season. For example, under-ice versus open water conditions can vary, but are not predicted separately for future scenarios.
- There is uncertainty associated with water quality predictions used as inputs.

Model Sensitivity

The BLM is most sensitive to changes in pH and dissolved organic carbon. Trials using the BLM were run to determine sensitivity to changes of the individual inputs. Maximum concentrations in Kennady Lake after refilling were assumed (Table AANDC_9-1) then each individual parameter was increased 25%, while holding the remaining parameters constant. As pH is based on a log scale, it was tested at pH 6.3, 6.8, and 7.0 (i.e., measured median Kennady Lake open-water baseline values) to simulate realistic pH changes. The resulting BLM-derived CEB was reported as a percentage of the original (Table AANDC_9-4).

The BLM model was most sensitive to pH, DOC, followed by percent humic acid. An increase in pH from 6.5 to pH 6.8 and 7.0 resulted in BLM-derived CEBs for copper that were 70% and 132% higher, while decreasing pH to 6.3 reduced the BLM-derived CEB 34% to 1.41 µg/L. Increasing DOC by 25% caused the BLM-derived CEB to increase approximately 25%; as the percent humic acid increased by 25% the CEB increased by 15.6%. As the BLM is most sensitive to pH and the amount and quality of DOC, it is important that these parameters be measured during monitoring, and included in new BLM-derived CEB predictions.

Table AANDC_9-4 Sensitivity of the BLM to 25% Increases in Individual Parameters With Other Parameters Unchanged

Parameter	Initial Concentration[(a)]	Increased 25%	Initial BLM-derived CEB (µg/L)[(a)]	BLM-derived CEB After 25% Increase in Parameters (µg/L)	% Change
Temperature (°C)	15	18.75	2.14	2.14	0.2
pH[(b)]	6.5	6.3[(b)]	2.14	1.41	-34
pH[(b)]	6.5	6.8[(b)]	2.14	3.64	70
pH[(b)]	6.5	7.0[(b)]	2.14	4.97	132
Dissolved Organic Carbon (mg/L)	4	5	2.14	2.68	25.5
Humic Acid (%)	10	12.5	2.14	2.47	15.6
Calcium (mg/L)	27	33.75	2.14	2.20	2.9
Magnesium (mg/L)	4.6	5.75	2.14	2.17	1.3
Sodium (mg/L)	15	18.75	2.14	2.20	2.9
Potassium (mg/L)	2.8	3.5	2.14	2.14	0.1
Sulphate (mg/L)	20	25	2.14	2.13	-0.5
Chloride (mg/L)	64	80	2.14	2.12	-0.9
Alkalinity (mg/L)	6.51	8.14	2.14	2.14	0.1

(a) The initial CEB and initial parameter concentrations presented are from the Kennady Lake maximum after filling scenario (Table AANDC_9-1).

(b) pH was tested at 6.3, 6.8, and 7.0 to simulate a range of pH changes.

% = percent; µg/L = micrograms per litre; mg/L = milligrams per litre.

Sources of Uncertainty

The BLM-derived CEBs and predicted water quality results are based on models, which have uncertainty associated with them. First, using baseline conditions where parameters were not predicted could lead to lower or higher copper BLM-derived CEBs. For example, DOC concentrations are expected to increase due to increased productivity in Kennady Lake (Section 8.2; De Beers 2011). This would mitigate copper toxicity and result in a higher BLM-derived CEB for copper. Uncertainty associated with the water quality predictions is discussed in Section 8.15.3 of the 2011 EIS Update. Predicted water quality is based on several inputs (i.e., surface flows, groundwater flows and seepage, background water quality and geochemical characterization), all of which have inherent variability and uncertainty. As such, it is suggested that water quality predictions should not be used to predict absolute concentrations, but rather as a planning tool and to develop monitoring plans (Appendix 8.I.5; De Beers 2011).

Uncertainty associated with the BLM and water quality predictions could alter the BLM-derived CEBs. As such, the BLM-derived CEBs using the predicted parameter concentrations are best estimates that need to be verified. Monitoring of water quality will be carried out to verify model inputs, particularly those parameters that were not predicted, and predictions will be adjusted accordingly. The BLM model will be used update BLM-derived CEBs when monitoring data are available. It will be important to measure all parameters that are required for the model, including the humic acid proportion of dissolved organic carbon. Adaptive management strategies will be adopted, if necessary (Section 8.15.3; De Beers 2011).

References

CCME (Canadian Council of Ministers of the Environment). 2007. A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life. Winnipeg, MB, Canada.

CCME. 2011. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table. Available at http://ceqg-rcqe.ccme.ca/. Accessed March 3, 2012.

De Beers (De Beers Canada Inc.). 2010. Environmental Impact Statement for the Gahcho Kué Project. Volumes 1, 2, 3a, 3b, 4, 5, 6a, 6b, 7 and Annexes A through N. Submitted to Mackenzie Valley Environmental Impact Review Board. December 2010.

De Beers. 2011. Environmental Impact Statement for the Gahcho Kué Project. Volumes 3a Revision 2, 3b Revision 2, 4 Revision 2, and 5 Revision 2. Submitted to the Mackenzie Valley Environmental Impact Review Board in Response to the Environmental Impact Statement Conformity Review. July 2011.

De Beers. 2012. Environmental Impact Statement Supplemental Information Submission for the Gahcho Kué Project. Submitted to the Mackenzie Valley Environmental Impact Review Board. April 2012.

Grosell M. 2012. Copper. In Wood CM, Farrell AP, Brauner CJ. Homeostasis and Toxicology of Essential Metals. Fish Physiology Volume 31 A. Academic Press / Elsevier, New York, NY, USA, pp 53-133.

HydroQual (HydroQual, Inc.) 2007a. The Biotic Ligand Model Windows Interface, Version 2.2.3: User's Guide and Reference Manual. Mahwah, NJ, USA.

HydroQual. 2007b. Biotic Ligand Model, Version 2.2.3. Available online: http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/pollutants/copper/2007_index.cfm. Accessed: February 27. 2012.

USEPA (United States Environmental Protection Agency). 2007. Aquatic Life Ambient Freshwater Quality Criteria - Copper. 2007 Revision. Washington, DC, USA. Available online: http://www.epa.gov/waterscience/criteria/aqlife.html.

USEPA. 2009. The Biotic Ligand Model: Technical Support Document for Its Application to the Evaluation of Water Quality Criteria for Copper. Washington,DC, USA Available online: http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/pollutants/copper/2007_index.cfm. Accessed February 27, 2012.

GAHCHO KUÉ PROJECT ENVIRONMENTAL IMPACT STATEMENT
INFORMATION REQUEST RESPONSES

Information Request Number: AANDC_10

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: Fish Tissue – potential for Hg Biomagnification

EIS Section: Section 8: KLOI Water Quality and Fish in Kennady Lake

Terms of Reference Section:

Preamble:

The EIS indicated that the baseline concentrations of mercury in fish tissue for fish caught from Kennady Lake exceed USEPA risk-based screening criteria for human consumption. The accumulation of mercury is generally strongly correlated with the rate of methylation in water bodies. Methylation tends to be greater in water bodies that have a higher trophic status. The higher trophic status leads to more organic carbon in sediments and anoxic zones that provide substrate for bacteria responsible for methylation.

Given (1) that an active mine may result in an incremental input of mercury, (2) that an increase in P loadings may cause a shift from oligotrophic to mesotrophic conditions, and (3) that these conditions could result in increased uptake of mercury (via methylation), some predictions regarding future concentrations of mercury in fish tissue should be made.

Request

1. Please estimate the mercury concentrations in the tissues of large bodied fish in lake N11 (and downstream) during operation, and in Kennady Lake post-closure;
2. Please also discuss the potential for increased accumulation of other metals due to a trophic shift in Kennady Lake; and
3. Discuss long-term management options if a problem occurs (and is irreversible).

Response

1. The mercury concentrations in the tissues of large bodied fish were estimated in Lake N11 (Table 9.9-9: Predicted Metal Concentrations in Fish Tissues in Lake N11 during Construction, Operation, and Closure, provided in Section 9 of the EIS [De Beers 2010]) and downstream in Lake 410 (Table 9.9-10: Predicted Metal Concentrations in Fish Tissues in Lake 410 during Construction, Operation, and Closure, provided in Section 9 of the EIS [De Beer 2010]) during construction, operation and closure. As well, mercury concentrations in the tissues of large bodied fish were estimated in Kennady Lake post-closure (Table 8.9-11: Predicted Metal Concentrations in Fish Tissues in Kennady Lake under Long-term Water Quality Scenario, provided in Section 8 of the EIS Update [De Beers 2011]).

   Since the submission of the 2011 EIS Update (De Beers 2011), the mine plan has been updated to reflect supplemental mitigation associated with the deposition of fine processed kimberlite (PK) to reduce potential loading of phosphorus. This supplemental mitigation has resulted in a lower volume of fine PK that will be deposited to the Fine PKC Facility. Therefore, the Fine Processed Kimberlite Containment (PKC) Facility's footprint has been reduced to Area 2, which reduces the Fine PK surface area by approximately half as it no longer includes Area 1. This reduction in size alters the projected long-term loading of geochemical sources to Kennady Lake, including mercury.

   Updated water quality modelling of these revised source terms do not change the conclusions of the aquatic health assessment in relation to mercury; the updated assessment of mercury concentrations in the tissues of large bodied fish in Lake N11 and Lake 410 during operation, and in Kennady Lake during post-closure are provided in Sections 8 and 9 of the 2012 EIS Supplement (De Beers 2012).

2. The reduction in size of the Fine PKC Facility under the current mine plan reduces the long-term TP loading from the facility to Kennady Lake. In addition, on-going geochemical testing of site-specific PK material has identified that the source term phosphorus loading from fine PK material is not as high as reported in the 2011 EIS Update (De Beers 2011). Updated water quality modelling based on revised source term inputs of TP projects the long-

term steady state TP concentrations to be 0.009 milligrams per litre (mg/L) in Kennady Lake and 0.006 mg/L in Lake 410, and a maximum of 0.005 mg/L in Lake N11 during operations (De Beers 2012). As a result, a long-term shift in trophic status in Kennady Lake is not predicted.

3. Various possible management options with respect to mercury accumulation in fish tissue may be employed in the unlikely scenario that mercury concentrations (adjusted for fish age, which is a major modifying factor) showed a significant upward trend. Possible management options include liming, fish barriers, fish consumption advisories, or selenium additions. Specific management options would be determined if and when necessary in consultation with regulatory agencies and communities.

References

De Beers (De Beers Canada Inc.). 2010. Environmental Impact Statement for the Gahcho Kué Project. Volumes 1, 2, 3a, 3b, 4, 5, 6a, 6b, 7 and Annexes A through N. Submitted to Mackenzie Valley Environmental Impact Review Board. December 2010.

De Beers. 2011. Environmental Impact Statement for the Gahcho Kué Project. Volumes 3a Revision 2, 3b Revision 2, 4 Revision 2, and 5 Revision 2. Submitted to the Mackenzie Valley Environmental Impact Review Board in Response to the Environmental Impact Statement Conformity Review. July 2011.

De Beers. 2012. Environmental Impact Statement Supplemental Information Submission for the Gahcho Kué Project. Submitted to the Mackenzie Valley Environmental Impact Review Board. April 2012.

Information Request Number: AANDC_11

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: Managing PAG mine rock/barren kimberlite

EIS Section: Section 3: Project Description

Terms of Reference Section:

Preamble:

It is reported (3.7.3.3) that PAG mine rock as well as barren kimberlite will be sequestered within the interior of the mine rock piles in areas that will allow permafrost to develop or will be underwater when Kennady Lake is refilled. Although these long term solutions for handling PAG materials are identified, the day to day activities to be undertaken with respect to the management of PAG materials at the site during construction and operation of the mine (i.e., prior to implementing these long term solutions) require more detailed discussion.

Request

Please describe the day to day activities that will take place at the mine site recognizing that some materials encountered during development and operation of the mine will be acid generating or at least potentially acid generating. Items that should be discussed include:

1. De Beers on-site PAG sampling and analysis capabilities as they relate to effective decision making with respect to materials handling on a day to day basis;

2. Procedures in place to ensure that PAG materials are not inadvertently used for construction of roads, airstrips, dykes, berms, etc.; and

3. Interim measures to be employed (e.g., storage location, duration, management and monitoring practices, etc) regarding the handling and storage of PAG materials (i.e., prior to encapsulation and/or underwaterstorage).

Response

1. De Beers plans to have potentially acid generating (PAG) sampling capability. The analysis will either be carried out on site or sent to a certified lab off site. The site specific mine rock classification criteria are discussed in Section 8.II.5.1.1 of Appendix 8.II of the 2010 EIS (De Beers 2010). The following procedures will be undertaken to identify and manage the placement of mine rock types in the field:

    - Lithological and/or geochemical criteria will be defined to segregate non-reactive mine rock from potentially reactive mine rock

    - A detailed plan for achieving segregation of non-reactive vs. potentially reactive mine rock will be developed for implementation as part of the mine plan. Such plans are in place for Diavik and Ekati and commonly include the following activities:

        - sample the blast hole cuttings for geochemical testing prior to the blast or removal of blasted rock

        - prepare maps showing the geochemical data, rock type designation, and designated mine rock disposal locations

        - trained mine geology personnel will map out the rock type limits practical for segregation

        - visually inspect the muck pile to confirm layout after the blast

        - demarcate rock type area(s) using colour coded flagging or other similar scheme

        - Inform drivers of the rock type they will be hauling; drivers will be made aware of the different dump locations for each rock type.

2. De Beers will use only non-reactive mine rock for mine site construction (roads, airstrips, dykes, berms, etc.). The procedures described above will be used to segregate non-reactive mine rock from potentially reactive mine rock.

3. Permanent storage areas for PAG rock will be available throughout the mine life. Therefore, interim measures need not be employed. The handling and storage of PAG materials includes the following:

   - The PAG materials will be placed directly within designated areas in the two mine rock piles and the mined-out 5034 pit according to the current mine rock management plan. Rock re-handling is not planned.

   - The materials encapsulating the portion of the PAG materials that are to be placed above the restored Kennady Lake water elevation will be placed around the PAG materials in the mine rock piles.

   - The mine rock piles are to be located inside the watershed of the water management system during mine operation. Therefore, the runoff from the mine rock piles will naturally flow into the controlled basins, which are internal to the water management system. The runoff water quality can be monitored to provide information for any required adjustment to the mine waste and water management plans during mine operation and later for finalizing mine closure plan.

References

De Beers (De Beers Canada Inc.). 2010. Environmental Impact Statement for the Gahcho Kué Project. Volumes 1, 2, 3a, 3b, 4, 5, 6a, 6b, 7 and Annexes A through N. Submitted to Mackenzie Valley Environmental Impact Review Board. December 2010.

GAHCHO KUÉ PROJECT ENVIRONMENTAL IMPACT STATEMENT
INFORMATION REQUEST RESPONSES

Information Request Number: AANDC_12

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: : Water Quality – Possible treatment options

EIS Section: Section 8: KLOI Water Quality and Fish in Kennady Lake, Section 10: KLOI Long-term Biophysical Effects, Closure and Reclamation

Terms of Reference Section:

Preamble:

During operations, water from the WMP will be discharged to Lake N11, provided that discharge criteria are achieved. Similarly the reclaimed portions of Kennady Lake will be re-connected with Area 8 post-closure, once appropriate water quality has been achieved. Contingency options will be required in the event the discharge criteria cannot be met or appropriate water quality has not been achieved.

Request

1. Please identify and evaluate contingency options available to DCI in the event water cannot be discharged from the WMP during operations.

2. Please identify and evaluate contingency options available to DCI in the event water in Kennady Lake does not meet water quality objectives post-closure.

Response

1. There are contingency options available in the event water cannot be discharged from the Water Management Pond (WMP) during operations (i.e,, discharge water criteria cannot be met). The exact contingency options depend on the circumstances and timing of the event. The following lists some of the contingency options in the event that water cannot be discharged from the WMP during operations:

   - An excess water storage capacity has been incorporated into the water management system during mine operation for the current water management plan. The excess capacity varies depending on the water levels in several basins in the water management system and the timing of the mined out open pits becoming available for water storage. This option would be the first option to be considered under the upset situation when water cannot be discharged from the WMP during operations. Note that the ultimate water storage capacity of the water management system for the current water management plan was determined based on a conservative assumption that water from the WMP to outside environment will be discharged only during the early mine operation period (up to Year 4).

- Discharge can be carried out during different periods of the year when water quality may be better, i.e. during periods when ice cover is on the lake, or when freshet is occurring.

- Separate the water sources based on water quality, sequester poor quality water (e.g., pit water) in an isolated water management pond or a mined-out pit, and discharge the better quality water (e.g., natural runoff water) when its water quality meets discharge criteria.

- Maximize the use of poor quality water (e.g., pit water) as process make-up water. A portion of the water will be locked in the fine PK within or the mined out pit, therefore, the overall water quality in the WMP could be improved.

- Remove suspended solids with a combination of flocculants and a settling pond to meet discharge criteria. For example, a filter dyke can be constructed inside of Area 7 to separate Area 7 into two cells - one cell for settling and another for clean water discharge.

- Further increase the overall water storage capacity of the water management system by raising dykes. This option will provide additional water storage capacity in the water management system.

- Install a water treatment plant to deal with specific water quality parameters of concern.

2. There are several contingency options available to DCI in the event water in Kennady Lake does not meet water quality objectives post-closure.

- The water quality will be monitored throughout the mine life to identify future risk and deal with the potential issues well in advance during mine operations and closure before Kennady Lake is fully restored. During closure, the rate of refilling of Kennady Lake is controlled by the pumping of water from N11 and by water flowing into Kennady Lake after the removal of dykes E, F and G. The following measures can be applied to identify the risk and deal with the potential water quality issues:
    - If a specific water quality issue is identified during mine operation, the overall water and mine waste management plans will be modified to mitigate the issue.
    - If a risk is identified during early mine closure, adjust the closure and refilling plan accordingly. For example, breaching of Dykes E, F, and G can be delayed and refilling pumping from Lake N11 may be adjusted to allow a longer closure period to deal with the potential water quality issue before the water level in the controlled basin is raised to its original lake elevation of 420.7 metre (m).
    - Identify the key sources of the poor quality water and develop specific plans to improve the water quality.
- In an unlikely case that the water quality cannot meet discharge criteria after the water level in the controlled basin continues to rise towards the original lake elevation of 420.7 m, the following measures can be applied:
    - Delay or constrict the flow rate after breaching of Dykes E, F, and G
    - Reduce the refilling pumping from Lake N11 may be adjusted to allow a longer closure period
    - Isolate the basin with poor quality water from the area where the water quality can meet discharge criteria. This will allow early restoration of a portion of the controlled basin. For example, Area 7 may be restored earlier.
    - Raise the containment dykes to store the poor quality water until the water quality meets discharge criteria.
    - Treat the poor quality water zone.

Information Request Number: AANDC_13

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: Limnology – potential for vertical mixing post-closure

EIS Section: Section 8: KLOI Water Quality and Fish in Kennady Lake

Terms of Reference Section:

Preamble:

Two models were used to evaluate the stratification in the Tuzo Pit: CE-QUALW2 for the first 100 years; and a long-term “vertical slice spreadsheet model” for 15,000 years. Insufficient information about these models, the inputs to them, and the results obtained from them, is provided to assess their effectiveness in predicting the water quality in Tuzo Pit and the restored Kennady Lake.

The conclusions drawn from the hydrodynamic modeling are given in 8.8.4.2.1:

> “The hydrodynamic results indicate that the rate of drop in pycnocline elevation will decline with time, which has two implications for water quality in Kennady Lake. First, it indicates that influences of Tuzo Pit water on Kennady Lake water quality will diminish with time, because the relative amounts of upward flux water will decrease accordingly. Secondly, it indicates a strengthening of the stratification as the pycnocline becomes deeper.”

and from the long-term modeling given in 8.8.4.2.2:

> “it may be concluded with some confidence from this modeling that stratification in Tuzo pit will strengthen in time.”

In both cases it is concluded that the stratification will strengthen with time, and the implication is that because the stratification is strong then the good quality surface water will be “isolated” from the poor quality deep water. AANDC is concerned that while a strong pycnocline will inhibit exchange of deep water with shallow water, it will never prevent it entirely. From Fick's Law the vertical mass transport of a solute per unit area is given by:

$$q = \varepsilon_V \frac{\delta C}{\delta z}$$

where ε_V is the vertical diffusivity, C is the concentration of solute, and z is the vertical direction. In general, the vertical diffusivity cannot be predicted with any confidence. In the case of the Tuzo Pit/Kennady Lake its estimation is particularly problematic given the unusual shape of the pit, the extreme climatic conditions and the absence of data from analogous systems. An appreciation for the range of possible values of vertical diffusivity is given by Powell Lake, which has been meromictic for at least 11,000 years. Estimates of the vertical diffusivity range from 474 m^2/yr (1.5 x 10^{-5} m^2/s) near the surface down to 0.55 m^2/yr (1.7 x 10^{-8} m^2/s) near the bottom (Sanderson et al. 1986). The latter value is just 3.7 times the vertical diffusivity of salt. As a result, there is a wide range to the potential flux of water from the Tuzo Pit. This range should be used to bound the predicted water quality.

Once solute has moved from Tuzo Pit into Kennady Lake the next level of uncertainty is what proportion of that material will be flushed from the lake due to fresh water inflows each season. It is difficult to predict how effectively the spring freshet will mix with the water in Kennady Lake. One important factor to consider is the effect of ice cover. When ice forms it excludes most of the salt present in the water. The effects of this exclusion are not well understood, and not incorporated into CE-QUAL-W2. This may be important in that the volume of ice cover is a significant proportion of the volume of the mixolimnion of the lake. After ice melt a fresh layer will be present on the surface of the lake, overlying a more saline layer. Thus, during spring freshet there are basically three water masses to consider in Kennady Lake: the fresh ice-melt, the more saline water below it (containing solute that originated in Tuzo Pit) and the spring freshet. The manner in which these water masses mix together governs the quality of the water flowing out of the lake each year and, ultimately, the water quality within the lake. The complexities of this mixing process are not likely to be captured by CE-QUAL-W2. Rather than trying to achieve accurate predictions, it is more realistic to run the model with a range of input conditions, and assumptions, to determine bounds on the potential water quality.

Request

1. Please summarize the data that were used as input to the models including:
   a) the flow rate of water to fill the pit and lake
   b) the time it will take to fill the pit and lake
   c) groundwater flow rates, before, during and after filling
   d) groundwater quality – summarize the parameters of concern and give the relevant concentrations
   e) the annual volume of freshwater inflow to Kennady Lake after filling, including:
      i) typical ice and snow thickness
      ii) volume and area of the section of the lake modeled

*Note that much of this information is already provided but not summarized in one area. The requested data should provide enough information for the reader to evaluate the results.

2. Please provide simple calculations to bound the uncertainty in the water quality. What would the water quality be?
   a) if the entire pit and lake were well mixed
   b) if the largest flux of deep water (obtained using an upper bound estimate of ε_v), mixed into a smaller volume of Kennady Lake (due to stratification as described above)
3. Please provide details of the vertical slice spreadsheet model. In particular provide details of the value(s) used for the vertical diffusivity and how they were determined. Please provide a plot of the predicted vertical flux of TDS versus time. Please provide an additional plot of the predicted vertical flux of TDS versus time if the vertical diffusivity is increased by a factor of 10. What

effect would such an increase in the estimate of vertical diffusivity have of the predicted water quality in Kennady Lake?

4. Please provide details of how CE-QUAL-W2 is able to predict the water quality in Kennady Lake. Please provide estimates of the inaccuracy of the modeling process.

Response

A detailed description of the hydrodynamic and vertical spreadsheet models is provided in Section 8.I.4 of Appendix 8.II in the 2012 EIS Supplement (De Beers 2012). The majority of the information requested in this IR is contained within that appendix. The model results are provided in Section 8 of the 2012 EIS Supplement. A summary of the model assumptions is provided in the responses below.

1. Please summarize the data that were used as input to the models including:
   a) the flow rate of water to fill the pit and lake
   b) the time it will take to fill the pit and lake
   c) groundwater flow rates, before, during and after filling
   d) groundwater quality – summarize the parameters of concern and give the relevant concentrations
   e) the annual volume of freshwater inflow to Kennady Lake after filling, including:
      i) typical ice and snow thickness
      ii) volume and area of the section of the lake modeled

a. The approximate annual average flows used to calculate the refill time for Kennady Lake are summarized in Table ANNDC_13-1.

Table AANDC_13-1. Summary of Kennady Lake Closure Inflows

Flow	Value (m^3/year)
Natural Runoff	1,524,600
Mine Rock Piles	308,000
Coarse PK Pile	67,200
Fine PKC Facility	309,000
D-E-B Watershed Inflows	1,217,836
Pumped Water from Lake N11	3,336,100

b. It is anticipated that the Tuzo pit void will be filled after a period of approximately 5.5 years and Kennady Lake will require approximately 8.7 years to refill (De Beers 2012).

c. Groundwater inflow rates during operations and refilling are presented in Tables 11.6-5 and 11.6-6, respectively in Section 11.6.4.1.2 of the 2010 EIS (De Beers 2010). Groundwater inflow rates following refilling are provided in Table 11.6.II-2 in Section 11.6.II.3.

d. Groundwater quality data are presented in Appendix G.I of Annex G (Hydrogeology Baseline) of the 2010 EIS. Groundwater quality parameters were correlated to TDS and non-correlated parameters (i.e. no relationship to TDS concentrations) for incorporation into the water quality modelling assessment. These data are presented in Tables 8.I-5 and 8.I-7, respectively in Section 8.I.2.4.5.2 of Appendix 8.II of the 2012 EIS Supplement.

e. The annual volumes of freshwater flowing into Kennady Lake are provided in Table AANDC_13-1. Runoff into the lake due to snowmelt is included in the monthly water balance, described in Attachment 8.II.1 of Appendix 8.II of the 2012 EIS Supplement that was applied to the hydrodynamic and water quality models. This water balance includes inflows from the surrounding watershed and at the lake surface. It is anticipated that the ice thickness will be approximately 125 cm each winter, based on measurements at Snap Lake (Golder 2011).

The 2D hydrodynamic model was configured to match the bathymetry in Kennady Lake including Areas 3/5 to Area 7. The volume and the area of the section modeled were 85 Mm^3 and 5.2 km^2, respectively.

2. Please provide simple calculations to bound the uncertainty in the water quality. What would the water quality be?

   a) if the entire pit and lake were well mixed

   b) if the largest flux of deep water (obtained using an upper bound estimate of ε_v), mixed into a smaller volume of Kennady Lake (due to stratification as described above)

a. Two calculations are provided to illustrate the whole lake TDS concentrations if the water stored in the monimolimnion were to completely mix in the overlying mixolimnion:

   i. The water quality following complete mixing the month prior to Kennady Lake being refilled in 2034; and

   ii. The Kennady Lake water quality following complete mixing after steady-state concentrations have been achieved in Kennady Lake circa, 2204.

   The mixed whole lake TDS concentrations for these two scenarios were simulated to be approximately 1,200 and 300 mg/L, respectively. It is important to note that the numbers presented in this response are considered overly conservative and do not represent an anticipated scenario of permanent meromixis.

b. A bounds on water quality estimates is provided by two sets of simulations: a conservatively derived, expected case, as provided in the 2012 EIS

Supplement, and a fully mixed condition, which could be considered worst-case, are provided in part a of this response.

3. Please provide details of the vertical slice spreadsheet model. In particular provide details of the value(s) used for the vertical diffusivity and how they were determined. Please provide a plot of the predicted vertical flux of TDS versus time. Please provide an additional plot of the predicted vertical flux of TDS versus time if the vertical diffusivity is increased by a factor of 10. What effect would such an increase in the estimate of vertical diffusivity have of the predicted water quality in Kennady Lake?

As stated in Section 8.8.4.2.2 of the 2011 EIS Update (De Beers 2011), vertical diffusion was not included as a process in the vertical slice model. Rather, a simple mass balance that included advective flux due to displacement by inflowing groundwater was used to simulate long-term conditions in the pit. The point of this calculation was not to predict absolute concentrations over 15,000 years, but instead to predict the general trend of the density of water beneath the pycnocline.

The EIS lists two sources of uncertainty in the results predicted by this spreadsheet model:

- vertical diffusion; and
- extrapolation of groundwater inflows beyond the modelled timeframe.

A third source of uncertainty that is implicit in all predictions that span such time frames is geologic processes. Of these three potential sources of uncertainty, vertical diffusion is thought to be the smallest. Adding this process to the calculation would change the predicted profile (i.e., change the shape of the curves in Figure 8.8-26), but it would not change the conclusion that inflows of saline groundwater at depth will lead to a strengthening of meromixis in the long term.

4. Please provide details of how CE-QUAL-W2 is able to predict the water quality in Kennady Lake. Please provide estimates of the inaccuracy of the modeling process.

The CE-QUAL-W2 model was used to predict the long-term stability of the pycnocline (chemocline) in the pit. This was completed by using a tracer constituent to estimate the rates of constituents released from the monimolimnion. The initial tracer concentration was set to 1 mg/L in the monimolimnion of both pits and 0 mg/L in the mixolimnion. Based on the simulated vertical profiles of tracer concentrations, equivalent replacement volumes in the monimolimnion were calculated. The calculated replacement volumes were then transferred to the Kennady Lake GoldSim™ water quality model, and these volumes were used as time series of water movement from each pit into the closure Kennady Lake. The associated mass of constituents from each pit was also transferred upwards in the model from the monimolimnion to the mixolimnion. An updated description of the model development and application is provided in Section 8.II.4 of Appendix 8.II of the 2012 EIS Supplement.

The uncertainty in the associated with the model is provided in Section 8.II.5 in Appendix 8.II of the 2012 EIS Supplement.

References

De Beers (De Beers Canada Inc.). 2011. Environmental Impact Statement for the Gahcho Kué Project. Volumes 3a Revision 2, 3b Revision 2, 4 Revision 2, and 5 Revision 2. Submitted to the Mackenzie Valley Environmental Impact Review Board in Response to the Environmental Impact Statement Conformity Review. July 2011.

De Beers. 2012. Environmental Impact Statement Supplemental Information Submission for the Gahcho Kué Project. Submitted to the Mackenzie Valley Environmental Impact Review Board. April 2012.

EBA. 2011. Updated Summary of Water Management and Balance during Mine Operation, Gahcho Kué, NWT (for updated fine PK disposal plan – Option 2). EBA File: E14101143.

Golder Associates Ltd. (Golder). 2011. Preliminary Water Quality Modelling Technical Memorandum. Supporting Document #7. De Beers Snap Lake Water License Application. Submitted to Mackenzie Valley Land and Water Board. June 2011.

GAHCHO KUÉ PROJECT ENVIRONMENTAL IMPACT STATEMENT
INFORMATION REQUEST RESPONSES

Information Request Number: AANDC_14

Source: Aboriginal Affairs and Northern Development Canada (AANDC)

Subject: Permafrost

EIS Section: Section 3: Project Description

Terms of Reference Section:

Preamble:

Reference. p. 3-104. “The upper portion of the thick cover of clean mine rock over the waste depository will be subject to annual freeze and thaw cycles, but the PK and PAG rock sequestered below are predicted to remain permanently frozen”

Request

1. Please describe the method of prediction and the numerical basis that led to this result. Please supply details of such prediction, including:

    a) The model of the thermal regime of the rock pile.

    b) The effect of the lake on the constructed pile’s thermal regime.

    c) The physical processes of heat transfer in the coarse rock pile.

    d) Thermal properties of the coarse rock required to model the thermal regime.

    e) Effect of climate change on temperatures within the rock piles.

    f) Time scale over which permafrost is expected to develop in the rock pile, and the time scale of which it is anticipated to be maintained, given the prospect of climate change in the region.

Response

Permafrost is expected to develop within the mine rock piles over a period of time; however it is not a requirement of the design that there is permafrost present. The statement referred to above is an observation of the likely conditions within the mine rock pile and not intended to be a prediction upon which the design is based.

Because the mine rock management for the Gahcho Kué Project is not dependent on permafrost development and its presence in the mine rock piles even though permafrost development would be potentially beneficial, a specific thermal analysis on the mine rock piles for the mine rock management plan presented in 2010 EIS (De Beers 2010) has not been conducted. Therefore, analysis details to answer the questions a) to f) are not applicable.

Projections of water quality in Kennady Lake did not include the development and persistence of permafrost conditions within the mine rock piles, the Coarse processed kimberlite (PK) Pile, and the Fine Processed Kimberlite Containment (PKC) Facility. It was assumed that seepage quantities from these facilities would be representative of no permafrost conditions, and provide seasonal geochemical loading to Kennady Lake after closure under long term conditions associated with climate change.

It is recognized that frozen layers will establish during the development of these facilities and that permafrost will likely continue to develop for a period of time following closure, which will result in lower rates of seepage through the facilities and geochemical loading to Kennady Lake than simulated in this environmental impact assessment.

References

De Beers (De Beers Canada Inc.). 2010. Environmental Impact Statement for the Gahcho Kué Project. Volumes 1, 2, 3a, 3b, 4, 5, 6a, 6b, 7 and Annexes A through N. Submitted to Mackenzie Valley Environmental Impact Review Board. December 2010.