Board Secretary

From: EA-SnapLake
Sent: Wednesday, March 19, 2003 6:07 PM
To: Board Secretary
Subject: RE: INAC's Addendum to Technical Reports

Here is INAC's email - you can print this off and log in public registry and refer to the hard copy you received the other day. Call me if you don't get this.

Glenda

-----Original Message-----
From: Fraser Fairman [mailto:fairmanf@inac-ainc.gc.ca]
Sent: Fri 2003-03-14 3:44 PM
To: dbevington@auroranet.nt.ca; colleen.english@ca.debeersgroup.com; John.McConnell@ca.debeersgroup.com; judy.langford@ca.debeersgroup.com; kevin.ledrew@ca.debeersgroup.com; robin.johnstone@ca.debeersgroup.com; letha@canada.com; BalintD@dfo-mpo.gc.ca; blaise@dfo-mpo.gc.ca; DahlJ@dfo-mpo.gc.ca; anne.wilson@ec.gc.ca; Mark.Dahl@ec.gc.ca; Mike.Fournier@ec.gc.ca; stephen.harbicht@ec.gc.ca; swilbur@entrix.com; byerses@escape.ca; ima.nwtmn@gardtal.com; edenholm@gartnerlee.com; gfratton@gartnerlee.com; smorison@gartnerlee.com; Dawn_Kelly@golder.com; hmachtans@golder.com; lgreen@golder.com; Gavin_More@gov.nt.ca; Jason_McNeill@gov.nt.ca; steven_matthews@gov.nt.ca; tpearse@gulfislands.com; Jagtar_Sandhu@hc-sc.gc.ca; Surinder_Grewal@hc-sc.gc.ca; Adelinca@hotmail.com; Keith_Jen@hotmail.com; Tamara Hamilton; Mary Tapsell; Buddy Williams; ellis@internorth.com; nlawson@jacqueswhitford.com; ARLaboucan@lutselke.com; Ritac@lutselke.com; wildlife@lutselke.com; wwfnwt@mailmarinenet.net; Alan Ehrlich; Bridgette Larocque; EA-SnapLake; Vern Christensen, Executive Director; kristyn@mvlwb.com; mvlwbpermit@mvlwb.com; jramsey@NRCan.gc.ca; bobz@nsma.net; garth@nt.sympatico.ca; jhutchison@nucleus.com; Chuck.Blyth@pc.gc.ca; SBriscoe@polarnet.ca; jfreeman@rfi.on.ca; michaelthoms@shaw.ca; ATgovt@ssimicro.com; denenationcp@ssimicro.com; econorth@ssimicro.com; mvaydik@ssimicro.com; Ravencom@ssimicro.com; SOLOWAD@tc.gc.ca; donihee@telusplanet.net; galson@telusplanet.net; carc@theedge.ca; cpawsnwt@theedge.ca; geonorth@theedge.ca; lucianoa@theedge.ca; zabey@tlicho.com; donihee@ucalgary.ca; laura@whatidene.org; Pewins@wwfcanada.org; tiacobelli@wwfcanada.org; execdir@ykchamber.com; rachelc@ykdene.com
Cc: Matt Bender; Sevn Bohnet; Kenneth Dahl; Francis Jackson; Malcolm Robb; Michael Roesch; Velma Sterenberg
Subject: INAC's Addendum to Technical Reports

Hi Glenda:

Please find attached, INAC's addendum to our Technical Reports, on the De Beers Snap Lake Diamond Project Environmental Assessment. This addendum focuses on Geotechnical, Hydrogeological, Geotechnical, Hydrological, Impact Assessment, Environmental Quality and Cumulative Effects Assessment Issues.

There still remains issues that INAC fells have not been fully addressed, however, we will continue to work with De Beers as move towards the Pre-Hearing Conference and the Public Hearings in April, to resolve these issues.

Should you have any questions please do not hesitate to contact Tamara Hamilton at 867-669-2616.

Cheers Fraser Fairman

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PO Box 1500
YELLOWKNIFE, NT X1A 2R3

March 14, 2003

RECEIVED
MAR 1 4 2003
MACKENZIE VALLEY ENVIRONMENTAL IMPACT REVIEW BOARD

Glenda Fratton
Mackenzie Valley Environmental Impact Review Board
PO Box 938
YELLOWKNIFE, NT X1A 2N7

Dear Ms. Fratton:

Re: Addendum to the Technical Submissions of the Environmental Assessment (EA) Report for the De Beers Canada Mining Inc. (DCMI) for the Proposed Snap Lake Diamond Project

The attached addendum is Indian and Northern Affairs Canada's (INAC's) response to the information that was submitted by De Beers between January 24, 2003 and February 28, 2003, as outlined in the Mackenzie Valley Environmental Impact Review Board's (Review Board's) letter of February 24, 2003, titled *Clarification on the De Beers EA Proceeding*.

Please refer to the executive summary, and the attachment which outlines our position on all outstanding issues as of March 14, 2003.

If you have any questions regarding the attached addendums, please do not hesitate to contact myself at 669-2647.

Yours Sincerely,

D Livingstone

David Livingstone
Director, Renewable Resources and Environment

Attachment

Canada

An Addendum to:

-An Evaluation of the Environmental Assessment of the Proposed Snap Lake Diamond Project-

Report Submitted to:

Mackenzie Valley Environmental Impact Review Board
PO Box 938
Yellowknife, NT
X1A 2N7

Submitted - March 14, 2003 - by:

Water Resources Division
Indian and Northern Affairs Canada
Bellanca Building, PO Box 1500
Yellowknife, Northwest Territories
X1A 1N5

Executive Summary

On February 14, 2003, the Water Resources Division Submitted a report titled "An Evaluation of the Environmental Assessment of the Proposed Snap Lake Diamond Project" which identified several water related issues with the project. Between January 24, 2003, and February 28, 2003, De Beers Canada Mining Inc. (DCMI) submitted numerous technical memorandums to the Mackenzie Valley Impact Review Board (MVEIRB) in response to many of the issues identified during the Technical Sessions, discussed during teleconferences and presented in technical reports submitted by various reviewers.

Upon review of the recently submitted, or "New" information, we continue to have outstanding concerns and issues with the environmental assessment of this project. Recognising the tremendous amount of new information provided by the proponent and the limited amount of time to review and respond to this information, we are submitting the comments contained in this report as a follow up addendum to our previous submission.

Please note that for the purposes of this addendum only those issues, where our concerns have changed or have been altered in response to the new information, are presented herein. All other issues which have not changed, remain as currently expressed in our February 14th report and should be considered 'as is'.

Conclusions

The Water Resources Division identified a substantial number of concerns that have not been resolved through the information requests, technical sessions, or recent submissions by the proponent. Together, the uncertainties associated with these unresolved issues lead us to conclude that the effects of mining activities on water quality in Snap Lake and associated impacts on aquatic organisms are substantially underestimated. Until the outstanding issues have been resolved, INAC continues to consider the EA to be incomplete and, as such, does not provide an adequate basis for assessing the impacts of the proposed project.

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1.0 Introduction

As indicated in our Technical Report Submission of February 14, 2003, INAC has identified a number of issues related to the proposed Snap Lake diamond project that were not been adequately addressed in the EA report, in the responses to information requests, or in the MVEIRB Technical Sessions. Between January 24 and February 28th, 2003, DCMI submitted a number of technical memorandums in response to many of the issues and concerns raised by reviewers throughout the process. The purpose of this addendum to our technical report is to identify to the MVEIRB, the issues which remain unresolved and are unchanged from our previous report and to provide updated comments and status of the concerns in response to the new information provided by DCMI.

2.0 Specific Comments

For ease of reference this addendum follows the same format as the technical report submitted on February 14th. Each issue is addressed with additional comments in regards to the new information provided by De Beers or if there are no additional comments the reader is referenced back to the original report. Each issues is discussed in the context of the original concern, a overview of the new information provided, our conclusions and a summary of the status of the issue.

2.1 Geochemical Issues

As indicated in the technical report submitted to the Mackenzie Valley Environmental Impact Review Board (MVEIRB) on February 14, 2003, INAC had two major and three minor unresolved geochemical issues concerning the predicted quality of water released from stored waste materials and discharged to Snap Lake as part of the proposed Snap Lake Diamond Project. These issues had not been adequately addressed in the EA Report, in the responses to information requests, or in the MVEIRB Technical Sessions.

The five geochemical issues were:

- Geochemical Reactivity of North Pile

- Pore Water Expulsion from the North Pile

- Potentially Incomplete Understanding of Kimberlite Geochemistry;

- Management of a Surface Stockpile of PAG material; and

- Quality Control for Construction Material.

The first two issues were discussed together.

Following submission of that technical report, DCMI has submitted a series of Technical Memoranda. The memorandum that are pertinent to the above geochemical issues are:

- North Pile Chemical Stability
- Snap Lake North Pile Seepage Collection.

DCMI also submitted a Technical Memorandum: 'Cemented Paste PK Kinetic Test Results' that have some bearing on previously predicted mine water quality.

2.1.1 Geochemistry of the North Pile

MVEIRB Terms of Reference: MVEIRB Terms of Reference (ToR) require De Beers to provide an analysis of the proposed development impacts on surface and ground waters, in particular the water chemistry impacts of surface runoff , and the effects of kimberlite and other materials stored in the North Pile, considering acid rock drainage, metal leaching and geochemistry (ToR Reference: line #336 to 341, 379 to 380 and 392). MVEIRB Terms of Reference also require De Beers to provide an analysis of the proposed development impacts on surface and ground waters, in particular the impact of water contained in the process kimberlite deposited in the North Pile and the potential for pore water expulsion during freeze back of the pile (ToR line # 307 to 308, 336 to 341, 379 and 380).

INAC's Concern: De Beers estimated the release of contaminants from the North Pile would arise from two sources:

- release of 14% process water as the paste settled (consolidated) into place in the North Pile, and
- chemical loads produced from the weathering of unfrozen material at the surface of the pile during operations and after closure.

In the technical report, INAC indicated that it was concerned that:

- De Beers did not account for additional draining of process water from unfrozen material (recently provided drained moisture content of 9.4%) ,
- the potential release of COPCs associated with process water expelled as the pile froze,
- the potential for additional weathering input from metavolcanics and/or kimberlite in the North Pile due to optimistic projections of freezing rates ; and,
- the assumption that no contaminant loads would arise from any material below 0° C, despite evidence in the literature that geochemical reactions continue below 0° C, and projected temperatures in substantial portions of the pile were only marginally below that temperature and above the freezing point depression temperature.

INAC concluded that impacts to Snap Lake would be higher than indicated in the EA, and that impacts might also be more concentrated in the North Arm of Snap Lake than projected, since the collections ditches were considered very unlikely to meet the performance objectives suggested by the proponent, such that seepage and runoff from the North Pile were likely to by-pass under the ditches. A rough quantitative example was provided, indicating, for TDS, the potential for additional loads that might be generated from the North Pile, and the potential impact on the North Arm of Snap Lake.

INAC recommended that De Beers should:

- reassess the potential release of soluble chemical products from materials in the North Pile on the basis of revised temperature conditions from upgraded thermal modeling
- conservatively bracket potential loads considering potential for release from materials that are just below 0 °C;
- reconsider potential impacts associated with cryoconcentration and pore water expulsion in light of revised thermal modeling and updated temperature conditions; and ,
- reassess selected mitigation strategies in light of modified thermal conditions and rates of freezing.

DCMI's Response:

DCMI has taken the concerns seriously. The limited time frame has not allowed a reassessment of contaminant released, and therefore DCMI has responded qualitatively, and has attempted to place the uncertainties in the context of the overall project. Their response was that:

- their revised thermal analyses supports their previous assumption that most of the pile will be below 0° C;
- that their previous analyses for contaminant release from the North Pile were conservative;
- that should the TDS scenarios roughly estimated by INAC occur (cryoconcentration and additional weathering from a warmer pile), it would be a relatively small increase in overall load to the Water Treatment Plant, and the additional discharged load to Snap Lake would be within the buffer provided by conservative sizing of the Water Treatment Plant discharge volume assumed in their impact assessment,
- that a revised ditch design will ensure collection of virtually all seepage and runoff from the North Pile, such that it will be transported to the Water Treatment Plant, and,
- that the Starter Cell provides an early opportunity to assess the accuracy of predictions and modify responses accordingly.

INAC's Conclusion:
INAC concludes on review of the additional submissions that contaminant loads potentially generated from the North Pile remain underestimated due to the slower freezing rates and warm temperatures, and that the potential increase in loads for specific COPC's have not be identified. Particularly, INAC does not agree that the revised thermal model is consistent with the previous model. Slower freezing rates and warmer temperatures are indicated, such that large portions of the pile are marginally frozen (ie. just below 0°C, but above the freezing point depression).

However, rough assessments conducted on TDS indicate that maximum additional discharges from the site may be in the order of 5 %, which suggests that uncertainties may not significantly increase projected impacts. DCMI should be required to estimate the maximum additional increases for other contaminants so that potential receiving impacts can be evaluated..

INAC concurs that the starter cell provides an opportunity to test predictions and modify mitigation measures, and that the revised collection ditch design is an improvement.

Thus, INAC concludes that the issue of appropriate estimates of contaminant loads is unresolved, but that the uncertainty may be within tolerable ranges, particularly given the proposed commitment to collect seepage and runoff, monitor early trends, and modify mitigation measures on the basis of field observations.

2.1.2 Geochemistry of Kimberlite

MVEIRB Terms of Reference: MVEIRB Terms of Reference (ToR) require De Beers to provide an analysis of the proposed development's impacts on surface and ground waters, in particular the water chemistry impacts of surface runoff, and the effects of kimberlite and other materials stored in the North Pile, considering acid rock drainage, metal leaching and geochemistry (ToR line # 336 to 341, 379, 380, and 392). MVEIRB ToR also require De Beers to consider accidents and malfunctions (ToR line # 160 – 164).

At issue is an incomplete understanding of the cause of acid seeps associated with kimberlite at BHP's Ekati™ site, and a need to address this uncertainty with a conceptual contingency response plan.

INAC's Concern: Uncertainties regarding kimberlite reactivity suggest that conceptual contingency planning may be appropriate.

DCMI's Response:

The starter cell provides adequate means to confirm predictions and modify mitigation measures, and that the revised collection ditches will provide the potential to collect any adverse drainage as required.

INAC's Conclusion:

INAC concurs that the Starter Cell provides some time to assess the accuracy of predictions and that the collection ditch design has been improved. There is still some uncertainty in the potential of these proposed actions to address poor quality kimberlite drainage should it occur over the longer term, as the Water Treatment Plant currently addresses total suspended solids loads and would not be capable of reducing dissolved contaminant loads should they arise from the North Pile.

2.1.3 PAG Stockpile

MVEIRB Terms of Reference: MVEIRB Terms of Reference (ToR) require De Beers to provide an analysis of the proposed development impacts on surface and ground waters, in particular the water chemistry impacts of surface runoff , and the effects of kimberlite and other materials stored in the North Pile, considering acid rock drainage, metal leaching and geochemistry (ToR Reference: line #336 to 341, 379 to 380 and 392).

INAC's Concern:
A PAG stockpile was identified by De Beers during the technical sessions which had not previously been part of the project descriptions.

DCMI's Response:
DCMI indicated that a the metavolcanic stockpile proposed and that testwork demonstrates that:

- not all metavolcanic rock has the potential to generate ARD; and
- even if this potential exists, it may not be released under ambient site conditions fro a considerable period of time.

DCMI noted that should the stockpile prove to b e acidic, than material would not be encapsulated in the North Pile, but rather be used as underground backfill, where any acidity would be neutralized.

INAC's Conclusion: DCMI's contingency plans to place the material underground appear to be appropriate. As noted earlier, logistics may not allow encapsulation. INAC notes that the proposed placement underground appears to be triggered only if the material becomes acidic. Even if the material does not become acidic, the material has the potential to act as an source of contaminants in the both short and long term. INAC has not confirmed whether the potential loads from this stockpile have been included in the impact assessments for operational and/or long term time frames, but this is likely a minor issue.

2.1.4 Quality Control for Construction Material

MVEIRB Terms of Reference: MVEIRB Terms of Reference (ToR) require De Beers to provide an analysis of the proposed development's impacts on surface and ground waters, in particular the water chemistry impacts of surface runoff, and the effects of kimberlite and other materials stored in the North Pile, considering acid rock drainage, metal leaching and geochemistry (ToR line # 336 to 341, 379, 380, and 392).
At issue is the basis used by De Beers in developing a criteria for identifying potentially problematic material, and, in particular, suitable rock for construction purposes. Selection of an inappropriate criteria may result in higher than predicted impacts.

Developer's Response: DCMI has not provided any response on this issue.

INAC's Conclusion: During discussions, INAC agreed that suitable clean construction rock was likely available, and that a more detailed justification for criteria that would identify material suitable for construction, based on site and rock specific kinetic test results, could be submitted as part of the regulatory review,

2.1.5 Cemented Paste PK Kinetic Test Results

DCMI suggests that these results demonstrate that values used in the EA for prediction of cemented PK paste backfill water quality were overly conservative.

INAC's Comments:

Values used in the EA may be conservative, based on the lower concentrations discharged from the more recent tests. However, the data are only presented in terms of concentrations. Given that the cemented paste tests were conducted on solid columns of material, the data should be converted to mass loads (mg/kg of sample/week) and loads relative to surface area (mg/mg exposed surface/week), and loading comparisons calculated. Release values from kinetic tests are generally applied in terms of loading rates, then checked for concentrations using solubility constraints. Kinetic test concentrations are seldom used to represent actual concentrations without modifications that address the variation between the kinetic test methods (water addition rates, grainsize, surface area exposed, weight of sample) and in-situ conditions.

2.2 Hydrogeologic Issues

Our initial report submitted on February 14, 2003 identified the following hydrogeologic issues, referred to in Section 2.2 of that report as:

- i) Quality of Connate groundwater Inflow;
- ii) Quality of Mine Water Discharges to Snap Lake; and
- iii) Water Quality in Snap Lake

An updated discussion of these issues in reference to the new information provided by the proponent is provided below.

2.2.1 Quality of Connate Groundwater Inflow

Original Issue

MVEIRB Terms of Reference (ToR) require De Beers to provide an analysis of the proposed development impacts on surface and ground waters, in particular the water chemistry impacts of groundwater from underground mine workings on Snap Lake (ToR Reference: line #221, 337 to 341, 344 to 355 and 381). Reliable characterization of the quality of connate groundwater inflow to the proposed mine is an important issue because large quantities of connate groundwater are predicted to be pumped from the underground mine workings to Snap Lake, and the vast majority of the dissolved chemical load to Snap Lake from the mining operation is derived from connate groundwater inflows.

The original issue was whether the quality of connate groundwater inflows described in the EA Report are reliable given the available information, in particular, in light of the probability that higher connate water concentrations will be encountered.

De Beers originally concluded in the EA Report that the concentrations of connate groundwater that provide the vast majority of dissolved contaminant load to mine water discharge and ultimately to Snap Lake during mining operations are represented by the average concentration of groundwater measured from granite water samples collected during the Advanced Exploration Program (AEP). In particular, De Beers assumed the average connate groundwater has 902 mg/L total dissolved solids (TDS), 330 mg/L chloride, and 0.06 mg/L dissolved phosphorous and that these concentrations will be representative of connate water quality inflows throughout the mining period.

Connate groundwater of this quality is mixed with Snap Lake inflows, and to a much lesser degree other water and chemical sources in the mine, on a time-varying basis using GoldSim, to determine the average quality of mine water discharge to the water treatment plant, to Snap Lake and ultimately within Snap Lake. Since the proposed water treatment technology (filtration/sedimentation) will not remove most major ions, the discharge to Snap Lake will be similar to the mine water discharge, particularly for TDS, chloride, and most major ions (e.g., calcium, sodium, potassium).

INAC did not agree with De Beers conclusion that the average concentration as measured for granite water samples during the AEP will be representative of average connate groundwater quality inflow to the mine throughout the duration of mining operations. INAC believed that the concentrations of connate groundwater inflow to the mine and hence the quality of mine water discharge to Snap Lake will be substantially higher than indicated in the EA Report (particularly for TDS, chloride, other major ions and dissolved phosphorous), and therefore impacts to Snap Lake will also be higher than indicated in the EA.
This issue was originally addressed in the EA Report in Sections 9.2.1.3, 9.4.2.2, and 9.6.3; Table Q-1, Appendix Q, Appendix III.2; and Appendix IX.1 (Sections 5.3.1, 5.4.1, 5.4.3).

New Information

Mine Water Assessment and Variability

The Mine Water Assessment and Variability Technical Memorandum presents new groundwater quality data from the AEP, a new assessment of the AEP groundwater quality data and quality-depth trends, additional description of the analysis of groundwater upwelling described in the EA Report, and the results of additional variability modelling of the GoldSim Site Water Quality Model.

The new groundwater quality data are from several relatively short underground drill holes (UG-173, UG-174, UG-175 and UG-176) sampled in mid July to mid August, 2001, after initial development of the GoldSim model. The water quality analyses from these drill holes show relatively low TDS, chloride and other major ions compared to the AEP groundwater data collected in May and June, 2001. De Beers recalculates average AEP mine inflow concentrations and concludes that the original values used in the EA Report are high relative to the updated averages and are not unduly influenced by drill water contamination.

De Beers calculates an average mine depth, weighted by area, that is equal to about 210 m below the surface of Snap Lake. This average mine depth was used to estimate average quality of connate water inflows based on the average AEP inflow concentrations from 155 m depth at Snap Lake and adjusted for depth increases from 155 to 210 m using the Diavik depth-concentration profile.

Several variability model runs using the GoldSim Site Water Quality model were completed by De Beers to look at the effects of changes in mine water inflow quality and quantity on discharges to Snap Lake. The variability runs (and assumptions on connate water TDS and chloride concentrations as listed in Table 9 of the Technical Memorandum) included:

- EA Assessed Case, as modelled in the EA Report (TDS = 902 mg/L, Cl = 330 mg/L) ;
- EA Expected Case, EA Assessed case adjusted to reflect current understanding (TDS = 902 mg/L, Cl = 330 mg/L);
- EA Expected Case + 1 SD Flow, Expected case with increased mine inflow (TDS - 902 mg/L, Cl = 330 mg/L);
- EA Expected Case + 1 SD Connate Water Concentration, Expected Case with increased connate water concentrations (TDS = 1362 mg/L, Cl = 525 mg/L);
- Depth Average Case, connate water concentration adjusted to value equivalent to average mine depth of 210 m (TDS = 883 mg/L, Cl = 410 mg/L); and

- Depth Average + Upwelling, Depth Average case with increased connate water concentrations due to upwelling (TDS = 1160 mg/L, Cl = 595 mg/L).

There is a discrepancy in the values of TDS assumed for connate groundwater listed in Tables 9 and 10 of the Technical Memorandum that needs to resolved or explained.

Based on these variability model runs, De Beers concludes that increasing mine inflows result in lower TDS in discharge water to Snap Lake than assumed in the EA Assessed case, that increasing connate water concentration by one standard deviation result in a 51% increase in TDS, that the Depth Average case result in similar TDS values, and that the Depth Average and Upwelling case result in a 25% increase in TDS.

Overall, De Beers concludes that a reasonable "worst-case" mine discharge water quality lies somewhere between the EA Assessed scenario and the variability scenarios provided and discussed in the February 28, 2003 Technical Memorandum.

<u>Algal Modelling Update</u>

The Algal Modelling Update Technical Memorandum and attachments present clarification of data and methods used to assess phosphorous concentrations in the EA Report, a review of phosphorous in mine water, an update of phosphorous loading to Snap Lake, and re-calibration and sensitivity analyses of the Snap Lake algal model.

The new information confirms that only orthophosphate was considered as the biologically available form of phosphorous in the EA Report, that dissolved phosphorous listed Table IX.1-12 of the EA Report is predominately orthophosphate, and that orthophosphate is the predominate form of phosphorous in groundwater. Analyses for total dissolved phosphorous include colloidal (<0.45 μm) and actual dissolved phosphorous. The portion of total dissolved phosphorous that is also biologically available in treated mine water discharge is likely to be about 0.020 mg/L.

The Technical Memorandum and attachments show that orthophosphate has relatively uniform concentrations in connate groundwater and does not show significant increases with salinity. Consequently, the concentrations of biologically available orthophosphate in connate groundwater and mine water discharge are not likely to exceed the values assumed in the EA Report of about 0.012 mg/L and 0.010 mg/L, respectively.

Although the concentrations of total dissolved phosphorous measured in the AEP do show higher concentrations than for orthophosphate and do show some variability with salinity, the updated concentrations measured in connate groundwater during the AEP (i.e., 0.047 mg/L) are very minor in comparison to the incremental loading introduced at the working face (i.e., 0.591 mg/L). Since most the total dissolved phosphorous above 0.020 mg/L is likely colloidal, the concentrations of biologically available dissolved phosphorous in connate groundwater are not likely to exceed the value of 0.06 mg/L originally assumed in the EA Report.

INAC Conclusions

INAC does not agree with De Beers overall conclusion that a reasonable "worst-case" mine discharge water quality lies somewhere between the EA Assessed scenario and the variability scenarios provided and discussed in the February 28, 2003 Technical Memorandum.

INAC still believes that the concentrations of connate groundwater inflow to the mine and hence the quality of mine water discharge to Snap Lake will be substantially higher than indicated in the EA Report and in the February 28, 2003 Technical Memorandum (particularly for TDS, chloride, other major ions), and therefore impacts to Snap Lake will also be higher than indicated in the EA. The evidence and rationale presented in our February 6, 2003 report for higher TDS, chloride and other major ions in connate groundwater remains relevant. Additionally, we offer the following new evidence and rationale.

The AEP water quality data is implicitly assumed by De Beers to representative of connate groundwater quality at the depths sampled. Connate groundwater is defined by De Beers as the groundwater in the bedrock surrounding the mine prior to mine development. INAC believes that many of the groundwater samples collected during the AEP, particularly those collected near the openings, show evidence of dilution by shallow groundwater and likely Snap Lake water, and hence are not truly representative of connate groundwater. Such dilution would be consistent with De Beers stated understanding of the groundwater flow system. De Beers have indicated that the transit time for Snap Lake water to recharge the mine workings is very short in the range of weeks to months and the AEP openings were open for at least this period of time prior to collection of AEP groundwater samples for characterization of granite groundwater quality. Consequently, dilution of AEP groundwater samples collected close to the AEP workings (e.g., within 100 m) due to inflow to the AEP openings should be expected based on De Beers conceptual hydrogeologic model of the mine.

Inspection of the new AEP groundwater table provided in the Technical Memorandum shows that there are spatial and temporal trends in granite groundwater quality that are indicative of dilution by shallow groundwater and Snap Lake water. Water samples collected farthest from the AEP openings (i.e., from the longest drill holes) show the highest TDS values. Examples include: UG-45, TDS = 1260 mg/L from 300 m; UG-83, TDS = 1100 mg/L from 350 m; and UG-106, TDS = 1630 from 343 m. Conversely, water samples collected from close to the AEP openings and later in the sampling program show the lowest TDS values. These examples include: UG-173, TDS = 590 mg/L from 67 m; UG-174, TDS = 540 from 72 m and UG-176, TDS = 220 mg/L from 82 m. The lowest TDS sample (220 mg/L from UG-176) was also the last sample collected (sampled August 12, 2001).

De Beers conclusion that the original AEP granite inflow concentrations used in the EA Report are high relative to the updated averages is a reflection of the fact that the new data were collected later than the original data and from shorter drill holes, not that the data are more representative of connate groundwater quality. The new data were collected several weeks to months later than the original data and the new data were collected from an average distance of 90 m from the AEP openings, whereas the original data were collected from and average distance of 267 m from the AEP openings.

In our judgement many of the AEP granite groundwater samples are influenced by shallow groundwater and Snap Lake water dilution and hence underestimate connate water TDS, chloride and major ion concentrations as defined by De Beers. Given this problem with the AEP data, greater reliance should be placed on other data sets including the North Lakes and depth versus TDS profiles developed from other areas of the Shield and perhaps from the Diavik site that may be more representative of connate groundwater quality.

The North Lakes groundwater samples from wells MW02-05 (depth 110 to 130 m) and MW02-03 (depth 190 to 215 m) show average chloride values of about 380 mg/L and 610 mg/L, respectively, and average TDS values of about 1100 mg/L and 1600 mg/L, respectively. These data suggest a 155 m depth average of 495 mg/L for chloride and 1350 mg/L for TDS, which are 51% and 91% greater than the De Beers-calculated 155 m average from the AEP sampling at 327 mg/L for chloride and 706 mg/L for TDS.

Since the data from MW02-03 is collected from a depth (190 to 215 m) that is approximately equal to the De Beers calculated average mine depth of 209 m, it is useful to compare the TDS and chloride data from this sample to that assumed in the EA Report. The data from MW02-03 are 77 % and 85 % greater than the TDS and chloride values, respectively assumed for connate granite groundwater in the EA Report.

The above North Lakes data were also compared to the TDS versus depth profiles presented in the Technical Memorandum. These data plot closest to the Frape and Fritz profile #1 rather than the Snap Lake profile #3 assumed by De Beers. This suggests that TDS, chloride and other major ions in connate granite groundwater will be higher than assumed by De Beers in the EA Report and in the Technical Memorandum.

Given the confirmed potential for upwelling of deeper saline water to occur, the most reliable and likely average concentrations of TDS and chloride in connate groundwater inflow are calculated as the concentrations detected in MW02-03 multiplied by an upwelling factor of 1.5. The resultant concentrations are 915 mg/L for chloride and 2400 for TDS. These values are 2.8 (Cl) and 2.7 (TDS) times greater that the values assumed in the EA Report. They are also greater by factors of 1.5 (Cl) and 1.8 (TDS) over the maximum values assumed in the new GoldSim model variability runs presented in the Technical Memorandum.

De Beers argues in the Technical Memorandum that the hydraulic conductivity profile assumed for the upwelling modelling assessment likely overestimates the upwelling of brackish to saline water because the profile does not decrease as quickly as other areas of the Canadian Shield and other granitic rock sites. The hydraulic conductivity profile assumed for Snap Lake is based on actual data from hydraulic testing at Snap Lake and at Diavik. It is recognized that the hydraulic conductivity assumed below depths of 500 at Snap Lake is higher than at other Canadian Shield sites, but the measured data at Snap Lake and Diavik in the upper 500 m are also higher than the other Canadian Shield sites. This suggests that the bedrock is generally more permeable at Snap Lake and Diavik, and that it is inappropriate to suggest that the hydraulic conductivity profile assumed for Snap Lake is overestimated and that the upwelling potential has also been overestimated. In our judgement, the estimates of upwelling are realistic and are not overestimated.

There is inconsistency between the hydraulic conductivity values listed in Table 4 and shown in Figure 3 for depths of 700 to 1000 m.

Considering the above and evidence/rationale provided in our earlier hydrogeologic assessment report, it is our scientific and professional opinion that concentrations of connate groundwater TDS, chloride and other major ions could easily be about 2 to 3 times higher than predicted in the EA Report.

Status of the Issue

The issue of underestimation of connate granite groundwater TDS, chloride and other major ion concentrations in the EA Report by factors of 2 to 3 remains unresolved at this time.

The issue of underestimation of dissolved phosphorous in connate granite groundwater in the EA Report has been resolved. The values of dissolved phosphorous and orthophosphate in connate groundwater assumed in the EA Report and in the Technical Memorandum on algal modelling in Snap Lake are considered acceptable.

2.2.2 Quality of Mine Water Discharges to Snap Lake

Original Issue

MVEIRB Terms of Reference require De Beers to provide an analysis of the proposed development impacts on surface and ground waters, in particular the water chemistry impacts of mine water discharge on Snap Lake (ToR Reference: line #221, 337 to 341, 344 to 355 and 381). Reliable characterization of the quality of water discharges from the proposed mine is an important issue because large quantities of mine water will be pumped to Snap Lake. For many of the dissolved constituents present in the mine water at elevated concentrations (e.g., TDS, chloride and other major ions), the proposed water treatment plant will not reduce the concentrations of these constituents, effectively resulting in discharge of untreated mine water to Snap Lake.

The original issue was whether the quality of mine water discharges to Snap Lake described in the EA Report are reliable given the available information, in particular, the probability of higher connate water concentrations and incomplete mixing within Snap Lake.

De Beers originally concluded that the mine water discharge to Snap Lake during operations, will have peak average annual and median TDS of 1229 mg/L and 602 mg/L, respectively, peak annual average and median chloride of 417.5 and 245.5 mg/L, respectively, and peak annual average and median dissolved phosphorous of 0.012 mg/L and 0.008 mg/L, respectively. These discharge concentrations, which are calculated using GoldSim, represent the major mass loading to Snap Lake from mining operations.

INAC did not agree with De Beers conclusion that the concentrations of mine water discharge to Snap Lake throughout the duration of mining operations will be as defined in the EA Report. INAC believed that the concentrations of mine water discharge to Snap Lake and hence the quality of Snap Lake water will be substantially higher than indicated in the EA Report (particularly for TDS, chloride, other major ions and dissolved phosphorous). Therefore, impacts to Snap Lake will also be higher than indicated in the EA.

This issue was originally addressed in the EA Report in Sections 9.4.2.2, and 9.6.3; and Appendix IX.1 (Sections 5.2, 5.3, 5.4).

New Information

The Mine Water Assessment and Variability Technical Memorandum uses new connate groundwater quality data from the AEP, compares GoldSim and RMA model calculations of chloride in the Effective Lake Volume of Snap Lake, and calculates with the GoldSim Site Water Quality Model new long-term average concentrations of mine water discharge to Snap Lake for the variability scenarios listed in Section 2.2.1 of this report.

The average year 15 to 22 concentrations of TDS and chloride in mine water discharge to Snap Lake calculated by De Beers (Table 10) for each of the new variability scenarios are as follows:

- EA Assessed Case, as modelled in the EA Report (TDS = 594 mg/L, Cl = 237 mg/L) ;
- EA Expected Case, EA Assessed case adjusted to reflect current understanding (TDS = 517 mg/L, Cl = 156 mg/L);
- EA Expected Case + 1 SD Flow, Expected case with increased mine inflow (TDS - 558 mg/L, Cl = 171 mg/L);
- EA Expected Case + 1 SD Connate Water Concentration, Expected Case with increased connate water concentrations (TDS = 897 mg/L, Cl = 247 mg/L);
- Depth Average Case, connate water concentration adjusted to value equivalent to average mine depth of 210 m (TDS = 585 mg/L, Cl = 194 mg/L); and
- Depth Average + Upwelling, Depth Average case with increased connate water concentrations due to upwelling (TDS = 742 mg/L, Cl = 280 mg/L).

De Beers compares the chloride concentrations within the Effective Lake Volume calculated with GoldSim to the concentrations determined using the fully mixed 2-D RMA plan model of Snap Lake. De Beers concludes that the water from Snap Lake that recharges the mine will likely have overestimated concentrations because the Effective Lake Volume gives slightly higher concentrations that those calculated using the more accurate RMA model. However, neither model considers density separation or incomplete vertical mixing in Snap Lake.

De Beers concludes that a reasonable "worst-case" mine discharge water quality lies somewhere between the EA Assessed scenario and the variability scenarios provided and discussed in the February 28, 2003 Technical Memorandum.

The Technical Memorandum on phosphorous and algal modelling shows that the vast majority of the total dissolved phosphate above about 0.020 mg/L in mine water discharge is introduced at the working face as colloidal material that will subsequently be removed with suspended solids during treatment of the mine water discharge.

INAC Conclusions

INAC does not agree with De Beers overall conclusion that a reasonable "worst-case" mine discharge water quality lies somewhere between the EA Assessed scenario and the variability scenarios provided and discussed in the February 28, 2003 Technical Memorandum that show maximum 53% increase of TDS in mine water discharge over the EA Assessed case.

INAC maintains there are two principal reasons to expect that the concentrations of treated mine water discharges to Snap Lake will be greater than predicted in the EA Report:

- Increased concentrations of connate groundwater inflow; and
- Incomplete mixing within the Effective Lake Volume of Snap Lake.

The rationale and evidence for increased concentrations in treated mine water discharges to Snap Lake presented in our February 6, 2003 report remain relevant. Additionally, we offer the following new evidence and rationale.

Since we believe that the TDS, chloride and other major ion concentrations in connate groundwater have been underestimated by factors of 2 to 3 over values assumed in the EA Report, we anticipate that mine water discharge concentrations to Snap Lake would also by underestimated by similar or slightly lower factors for TDS, chloride and other major ions.

The results of the variability analyses as listed in Table 10 are insightful in assessing the likely changes in treated mine water discharge due to changes in connate water concentrations. Table 10 shows that increasing the connate water TDS and chloride concentrations by about 60% (i.e., + 1 Standard Deviation Concentration case over EA Expected case) resulted in increases in treated discharge concentrations of TDS and chloride to Snap Lake of about 60%. Increasing connate water TDS and chloride by 70% and 80%, respectively, (i.e., Depth Average and Upwelling case over EA Expected case), resulted in increases in treated discharge concentrations of TDS by 43% and chloride by 80%.

The February 28, 2003 Technical Memoranda do not discuss the issue of density separation and incomplete vertical mixing in Snap Lake that was raised in our February 6, 2003 report as a cause of increased concentrations of TDS, chloride and other major ions in treated mine water discharge to Snap Lake.

Consequently, given the new information contained in the Technical Memoranda, we believe that the concentrations of TDS, chloride and other major ions in treated mine water discharge remain underestimated in the EA Report by factors of 2 to 3.

Status of the Issue

The issue of underestimation of TDS, chloride and other major ion concentrations in mine water discharge to Snap Lake in the EA Report by factors of 2 to 3 remains unresolved at this time.

The issue of underestimation of dissolved phosphorous concentration in mine water discharge in the EA Report has been resolved. The values of dissolved phosphorous and orthophosphate in treated mine water discharge assumed in the EA Report and in the Technical Memorandum on algal modelling in Snap Lake are considered acceptable.

2.2.3 Water Quality in Snap Lake

Original Issue

MVEIRB Terms of Reference require De Beers to provide an analysis of the proposed development impacts on surface and ground waters, in particular the water chemistry impacts of underground mine water discharges on Snap Lake and the Lockhart River watershed (ToR Reference: line #221, 337 to 341, 344 to 355 and 381). Reliable characterization of the water quality within Snap Lake is important because Snap Lake is the receptor for all mine water discharges.

The original issue was whether the predictions of water quality within Snap Lake described in the EA Report are reliable given the available information, in particular, the probability of higher mine water discharge concentrations and incomplete mixing within Snap Lake.

De Beers originally concluded that the maximum ice-covered concentration after initial mixing in Snap Lake during mine operations will be 137 mg/L for chloride and 350 mg/L for TDS. De Beers concluded that the maximum ice-free concentration within 1% of Snap Lake will be 177 mg/L for chloride and 444 mg/L for TDS. The higher ice-free concentrations are due to the fact that Snap Lake model used to determine the values did not consider the turbulent mixing of the diffuser. De Beers also concluded that maximum average TDS concentration in Snap Lake will be about 330 mg/L. These results were generated based on modelling of water quality in Snap Lake in the near-field using the US EPA Cormix model for the diffuser and in the far-field using the RMA 2-D plan models of Snap Lake. GoldSim provided the mine water quality and quantity discharge data for input to these models.

INAC did not agree with De Beers conclusion that the concentrations of TDS, chloride, other major ions and dissolved phosphorous in Snap Lake throughout the duration of mining operations will be as defined in the EA Report. INAC believed that the concentrations in Snap Lake will be substantially higher than indicated in the EA Report (particularly for TDS, chloride, other major ions and dissolved phosphorous at depth in the Lake). Therefore impacts to Snap Lake will also be higher than indicated in the EA.

This issue was originally addressed in the EA Report in Sections 9.4.2.2, 9.4.2.3 and 9.6.3; Appendix IX.1 (Sections 5.2, 5.3 and 5.4); and Appendix IX.7.

New Information

The Mine Water Assessment and Variability Technical Memorandum provides new information on water quality within the Effective Lake Volume of Snap Lake that recharges the mine, and a comparison of chloride in Snap Lake determined using the Effective Lake Volume approach of GoldSim and the plan 2-D RMA model, that was briefly discussed in Section 3.2 of this report.

The average year 15 to 22 concentrations of TDS and chloride in the Effective Lake Volume of Snap Lake that recharges the mine are calculated by De Beers (Table 10) for each of the new variability scenarios as follows:

- EA Assessed Case, as modelled in the EA Report (TDS = 233 mg/L, Cl = 92 mg/L) ;
- EA Expected Case, EA Assessed case adjusted to reflect current understanding (TDS = 207 mg/L, Cl = 62 mg/L);
- EA Expected Case + 1 SD Flow, Expected case with increased mine inflow (TDS = 249 mg/L, Cl = 75 mg/L);
- EA Expected Case + 1 SD Connate Water Concentration, Expected Case with increased connate water concentrations (TDS = 357 mg/L, Cl = 97 mg/L);
- Depth Average Case, connate water concentration adjusted to value equivalent to average mine depth of 210 m (TDS = 233 mg/L, Cl = 76 mg/L); and
- Depth Average + Upwelling, Depth Average case with increased connate water concentrations due to upwelling (TDS = 295 mg/L, Cl = 110 mg/L).

Although the Mine Water Assessment and Variability Technical Memorandum does not present new predictions of water quality within the rest of Snap Lake, De Beers implicitly concludes based on conclusions concerning mine water discharge to Snap Lake, that the "worst-case" water quality in Snap Lake is likely to lie somewhere between the EA Assessed case and the variability scenarios described in the Technical Memorandum that show a maximum 53 % increase in TDS in the Effective Lake Volume of Snap Lake over values for the EA Assessed case.

The Algal Modelling Update Technical Memorandum and attachments present clarification of data and methods used to assess phosphorous concentrations in the EA Report, a review of phosphorous in mine water, an update of phosphorous loading to Snap Lake, and re-calibration and sensitivity analyses of the Snap Lake algal model.

INAC Conclusions

INAC does not agree with De Beers implicit conclusion that a reasonable "worst-case" Snap Lake water quality lies somewhere between the EA Assessed scenario and the variability scenarios provided and discussed in the February 28, 2003 Technical Memorandum that show a maximum 53% increase in TDS in the Effective Lake Volume of Snap Lake over the EA Assessed case.

INAC maintains there are two principal reasons to expect that the concentrations in Snap Lake will be greater than predicted in the EA Report:

- Increased concentrations in mine water discharge; and
- Density-driven flow separation in Snap Lake.

Since we believe that the TDS, chloride and other major ion concentrations in mine water discharge have been underestimated by factors of 2 to 3 over values assumed in the EA Report, we anticipate that water concentrations in Snap Lake would also by underestimated by similar factors for TDS, chloride and other major ions.

The results of the variability analyses as listed in Table 10 are also insightful in assessing the likely changes in Snap Lake water quality due to changes in mine water discharge concentrations. Table 10 shows that increasing mine water discharge TDS and chloride concentrations by about 73% and 58 %, respectively, (i.e., + 1 Standard Deviation Concentration case over EA Expected case) resulted in increases in Effective Lake Volume concentrations of TDS and chloride in Snap Lake by about 73% and 56%, respectively. Increasing mine water discharge TDS and chloride by 43% and 79%, respectively, (i.e., Depth Average and Upwelling case over EA Expected case), resulted in increases in Effective Lake Volume concentrations of TDS by 43% and chloride by 77%. This suggests a near one-to-one relation between increases in TDS, chloride and other major ions in mine water discharge and in Snap Lake.

The February 28, 2003 Technical Memoranda do not discuss the issue of density-driven flow separation and incomplete vertical mixing in Snap Lake that was raised in our February 6, 2003 report as a cause of increased concentrations of TDS, chloride and other major ions in Snap Lake.

Consequently, given the new information contained in the Technical Memoranda, we believe that the concentrations of TDS, chloride and other major ions in Snap Lake remain underestimated in the EA Report by factors of 2 to 4.

Status of the Issue

The issue of underestimation of TDS, chloride and other major ion concentrations in Snap Lake in the EA Report by factors of 2 to 4 remains unresolved at this time.

The issues of underestimation of dissolved phosphorous concentration and impact within Snap Lake in the EA Report have been resolved. The values of biologically available dissolved phosphorous and orthophosphate in Snap Lake assumed in the EA Report and in the Technical Memorandum on algal modelling in Snap Lake are considered acceptable.

2.3 Geotechnical Issues

A single frost heave test was conducted. This was conducted with a sample which had 29.5% moisture content which is less than the 33% moisture content of the conservative thermal model analysis. The sample was frozen over a period of 5 days, which is much faster than the rate which will occur in the field for a large portion of the north pile.

The proponent has presented the results of modeling which was conducted with the TEMP/W two-dimensional model. The results are based upon two potential paste types. Type B, with the higher moisture content is the conservative case. As described in previous reviews, there is concern that the many of the operational parameters for construction of the north pile will favor a wetter paste composition.

The modeling has been based on deposition in 0.75 m thick layers. While this may be readily achieved in summer conditions, the proponent has acknowledged (Dec. technical sessions) that winter discharge may require the use of elevated discharge towers which will result in much thicker layers of deposited paste.

DCMI Conclusion

The result of the modeling indicates that much of the pile, possibly in the order of 50%, will be unfrozen at the end of mining. This material will gradually freeze over the following century.

Discussion

The results give improved confidence that EA predictions are reasonable, however some doubts/uncertainty still exists because of the limitations noted above.

Although the results are possibly not as conservative as they could be, the conclusion that a significant portion of the north pile being unfrozen at the end of operations appears to be reasonable.

Frost susceptibility of the material, as tested, is relatively low. Therefore, while some water may be contained in pile, not all will be.

The results suggest that there is good potential for cryo-concentration of dissolved solids in the paste pore water. The freezing over a period of many decades will limit the rate at which contaminants are released to the environment.

The average temperature of the pile is expected to be in the order of -0.2 degrees Celsius. At this temperature, the leaching of metals from the kimberlite material will not be zero as has been suggested by the proponent. Further consideration of the potential leaching of unfrozen kimberlite may be required in the geochemical model.

The combination of cryo-concentration and sub-zero degree metal leaching may result in higher than anticipated rates of release to the north arm of Snap Lake.

INAC Conclusion

Not-withstanding the concerns described above, the analyses and modeling give a reasonable indication as to how the pile may behave during and following operations. Considering the unique tailings disposal concept which has been proposed for the Snap Lake project, it may not be possible to significantly improve on the current predictions. In recognition of this, the proponent has provided for several contingencies. These include:

i. Monitoring of the Starter Cell, (scope of monitoring to be developed during the regulatory phase),
ii. Two options for modification of the seepage collection ditch,
iii. Commitment to provide long-term collection and treatment of seepage water, if necessary.

Status of Issue: This issue is not fully resolved due to the uncertainties in the testing and modeling. The work to date suggests that the risk of adverse impacts is low. A key aspect of the current design is the allowance for contingencies.

2.4 Permafrost and Thermal Issues

2.4.1 General Considerations Regarding the North Pile

ToR line 300-301. *Impact on permafrost physical conditions and thermal regime.*

The North Pile proposal for containment of mine tailings represents the first attempt at this method of mine waste disposal in a permafrost environment. Therefore, MVEIRB must recognize that the technology is untried and untested for an environment with potentially severe operating conditions during several months of the year.

The information provided by DCMI has gone some way towards resolving the issues discussed in the previous report. In particular:

i. The geothermal gradient has been corrected
ii. The thermal properties have been improved
iii. The surface temperature of the Pile has been rationally specified
iv. An unfrozen water content characteristic has been supplied.

The following sections address the geothermal and freezing characterization issues.

2.4.2 North Pile Geothermal Modeling

Original Issue

ToR lines 300-301 and lines 307-309 refer to *the impact on the permafrost thermal regime* and *the impact of the pore water contained in the processed kimberlite deposited in the north pile and the potential for pore-water expulsion during freeze back of the pile.*

DCMI has presented the results of modeling with TEMP/W (EA Report p. 10-46) to assess the thermal conditions in the North Pile from deposition of paste until closure of the Mine. DCMI now considers that for a paste deposition rate of 3 m/yr, the entire pile will not be frozen until many years after cessation of mine operations. The Pile will be partially frozen within a few years of deposition.

The revised model calibrations are in better agreement with field conditions than the data reported from the initial modeling.

Large portions of the cross-section report temperatures above -0.5°C. DCMI recognizes that at these temperatures the Pile materials are not completely frozen.

Geothermal modeling technique

The TEMP/W model calculates the flow of heat in a designed structure and predicts the temperature throughout the structure after defined time intervals. In this model, heat flow is by conduction only. No radiative or convective transfers are considered. The latter may be of considerable importance in a structure such as the North Pile, but for the purposes of EA, conduction, if properly described, is likely a sufficient estimate. For the purposes of regulation and design, convective components must be considered.

Heat flows into the bottom of the pile from the Earth, at a rate specified as the geothermal flux. Heat flows into or out of the upper surface of the pile at a rate determined by the surface temperature of the pile and the surface temperature gradient. Within the pile temperatures are controlled by the heat flow and the thermal properties of the materials, especially the thermal conductivity and heat capacity. For freezing conditions, the rate of freezing is affected by the latent heat of freezing of pore solution, and the distribution of this latent heat over the range of freezing temperatures for such solutions.

TEMP/W is a model that allows surface temperature to change over time, but is relatively inflexible in the geometry of the cross-section being examined.

2.4.3 Geothermal Flux

Original Issue

The geothermal flux prescribed for the model by DCMI was 0.004 Wm^{-2} (EA submission, p. 10-46). Standard values for the geothermal flux in the Canadian Shield are one order of magnitude higher (Judge 1973). IR3.4.17(b) requested DCMI to clarify the assignment of 0.004 Wm^{-2}. The response indicated that this value was chosen as it "provided the best fit for the existing thermal regime". At the Technical Hearing INAC pointed out that the value was too low, and showed that DCMI's field data from the North Lakes program indicated a geothermal flux of between 0.03 and 0.05 Wm^{-2} from data collected in holes TH02-01 and TH02-02. INAC requested resolution of the effect of this error on the performance of the geothermal model.

DCMI Conclusion

DCMI has used values close to 0.04 Wm^{-2} in the revised modeling.

INAC Conclusion

INAC recognizes that DCMI has corrected this error.

2.4.4 N-Factors

Original Issue

TEMP/W uses n-factors to obtain the surface temperature of the pile. The n-factors are the ratio of the number of degree-days measured at the ground surface to the number of degree-days measured in the air for the freezing and thawing seasons. For a specific site, there are two n-factors, one for freezing conditions, n_f, and one for thawing conditions, n_t. The n-factors used in the thermal modeling are presented on p. 10-47 of the EA report. Since the n-factors assigned are the same for all months of each season, INAC considers that these have been assigned without consideration for changing snow conditions through the winter season, and are a source of error in the model.

DCMI Conclusion

DCMI has revised its specification of n-factors and surface temperature conditions within TEMP/W, by examining various impacts of snow cover, and various snow cover regimes.

INAC Conclusion

INAC recognizes that DCMI has corrected this error.

2.4.5 Thermal Properties

Original Issue

The specification of thermal properties of the North Pile constituents is critical to determination of the thermal regime of the Pile. INAC has noted several errors in the thermal properties described in the documentation submitted by DCMI. These errors have been communicated to DCMI.

DCMI Conclusion

The thermal properties have been revised and adjusted.

INAC Conclusion

INAC considers that DCMI have improved the specification of thermal properties in the North Pile thermal model. However, the determination of the unfrozen water content characteristic has been completed in a relatively crude fashion, and this compounds the uncertainty inherent in the modeling exercise.

INAC Summary of Improved Thermal Modeling

As indicated above, the geothermal gradient has been corrected, the thermal properties have been improved, the surface temperature has been better specified, and an unfrozen water content characteristic has been specified.

All of these contributions improve the thermal modeling. The result is a simulation of the North Pile indicating that the mass of tailings is partially frozen at the end of mine life, and that they take many subsequent decades, perhaps several centuries, to freeze completely.

Within this context we note several points that maintain our uncertainty with the model predictions, and indicate the critical importance of careful monitoring of the evolution of the Pile during construction, throughout mine life and following cessation of operations, as the mass continues to evolve towards equilibrium conditions.

(a) The unfrozen water content characteristic curve provided by DCMI is of coarse resolution, with determinations at few temperatures, and none in the interval 0 to –0.4°C, where most freezing occurs.

(b) The unfrozen water content characteristic curve was not determined using process water for the pore fluids.

(c) It is not clear if the curve was generated during freezing of the soil sample or during thawing. Since there is usually hysteresis between these paths, this factor is of consequence to the interpretation of the data.

As a result, the unfrozen water content characteristic provided can only be considered an approximate estimate of the properties requested.

2.4.5.1 As stated above, the model is considers heat transfer exclusively by conduction, and does not consider the movement of water within the Pile as part of the thermal calculations. In a Pile such as proposed, this is a limitation on the utility of the model, and adds uncertainty to the prediction.

2.4.5.2 The model is based on application to the pile of planar, uniform layers at a constant rate. This is a simplification of the deposition of paste from spigots, which will form conical piles of tailings. This indicates that a more complicated thermal structure is likely in the Pile as built than as simulated by the model.

All of the above points indicate the inherent uncertainty in the pile design, and point to a critical requirement for monitoring the evolution of pile temperatures throughout mine life and beyond. INAC considers that a pile thermal monitoring program should be established by DCMI and that reports on thermal data and interpretation of these data should be submitted annually to an independent panel of technical experts reporting to the Board.

2.4.6 Cryoconcentration

Original Issue

ToR lines 307-309. *Impact of water content contained in the processed kimberlite deposited in the North Pile and the potential for pore-water expulsion during freeze back of the pile*

The behavior of the North Pile during freezing is the subject of considerable concern expressed at the Technical Hearings by INAC. The paste is to be saturated with process water when it is deposited in the pile and the destination of the water is at issue. DCMI has assumed that the majority of the pore water will freeze in the pile, and the majority of the brines will be retained in the pile along with it. INAC requested freezing tests or characterization of the freezing behavior of the paste.

DCMI Conclusion

DCMI has conducted one frost-heave test and has used its result to maintain that most of the process water will freeze in the pile and that the bulk of the remainder will be collected by the perimeter ditches.

INAC Conclusion

INAC concludes that DCMI has made progress on this issue, but that submission of one, unreplicated, laboratory test does constitute resolution, and considerable uncertainty in Pile behavior remains.

INAC Rationale

As with the unfrozen water content determination, the work reported on frost susceptibility is presented in a minimalist fashion. One test has been conducted on the paste. The following points address the test described by DCMI.

(i) The pore fluid used to saturate the sample tested was not equivalent to process water. The composition of the pore water was not specified.
(ii) The test was conducted with water supplied from the top of the cell, rather than the conventional downward freezing, with water supplied from below. This likely enhances the measured heave.
(iii) Ice lenses were not observed in the frozen paste, except near the final location of the frost line. It is not clear of local effects, such as extra silt at that location, contributed to the result.
(iv)The paste was tested with a relatively low water content (29.5%), considerably less than the field moisture content expected following deposition.
(v)The heave rate measured is an order of magnitude less than for other silty soils, and indicates a relatively low frost susceptibility for the medium.
(vi)Only one test has been conducted. No replication of the data with other samples has been provided.

Summary

As with the thermal modeling, INAC considers the factors identified above imply that there is uncertainty in the conclusions drawn by DCMI on the basis of one frost-heave test. Therefore the seepage from the pile predicted by DCMI is subject to error. The enhancements to ditch design and commitment to seepage treatment in the long run are critical aspects of DCMI's design proposal.

Conclusion In summary, INAC does not consider that the permafrost and geothermal issues raised at the Technical Hearing have been resolved, but recognizes that DCMI has made considerable progress to this end.

2.5 Hydrological Issues

2.5.1 Water Management Components: Water Treatment Plant WTP) and Water Management Pond (WMP).

Upon review of the recent information submitted by the proponent, our concerns as expressed in our technical report submitted February 14, 2003 have not changed. The MVEIRB should refer to the comments presented in section 2.5.1 of that report.

2.5.2 WMP Effluent Mixing in Snap Lake.

Upon review of the recent information submitted by the proponent, our concerns as expressed in our technical report submitted February 14, 2003 have not changed. The MVEIRB should refer to the comments presented in section 2.5.2 of that report.

2.5.3 North Pile Seepage.

Original Issue

The water balance model for the North Pile indicates that in the order of one percent of pile seepage plus surface runoff water from the pile would enter the north arm of Snap Lake by seeping beneath the proposed perimeter ditches paralleling the north side of the pile. INAC are concerned that: the volume of water may be greater than assumed; and, that no serious consideration has been given to the fate of seep water within this area of the lake.

It appears that DCMI are of the opinion that the volume of seepage water that might enter the north arm of the lake is minor and unlikely to have a measurable impact on the quality of lake water.

New Information

Upon a review of the Technical Memorandum "Snap Lake North Pile Seepage Collection" (Golder Associates Ltd., 27 February 03) it appears that much greater consideration has been given to this issue since the November 02 Technical Sessions. Bore hole data have been presented in reasonable detail, and conceptual ditch designs have been provided, along with reasonable arguments as to why North Pile seepage into the North Arm of Snap Lake is unlikely to be significant.

INAC's Conclusion

A commitment has been made to monitor ditch performance and to make any necessary modifications. It will be important to include this particular monitoring as a condition of any EA approval and regulatory permits.

2.6 Impact Assessment Issues

Upon review of the recent information submitted by the proponent, our concerns as expressed in our technical report submitted February 14, 2003 have not changed. The MVEIRB should refer to the comments presented in the following sections of that report.

2.6.1 Development of Site-Specific Water Quality Benchmarks

2.6.2 Selection of Impact Assessment Criteria

2.7 Environmental Quality Issues

As indicated in the technical report submitted to MVEIRB on February 14, 2002 (An Evaluation of the Environmental Assessment of the Proposed Snap Lake Diamond Project), Indian and Northern Affairs Canada (INAC) has identified five unresolved issues related to environmental quality, including:

1. the adequacy of baseline environmental quality data;
2. the accuracy of the predicted concentrations of COPCs in Snap Lake during mine operations;
3. the adequacy of the assessment of the impacts of total dissolved solids (and associated major ions) on aquatic organisms;
4. the adequacy of the nutrient modelling that has been conducted to evaluate the potential for lake eutrophication; and,
5. the adequacy of evaluation of the secondary impacts of lake eutrophication on aquatic organisms.

Each of these issues is discussed in the following sections of this report.

2.7.1 Adequacy of Baseline Environmental Information

INAC's Concern: In its technical report, INAC indicated that the baseline water quality and sediment quality data are generally sufficient to support the EA. However, INAC is concerned that the baseline data that have been collected to date are insufficient for evaluating the accuracy of those predictions during mining activities (i.e., to support the assessment of effects using the results of the aquatic effects monitoring program). That is, the water quality and sediment quality data may not be sufficient to support statistical analyses to determine changes in the physical, chemical, and/or biological characteristics of Snap Lake or to evaluate the severity of any changes that have occurred. Importantly, biological data that have been collected to date may not be sufficient to support the EA and are unlikely to support subsequent evaluations of the impact hypotheses.

To address this concern, INAC recommended that statistical power analyses be conducted to determine the quantity of data that is required for each variable to detect changes of various specific magnitudes (e.g., 10%, 20%, 50%) with specific levels of confidence (e.g., p=0.5, p=0.75, p=0.9). Such statistical analyses are needed to identify the additional pre-development water quality, sediment quality, and biological data that are needed to adequately characterize temporal and spatial variability in baseline conditions in Snap Lake and associated water bodies. Such data are required to support subsequent data analyses to evaluate the impact hypotheses that are presented in the EA report (i.e., to assess the nature, magnitude, and extent of environmental effects associated with the development).

DCMI Response: DCMI has provided some additional information that is relevant for establishing baseline water quality conditions in Snap Lake. More specifically, a technical memorandum providing additional information on baseline dissolved oxygen levels in Snap Lake under ice-covered conditions has been submitted by DCMI (i.e., Himbeault 2003).

Status of Concern: While DCMI has provided some additional information related to the baseline environmental quality data (i.e., for dissolved oxygen), the baseline data for most of the water-borne and sediment-associated COPCs remains insufficient for assessing the effects of the project, using the data collected under the Aquatic Effects Monitoring Program. In addition, none on the requested statistical analyses of existing baseline data have been completed. Therefore, this issue remains outstanding for INAC.

2.7.2 Predicted Concentrations of COPCs in Snap Lake

INAC's Concern: In its technical report, INAC indicated that the levels of several COPCs (e.g., total dissolved solids and chloride) are likely to be higher than those that were predicted in the EA report. More specifically, INAC believes that the concentrations of total dissolved solids and chloride could be substantially higher than was predicted for wastewater discharged from the mine site. In addition, the lack of mixing under ice-covered conditions and the negative buoyancy of the effluent could result in higher than anticipated levels of such COPCs in water at the bottom of Snap Lake during the winter. Because the concentrations of these substances in Snap Lake are likely to be higher than was predicted in the EA report in portions of the lake (i.e., particularly in deeper areas), it is likely the impacts on ecological receptors will be greater in severity and areal extent than were predicted in the EA report. To address this issue, INAC recommended that predicted concentrations of key COPCs in Snap Lake be re-evaluated using more conservative assumptions.

DCMI Response: DCMI has provided additional information for assessing the potential effects of mining activities on water quality conditions in Snap Lake. More specifically, this additional information provides a basis for evaluating the potential variability in mine water quality and quantity (De Vos and Chorley 2003). These results suggest that increasing the flow of water into the mine by one standard deviation would increase TDS concentrations by about 8% (i.e., to 558 mg/L from the expected case of 517 mg/L). However, increasing the concentration of TDS in connate water by one standard deviation would increase the concentration of TDS in mine water by 51% (i.e., to 897 mg/L).

Status of Concern: While the additional information on the potential levels of TDS in mine water provide useful information for evaluating the sensitivity of the EA predictions relative to the underlying assumptions, they do not consider the results of the North Lake Study. Hence, even the average plus one standard deviation case could be underestimating the concentrations of TDS in mine water. Likewise, the concentrations of chloride and other major ions could be similarly underestimated. Underestimation of the levels of major ions in mine water is likely to result in underestimations of the levels of major ions in Snap Lake, as Higgs (2003) concluded that large scale removal of major ions from mine water would not be practical at this site. The impacts associated with releases of major ions to Snap Lake could, therefore, be substantially underestimated. This issue remains outstanding for INAC.

2.7.3 Adequacy of the Assessment of the Impacts of Total Dissolved Solids

INAC's Concern: INAC has reviewed the assessment of the impacts associated with the releases of TDS and other major ions into Snap Lake and determined that it is largely inadequate.

The assessment of the impacts associated with the releases of TDS and other major ions into Snap Lake, as presented in the EA report and clarified at the MVEIRB Technical Sessions, is considered to be inadequate for several reasons. First, it is likely that the predicted concentrations of these COPCs are not based on accurate estimates of the loadings of these substances to Snap Lake (Also see Raven 2003). Accordingly, the predicted COPC concentrations used in the assessment are too low, likely by a factor of two or three. Second, the potential effects of increased levels of total dissolved solids and associated major ions on the structure of the aquatic community have not been adequately assessed in the EA report, associated documentation, nor in any of the supplemental information provided to date. Consequently, it is likely that the effects on sensitive environmental receptors that were predicted in the EA report are substantially underestimated.

DCMI Response: In response to concerns related to the assessment of the impacts of releases of major ions into the receiving environment, DCMI (2003a) conducted a supplemental evaluation of the potential effects of TDS in the aquatic communities of Snap Lake. This evaluation was based on maximum average whole-lake TDS concentrations of 350 mg/L during the winter under ice and 444 mg/L during the summer months. For chloride, the predicted maximum average whole-lake concentrations were 137 mg/L during the winter under ice and 177 mg/L during the summer months. These were the predicted concentrations of TDS and chloride that were used in the EA. Based on the results of the revised assessment, DCMI (2003a) concluded that releases of TDS into Snap Lake would not cause major shifts in aquatic community biomass or diversity. However, some subtle changes in the relative abundance and dominance of some zooplankton species could occur. No adverse effects on lake trout populations were predicted.

Status of Concern: This issue still remains an outstanding concern for INAC for several reasons. First, the evaluation of the potential effects of TDS on the aquatic communities of Snap Lake (DCMI 2003a) did not consider the results of the revised mine water assessment and variability evaluation (De Vos and Chorley 2003; i.e., the EA case was used in this evaluation). Hence, the predicted levels of major ions in Snap Lake are likely to have been underestimated. In addition, data from the North Lakes study suggest that the levels of major ions in deep connate water could be much higher than those estimated in the EA report. Hence, the supplemental evaluation of the effects of major ions, including TDS, on the aquatic communities of Snap Lake (DCMI 2003a) probably substantially underestimated the effects of major ion releases to this water body.

This evaluation also failed to recognize that British Columbia has established a water quality guideline of 150 mg/L for chloride, with an HC5 concentration of 213 mg/L reported (Nagpal *et al.* 2002). As actual concentrations of major ions in Snap Lake are likely to be higher than those predicted by DCMI (2003a) and effect concentrations are likely to be lower than assumed by DCMI (2003a), it is likely that the supplemental evaluation provides an underestimate of the effects on aquatic communities associated with releases of major ions from the proposed mine site. Therefore, this issue remains outstanding for INAC.

2.7.4 Adequacy of the Nutrient Modelling

INAC's Concern: INAC has repeated expressed concern that the results of the nutrient modelling that was conducted by DCMI are likely to substantially underestimate the impacts of the proposed Snap Lake diamond project. This concern was based on the fact that the original modelling effort was focussed primarily on orthophosphate, with the other forms of phosphorus largely ignored. As dissolved and total phosphorus levels are likely to be elevated in mine water and the mine water treatment system is designed for TSS removal only (i.e., only total phosphorus will be removed from the wastewater stream to an appreciable extent), the results of the nutrient modelling presented in the EA report are likely to substantially underestimate the levels of bioavailable phosphorus in Snap Lake during mine life. In turn, the effects of phosphorus releases from the mine on the trophic status of Snap Lake are likely to be substantially underestimated.

DCMI Response: In response to reviewers concerns related to the nutrient modelling that was presented in the EA report, DCMI conducted a more comprehensive evaluation of the potential effects of phosphorus enrichment on the productivity of Snap Lake (DCMI 2003b). In addition, DCMI prepared an update of the nutrient and algal modelling for Snap Lake (Digel *et al.* 2003). Based on the results of the first investigation (DCMI 2003b), DCMI concluded that elevated levels of phosphorus in Snap Lake are expected to have low to negligible effects on resident aquatic communities. Based on the results of the second study which considered various scenarios relative to the bioavailability of phosphorus species (Digel *et al.* 2003), DCMI concluded that the integrity and function of the aquatic ecosystem in Snap Lake will remain intact for the range for phosphorus loadings evaluated. Some increase in algal biomass and, to a lesser extent, zooplankton and benthic invertebrate biomass could be expected. No loss of species richness and no change in the oligo-mesotrophic status of the lake are expected.

Status of Concern: The additional work completed by DCMI provides important information for assessing the sensitivity of the impact assessment predictions due to either increased loadings of phosphorus from the mine or increased bioavailability of certain forms of phosphorus (i.e., relative to the EA case). Nevertheless, INAC is still concerned that the underlying assumptions used to generate the predictions may be faulty. For example, the assumption that the phosphorus present under baseline conditions is largely in the form of orthophosphate may serve to overestimate the amount of bioavailable phosphorus under baseline conditions. In addition, the results of supplemental monitoring activities show that chlorophyll *a* levels could substantially higher (i.e., by 50%) than was predicted in the EA report, if a substantial potion of the dissolved phosphorus is bioavailable. Although such increases in chlorophyll *a* levels may not alter the trophic status of the lake, they could have secondary effects on the aquatic communities in the lake by reducing dissolved oxygen levels under ice (as discussed below). This issue remains outstanding for INAC.

2.7.5 Adequacy of the Assessment of the Secondary Effects of Lake Eutrophication

INAC's Concern: INAC is concerned that the results of the nutrient modelling that was conducted by DCMI are likely to substantially underestimate the impacts of the proposed development on the trophic status of Snap Lake. The results presented in the EA report indicated that dissolved oxygen (DO) levels under ice could decrease by 1 to 3 mg/L and, as a result, approach levels of concern for lake trout. Because the phosphorus modelling that was presented in the EA report likely underestimated the effects in Snap Lake, it is possible that the levels of DO in Snap Lake during the winter could be depressed to levels that are associated with chronic effects in fish and/or other aquatic organisms. Additionally, low levels of DO tend to result in increased toxicity of other COPCs, which would result in decreased chronic toxicity thresholds for other COPCs. Hence, it is likely that the EA report has underestimated the secondary effects of lake eutrophication on fish and other aquatic organisms.

DCMI's Response: In response to concerns regarding the secondary effects of lake eutrophication, DCMI collected additional baseline data on the levels of DO under ice in early 2003. The results of this monitoring program indicated that 21 of the 50 locations sampled had minimum DO levels that were less than the Canadian water quality guideline for freshwater life (i.e., 6.5 mg/L; CCME 1999). Fully 20% of the locations (i.e., 10 of 50) had minimum DO levels of less than 3.0 mg/L (Himbeault 2003). Based on these results, DCMI concluded that Snap Lake is subject to DO depressions under ice under baseline conditions and that fish likely avoid deep areas under natural conditions and that this response would continue during mine operations.

Status of Concern: The additional information provided by DCMI (Himbeault 2003) emphasizes the sensitivity of Snap Lake to nutrient additions and associated primary and secondary effects on aquatic organisms. In the EA report, it was predicted that DO levels under ice could decrease by 1 to 3 mg/L in response to nutrient releases from the mine. The results of supplemental modelling of algal responses to various phosphorus discharge scenarios (Digel *et al.* 2003) indicate that chlorophyll *a* levels could be as much as 50% higher than those predicted in the EA case. Settling of this additional algal biomass in deeper areas within the lake could result in DO depressions under ice in excess of those predicted for the EA case. As a result, a larger proportion of the lake is likely to have harmfully low levels of DO during the winter and spring months. Such DO depressions would necessarily adversely affect benthic invertebrates and may adversely affect benthic fish populations. Lake trout that are unable to seek refuge in areas with high levels of DO would also be adversely affected. The toxicity of other COPCs would also be much greater if low DO levels were evident in portions of Snap Lake under ice covered conditions. Therefore, INAC is still concerned that the secondary effects of lake eutrophication have been underestimated. Hence, this issue remains outstanding for INAC.

2.8 Cumulative Effects Assessment Issues

INAC's Concern: Based on the results of its technical evaluation, INAC concluded that the assessment of cumulative effects presented in the EA report does not provide an adequate basis for evaluating the effects of the proposed Snap Lake diamond project nor the interactive effects between the project and other anthropogenic activities that could influence aquatic resources in the Lockhart River Basin. The cumulative effects assessment is considered to be incomplete for several reasons. First, it is apparent from the foregoing discussions on impact assessment issues and on environmental quality issues that the EA report has underestimated the effects of the various mining activities and associated discharges of COPCs on aquatic organisms. Second, the interactive effects of multiple COPCs have not been adequately addressed in the EA report. Third, the interactive effects of the Snap Lake project with other land and water use activities in the Lockhart River Basin have not been fully evaluated. Finally, the interactive effects of the project with other human activities (e.g., long-range transport of atmospheric pollutants, global climate change, etc.) have not been assessed.

DCMI Response: DCMI has not responded to these concerns by expanding the analysis of cumulative effects that was presented in the EA report. Rather, DCMI (2003c) has indicated that these concerns will be addressed through the collection of project-specific data that would contribute to a regional cumulative effects monitoring program (i.e., that would be overseen by a regional monitoring agency).

Status of Concern: The lack of an appropriate cumulative effects assessment represents an outstanding issue for INAC. This issue is critically important because the current deficiencies in the cumulative effects assessment will make it very difficult to design a monitoring program for the proposed project that will provide the required data for assessing cumulative environmental effects (i.e., it is not possible to accurately identify cumulative effects indicators or to identify the potential temporal or spatial scope of the cumulative effects). For this reason, it was recommended that the cumulative effects assessment be expanded to evaluate interactive effects of project activities and interactions between project activities and other activities that occur elsewhere in the Lockhart River Basin. As no additional work has been completed by DCMI on the cumulative effects assessment, this issue remains outstanding for INAC.

3.0 Conclusions

The Water Resources Division identified a substantial number of concerns that have not been resolved through the information requests, technical sessions, or recent submissions by the proponent. Together, the uncertainties associated with these unresolved issues lead us to conclude that the effects of mining activities on water quality in Snap Lake and associated impacts on aquatic organisms are substantially underestimated. Until the outstanding issues have been resolved, INAC continues to consider the EA to be incomplete and, as such, does not provide an adequate basis for assessing the impacts of the proposed project.