Review of Amendment Application (Dec. 2013) for the Snap Lake Mine

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Scope

- Review of documents submitted by DBCI to the MVLWB in support of a water licence amendment application for the Snap Lake mine;

- Focus on specific questions posed by the MVLWB related to:

  - Assessment of proposed WQOs – appropriate?
  - Assessment of the predictions for Snap Lake - contaminants likely to exceed proposed WQOs?
  - Assessment of potential effects on aquatic life for those contaminants likely to exceed proposed WQOs
  - Assessment of mitigation measures that can be implemented to prevent exceedance, minimize effects
  - Assessment of EQC calculations – appropriate?

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Documents Reviewed

- TDS Response Plan (DBCI, Dec., 2013)
- Nitrogen Response Plan (DBCI, Dec., 2013)
- Strontium Response Plan (DBCI, Dec., 2013)
- Evaluation of EQC Report (DBCI, Dec., 2013)
- Groundwater Flow Model Update (Itasca Denver, Aug., 2013; Oct., 2013)
- Mine Site Water Quality Model Update (DBCI, Dec., 2013)
- Snap Lake Hydrodynamic and Water Quality Model Report (DBCI, Dec., 2013)
- 2012 Plume Characterization Study (Golder, Jan., 2013)

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Assessment of Proposed WQOs

Total Dissolved Solids (TDS)

- Toxicity tests with six species – Snap Lake ion mixture
- Two alga, rotifer, two daphnids, midge, lake trout
- Dose-response was seen only for the two daphnids
- *Lowest IC20 (**684 mg/L**) selected as proposed SSWQO*
- TDS now approaches 300 mg/L in diffuser area
- EAR predicted maximum whole-lake average of 350 mg/L
- Current predictions for lake are as high as 1700 mg/L
- *Lowest IC20 among the site-specific tests is reasonable*
- Value of 684 mg/L in the range of 500-1000 mg/L use by Alaska for permitting

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Assessment of Proposed WQOs

Chloride

- Accounts for 45% of TDS in Snap Lake (mainly $CaCl_2$)
- Proposed WQO for chloride is hardness-dependent (eq'n from Elphick et al., 2011) – maximum at H=160mg/L is **388 mg/L**
- *45% of 684 mg/L TDS is 308 mg/L chloride, so WQO for TDS will be limiting for chloride*
- Chloride WQO equation based on a daphnid IC25 hardness relationship, adjusted down slightly to the HC_5 of a SSD
- Accepted as the SSWQO for the Ekati mine site (WLWB, 2013)
- CCME (2011) WQG is 120 mg/L - SSD approach – no hardness adjustment; mussels most sensitive (not in Snap L), next was fingernail clam - LOEC 121 mg/L NaCl, 756 mg/L $CaCl_2$
- *Proposed WQO likely protective under Snap Lake conditions*

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Assessment of Proposed WQOs

Fluoride

- Very minor component of TDS in Snap Lake
- Proposed WQO is **2.46 mg/L** – HC_5 of a SSD
- CCME (2002) WQG (interim) is 0.12 mg/L – 6-day LC50 for caddisfly, divided by 100-fold safety factor – this WQG is well below the range of effect levels
- Few effect levels below proposed WQO – fingernail clam MATC 2.25 mg/L, rainbow trout 10-day LC50 2.2 mg/L
- Current prediction for lake – not to exceed 0.5 mg/L
- *Proposed WQO likely protective of aquatic life, but a lower target value in the lake could be achieved*
- MAC for drinking water is 1.5 mg/L (dental fluorosis)

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Assessment of Proposed WQOs

Nitrate

- Nitrogen releases (as NH_4^+ and NO_3) from explosives residue
- Proposed WQO for NO_3-N is hardness-dependent (eq'n from Rescan, 2012) – maximum at H=160 mg/L is **16.4 mg/L**
- Nitrate-N equation based on HC5 of a SSD, adjusted for hardness using a multi-species hardness relationship
- Accepted as the SSWQO for the Ekati mine site (WLWB, 2013)
- Toxicity tests performed on sensitive species from Rescan SSD, using synthetic Snap Lake water, H=140 and 350 mg/L, to confirm effect levels above proposed WQO (lowest 16.7 mg/L)
- Would effect levels fall below proposed WQO at higher H?
- *Proposed WQO seems protective, but uncertain for high H*
- *Could meet a lower target in the lake (prediction up to 9 mg/L)*

MAC for drinking water is 10 mg/L NO_3-N

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Assessment of Proposed WQOs

Ammonia (total)

- Includes ionized (NH_4^+) and unionized (NH_3) forms
- Proposed WQO for total ammonia-N is the **CCME (2010)** equation – depends on pH and temperature – achieves 0.019 mg/L NH_3 - WQO lower at high pH and temperature
- Proposed to evaluate at 85th percentile of Snap Lake pH and temperature (7.14 and 13.7^{o}C) – WQO 5.21 mg/L
- Calculated WQO is incorrect – should be 4.6 mg/L as N
- *Proposed WQO = CCME will be protective of aquatic life*
- Predicted maximum is 2.5 mg/L in the diffuser area

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Assessment of Proposed WQOs

Strontium

- Very soluble in water, chemically similar to calcium
- CCME has not defined a WQG for strontium
- Two reported values are well below others in the literature
- Birge et al 1980 and Borgmann et al 2005 studies were repeated – rainbow trout survival, amphipod growth
- Results used with other effect levels to create a SSD – the HC5 of 14.1 mg/L was initially proposed (DBCI, 2013)
- Two acute studies were removed, revised HC5 **10.7 mg/L**
- *This WQO should be protective of aquatic life, but a lower target value in the lake is possible (predicted max 4 mg/L)*

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Assessment of Proposed WQOs

Sulphate

- Accounts for 9% of TDS in Snap Lake
- CCME has not defined a WQG for sulphate
- Proposed WQO from B.C. MOE (2013) is a step function of hardness – 308 mg/L at H=76-180 mg/L, 429 mg/L at H=181-250 mg/L – based on rainbow trout embryo test
- *Concern about combined effects at H above 250 – MOE recommends toxicity testing with site water if H > 250*
- Fertilization and pre-eyed embryos of salmonids may be more sensitive – MOE recommends more research
- *Proposed WQO seems protective; uncertainty for high H*

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Assessment of Models

Groundwater Flow Model

- Unanticipated increases in underground flows (DBCI, 2013) – updated flow model to predict future flows (Itasca, 2013)
- New data on structure zones (faults), hydraulic conductivity, measured inflows and TDS concentrations, Mine Plan changes
- Model calibrated using measured TDS and flows
- *Model appears to be appropriate, but some limitations*
- Full delineation of the Snap and Crackle faults has not been completed – assumed to extend to model boundaries
- Hydraulic conductivities assigned to layers through calibration to match measured flows – assumed to decrease with depth – no correlation shown with measured hydraulic conductivities

Assessment of Models

Groundwater Flow Model

- Footwall TDS concentrations assumed constant, but measured values increased from 2012 to 2013 – no assessment of trend
- October model used arithmetic TDS inputs, but geometric mean inputs gave better correlation of predicted TDS with recent data
- *Overall, the groundwater model appears to accurately represent current and historical inflows, and to approximate current and historical TDS concentrations*
- *Uncertainties associated with hydraulic parameters of future mining areas, and measured TDS concentrations are limitations*
- *Itasca recommends further delineation of Snap and Crackle faults, additional boreholes and hydraulic testing, and increased TDS monitoring*

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Assessment of Models

Mine Site Model

- Collects inputs from various mine sources, including the mine itself, the north pile, the mine site, the WTP, and the WMP
- Links to Snap Lake Model via inflow of lake water to mine, and effluent discharge to the lake – the two models run iteratively to allow mass and flow balance
- *Uncertainties related to: possible deviations from the Mine Plan, groundwater flows, system complexity somewhat simplified*
- *Some contaminants slightly over-predicted in final discharge, including fluoride, iron, ammonia, and TDS*
- *Reasonably good calibration – realistic to slightly conservative*

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Assessment of Models

Snap Lake Model

- 3-D hydrodynamic model – input data are meteorological (wind, temperature, pressure), hydrological (flows of effluent, non-point sources, tributaries) and chemical (site monitoring data)
- Calibrated to measured data from 2004 to 2012 – after calibration some over-predictions (metals, fluoride) or slight under-predictions remain (magnesium)
- *Key uncertainties relate to the upstream models (future groundwater flows , possible deviations from the Mine Plan)*
- *Reasonably good calibration – no large under-predictions or over-predictions for contaminants that approach/exceed WQOs*
- *Subject to the key uncertainties, we have confidence in the predictions that TDS and chloride will exceed proposed WQOs*

Assessment of Effects

- Without mitigation, TDS and chloride are predicted to exceed proposed WQOs as early as 2015 to 2016

Total Dissolved Solids

- Predicted peak concentrations about 1700 mg/L in Snap Lake for the worst case scenario, 820 mg/L for best case
- For sensitive daphnids (*C. dubia*) at 1700 mg/L we expect more than 50% inhibition of reproduction (IC50 is 1368 mg/L)
- *Likely reduced abundance or possibly loss of such species in Snap Lake, and in downstream lakes 1 and 2*
- For other invertebrates tested (rotifer, midge) and fish tested (lake trout, grayling) no effect in tests up to about 1500 mg/L
- EAR predicted minor changes in zooplankton community
- *No evidence to suggest major community changes; uncertain*

Assessment of Effects

Chloride

- Predicted peak concentrations about 800 mg/L in Snap Lake for the worst case scenario, 390 mg/L for best case
- For sensitive zooplankton at 800 mg/L we expect at least 25% inhibition of reproduction (HC5 of SSD is 388 mg/L)
- *Likely reduced abundance or possibly loss of such species in Snap Lake, and in downstream lakes 1 and 2*
- For other taxa, likely little or no adverse effect
- EAR predicted minor changes in zooplankton community
- *No evidence to suggest major community changes; uncertain*

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Assessment of Mitigation Measures

- Mitigation strategy proposed for TDS and chloride – WTP expansion, segregation of water considered, found not feasible
- Mitigation strategy proposed for nitrate – review of blasting and explosives loading/storage practices, consideration of treatment
- *Mitigations are not described or evaluated in sufficient detail to judge their effectiveness – pilot studies are planned*
- WTP Alternatives Evaluation (CH2MHill, 2012) suggests that removal efficiencies > 90% are possible using reverse osmosis
- *Mitigations to achieve EQCs that allow proposed WQOs to be met seem to be technically feasible*

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Thank you.

- Questions?

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