Terms of Reference for the EKATI Pit Lake Studies

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Background

- The development of the 2004 Terms of reference (TOR) for the pit lakes studies followed the requirements outlined in Part I (item 1) and Part L (item 1b) of the Water License MV2001L2-0008 granted by the Mackenzie Valley Land and Water Board (MVLWB)
- The WLWB directed BHPB to include Pit Lakes Studies as part of the Interim Closure and Reclamation Plan (ICRP), April 30, 2007
- The Pit Lakes Studies in the ICRP have been extended to include all open pits at closure
- The open pits are Sable, Pigeon, Beartooth, Panda, Koala (and Koala North), Fox and Misery

Background

- The ICRP Pit Lakes Studies address the following research for the proposed flooding of the open pits:
  - Review the state of knowledge on mining pit lakes
  - Review of data requirements and data gaps
  - Waste characterization
  - Water balance at closure
  - Pit lake stability modeling
  - Water load balance model
  - Analysis of fish habitat and fish communities in source lakes
  - Summary of pit lakes studies

Reclamation Plans and Criteria

- BHPB proposes three stages of reclamation for the EKATI open pits:
  - Decommissioning – Removal of structures and contaminants, creation of stable geotechnical structures, landscaping and pump flooding of open pits
  - Reclamation – Stabilization of water quality and surrounding pit perimeter
  - Closure Criteria Conformance – Monitoring pit lake water quality and bank stabilization

Task 1: Review of the State of Knowledge on Pit Lakes

- There is a large amount of existing knowledge and literature on the conversion of open pit mines into pit lakes
- Drawing from this knowledge base has and will continue to improve the design and implementation of the closure concept for EKATI
- Review completed December 2005: 102 papers selected and reviewed on the topics of:
  - Physical limnology and pit lake numerical modeling
  - Geochemistry of pit lakes
  - Biology of pit lakes
- BHP Billiton continues to study pit lakes, particularly its research conducted at the Island Copper Closed Mine, British Columbia

Task 1: Review of the State of Knowledge on Pit Lakes

- The December 2005 literature review found:
  - Most pit lakes that have been studied have ARD issues
  - Salt exclusion can be an important factor affecting pit lake water density
  - Compressibility of water in lakes greater than 100 m deep can play a role determining the extent of vertical mixing
  - A number of applicable modeling tools exist, each with benefits and drawbacks. There is no single perfect modeling tool for pit lakes
  - Residual material left in pit prior to flooding can be very important in determining final lake water chemistry, however, this is most important in ARD generating mines
  - Biological data for pit lakes is lacking in the literature by comparison to other topics
  - No examples of drawdown effects in source lakes was found in the literature, however, some examples of drawdown effects exists for reservoirs and small impoundments

Task 2: Review Data Gap Requirements, Available Data and Data Gaps

- Comprehensive baseline data for regulatory applications and pre-development were collected in 1995 and since operations began in 1998
- Data gap review completed in December 2005. A matrix of data requirements was prepared for each of the relevant project tasks
- Key data gaps were identified for and a field sampling program was undertaken to collect key data on source lakes
- Data on pit geometry and pit groundwater conditions, will be forthcoming with future development of the Pigeon and Sable pits, although best current predictions will be used for the pit lake studies
- Ongoing monitoring of meteorology, hydrology, water quality, aquatic and waste rock characterization will provide additional data for the pit lake studies

Task 3: Waste Characterization

- This task focuses on the characterization of the waste rock piles and their potential to generate ML/ARD, and in pit materials (ANFO, kimberlite, pit walls)
- Currently available waste rock data will be summarized to determine representative waste rock runoff at closure
- Pit sump and Misery in pit water data will be summarized to evaluate residual ANFO contributions

Task 4: Water Balance at Closure

- After flooding of the open pits, the pits will be connected with streams and lakes in their natural watersheds
- This task will use predictive tools for the assessment of water budgets for the pit lakes under a range of scenarios covering the short, medium and long-term life of the pit lakes

Task 4: Water Balance at Closure

- The four main issues that require hydrological and water balance assessments are:
  - Impact of water removal on source water bodies during infilling of the pit lakes
  - Impact of water removal on streams and water bodies downstream of source water bodies
  - Prediction of rate of pit infilling (with water and processed kimberlite)
  - Long-term flow through rates and water level variations of the pit lakes

Task 4: Water Balance at Closure

- Requires the development of water balance model that includes representations of all relevant hydrological inflows and outflows
- GoldSim Version 9.0, a dynamic mass balance software, will be used to complete the water balance modeling
- Water balance models will be calibrated using available data, and sensitivity runs will be undertaken
- Key model scenario runs will be designed to model pit infilling strategies

Task 5: Pit Lake Stability Modelling

- This task will present a strategy for modeling the physical stability of the proposed pit lakes, and determine the likelihood of permanent meromixis
- Pit lakes differ from natural lakes due to depth and relatively small surface area
- As a result, there is potential for pit lakes to be meromictic (*i.e.*, not to mix throughout their depth)

Task 5: Pit Lake Stability Modelling

- A semi-analytic model will first be used to identify factors affecting meromixis of the proposed pit lakes
- A more detailed numerical model, such as Dynamic Resevoir Simulation Model (DYRESM) or box model, will then be used to model the physical stability of the pit lakes
- A technical report will describe the parameterization of stability models, along with model assumptions, data limitations and the results of model calibration and sensitivity analysis
- Selected model runs will be presented in the context of pit infilling strategies and their effect on pit lake stability
- Model results will be used in the water load balance modeling in Task 6

Task 6: Water Load Balance Model

- A water quality model will be 'linked' to the water balance model described in Task 4 and pit lake stability model of Task 5, and used to describe the driving factors in determining the ultimate water quality of the pit lakes
- Linking of the load balance to the water balance allows consideration of the following:
  - Source water flow and quality
  - Natural runoff and precipitation inputs
  - Runoff quantities and qualities from waste rock piles
  - Leaching rates and qualities from pit walls
  - Loading from residual pit material (ANFO)
  - Leaching from in pit material (waste rock and processed kimberlite)
  - Groundwater quality and quantity

Task 7: Analysis of Fish Habitat and Fish Communities

- The open pit infilling strategy will have the potential to temporarily reduce the littoral habitat in the source lakes and downgradient stream habitat
- Pit infilling scenarios established in the water balance model will be used to evaluate potential effects on fish and fish habitat in source streams and lakes (drawdown of source lake water)
- This tasks involves detailed mapping of fish habitat in the littoral zones of source lakes where drawdown may occur.

Task 8: Report Summarizing Tasks

- Task 8 consists of a report summarizing the results of the work under the pit lakes TOR tasks 1 to 8
- Each pit flooding scenario will be described in terms of environmental and design issues

Questions/Comments