APPENDIX 8.I

WATER QUALITY MODEL REPORT

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8.I.1 INTRODUCTION

De Beers Canada Inc. (De Beers) proposes to mine diamonds from three open pits (5034, Hearne, and Tuzo) at Kennady Lake, a headwater lake within the Lockhart River system, located approximately 280 kilometres (km) northeast of Yellowknife in the Northwest Territories (NWT), Canada. Mining from these three pits will require partial dewatering of Kennady Lake. Dewatering activities, mining, material placement and other site activities or water management strategies have the potential to impact the water quality in Kennady Lake and subsequently, in the downstream receiving environment during post-closure, when water will be released.

Water quality models are often used as a tool to provide an estimate of the direction and magnitude of impacts from proposed mining operations. A water quality model, to the extent practicable, should include the natural and anthropogenic processes that could affect the site water quality during operations and closure of mining facilities.

Three water quality models were developed for the Gahcho Kué Project (Project) to evaluate the magnitude and direction of impacts mining could have on Kennady Lake and in the downstream receiving environment. The water quality models were linked together at key times and nodes. The Kennady Lake model covered the portion of Kennady Lake that will be isolated from the receiving environment during mining (i.e., the controlled area). The downstream water quality model included Area 8, the Interlakes (i.e., the L and M watersheds), the N watershed, and Lake 410. These models were linked together during any planned hydraulic connections, including pumping between systems, and at closure. The hydrodynamic model was used to determine the amount of water in Tuzo Pit that would interact with Kennady Lake. These models are described individually in the following subsections.

The steps used to assess the Project effects on water quality are as follows:

- identify the spatial boundaries of the assessment;
- select time periods for the assessment;
- select the assessment locations on the watercourses where changes will be quantified;
- identify environmental design features and mitigation to reduce the effects to water quality; and
- develop models to quantify the changes in water quality;

This appendix presents the model approach, methods, inputs and assumptions related to the water quality predictions for the Project. Model results and interpretation are presented in Section 8.8 and 9.8, and detailed results are provided in Appendix 8.III and Appendix 9.I.

8.I.2 KENNADY LAKE WATER QUALITY MODEL

8.I.2.1 SITE OVERVIEW

Diamondiferous kimberlite pipes will be mined at three open pits (5034, Hearne and Tuzo) at the Project. All three kimberlite pipes are located beneath Kennady Lake. As such, segmentation and partial dewatering of Kennady Lake will be required to gain access to the open pits.

To facilitate the design of the Project, Kennady Lake will be divided into six principal areas whose limits are truncated by one or more filter dykes or impermeable, earth-filled dykes. Additional details of Kennady Lake water management are discussed in Section 8.4.2.3. Figure 8.I-1 presents the limits of each Kennady Lake area and Table 8.I-1 provides a brief description of each area. The water quality model inputs and assumptions presented in the subsequent sections are discussed with reference to these areas.

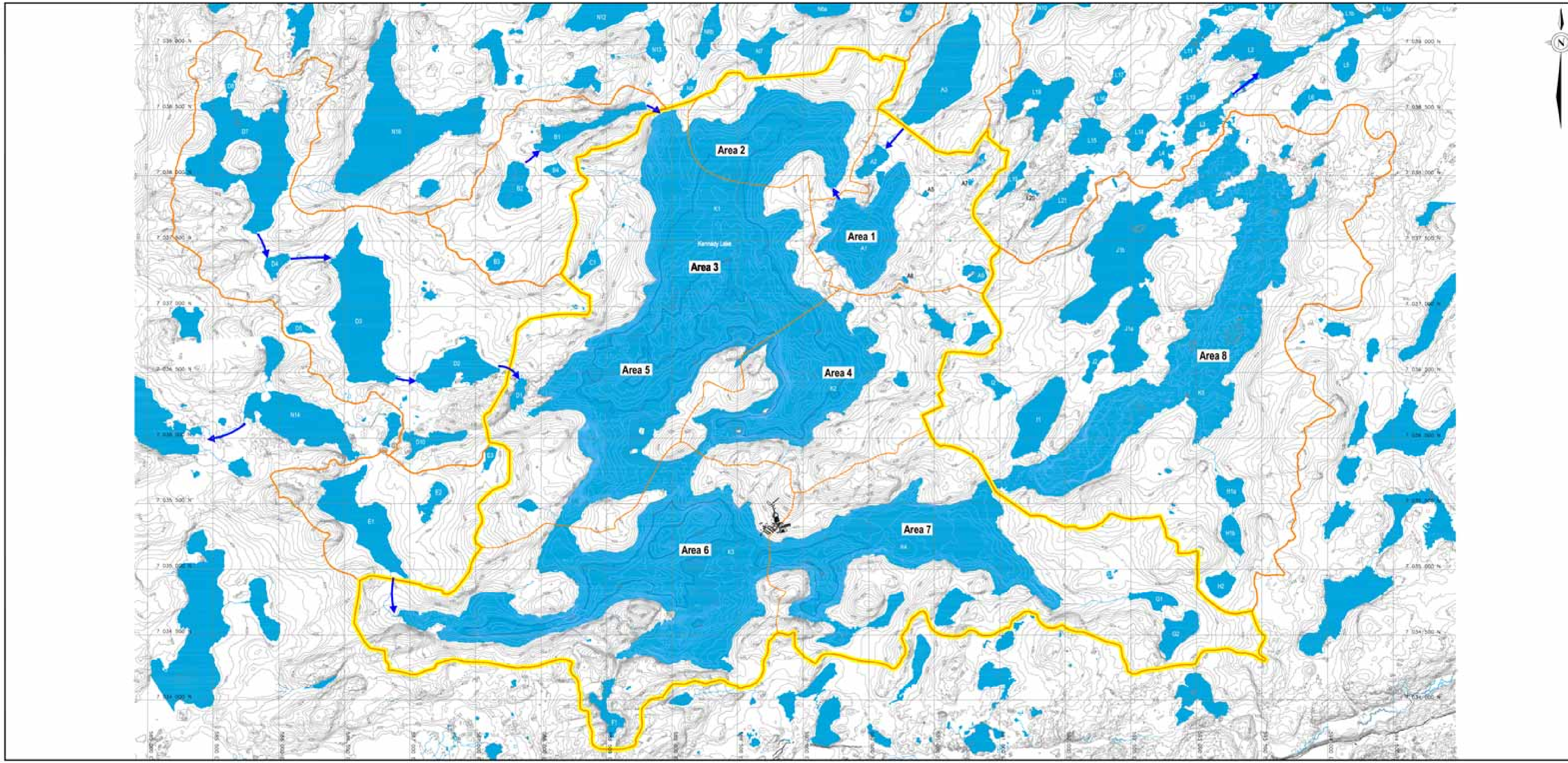
Table 8.I-1 Summary of Kennady Lake Areas

Area	Description
Areas 1 and 2 (Fine Processed Kimberlite Containment Facility)	Located in the northeast corner of Kennady Lake and is designated for fine processed kimberlite deposition
Areas 3 and 5 (Water Management Pond)	This area will operate as the site water management pond and will provide the primary source of process reclaim water and is located in north of Kennady Lake.
Area 4	Located to the southeast of Areas 3 and 5. Location of the Tuzo kimberlite pipe
Area 6	Located to the south of Areas 3 and 5. Location of the 5034 and Hearne kimberlite pipes.
Area 7	Truncates Area 6 to the east.
Area 8	East basin of Kennady Lake outside of project footprint.

Mining of the three open pits at the Project will require the construction of the following mine site facilities:

- Water Management Pond (WMP).
- Process Plant;
- West and South Mine Rock Piles;
- Coarse Processed Kimberlite (PK) Pile;
- Fine Processed Kimberlite Containment (PKC) Facility;

Figure 8.I-2 presents the location of each of these facilities in relation to each Kennady Lake area.



LEGEND

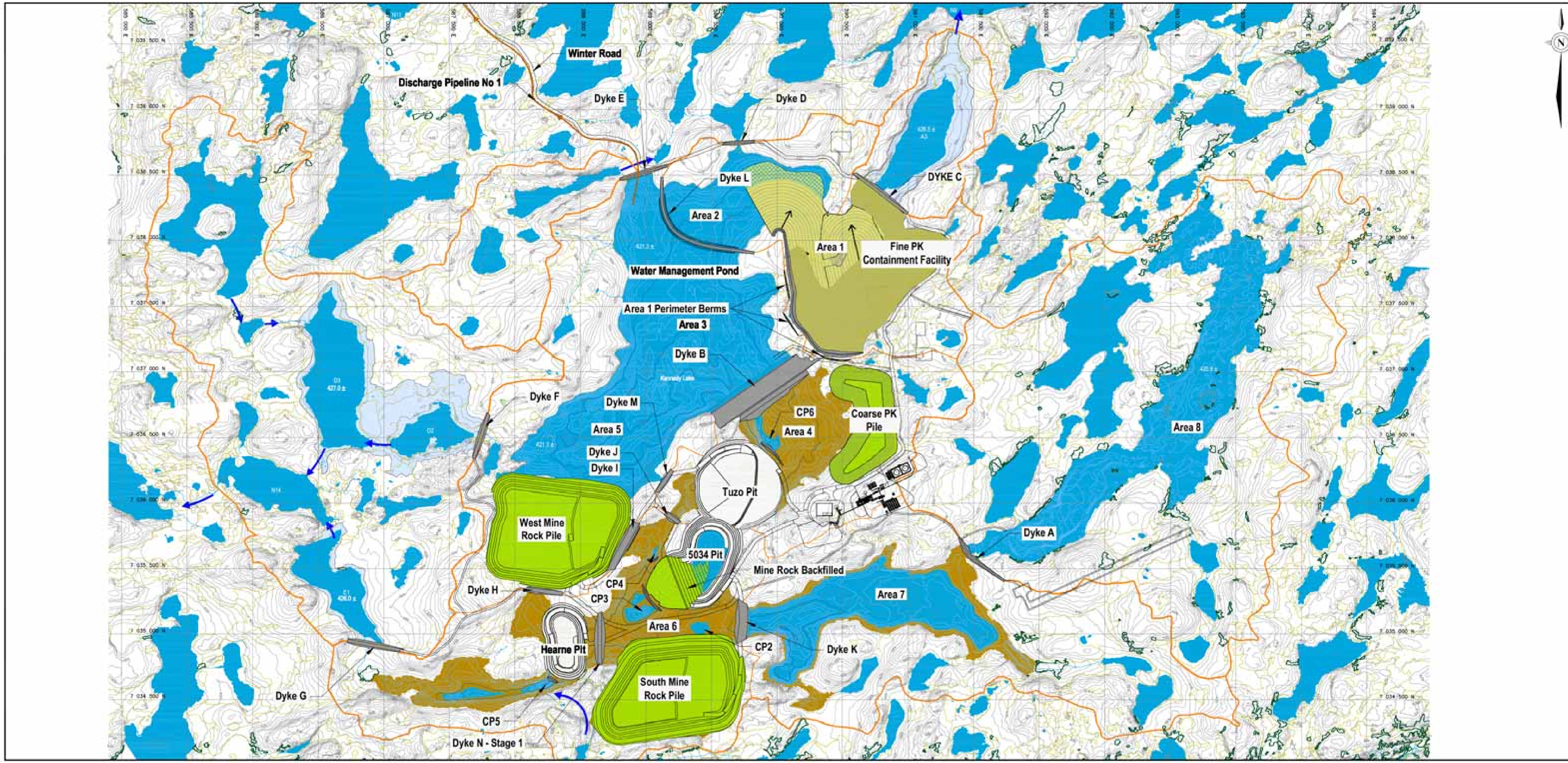
- Existing Ground Contours 5m Index - 1m Intermediate
- Bathymetry Contours 5m Index - 1m Intermediate
- Controlled Area Boundary
- Marsh Area
- Scrub
- Sub-watershed Boundary
- Drainage Flow Direction
- Lake/Pond

NOTES
Base data source: EBA Figure 4.5 - Stage 2 - Water Management During Mine Operation Years 1 to 3 (2015 to 2017)

GAHCHO KUÉ PROJECT

Kennady Lake Areas

PROJECTION: UTM Zone 12	DATUM: NAD83		DE BEERS CANADA
SCALE 500 0 500 METRES			
FILE No: E-SWQ-005-CAD			DATE: December 16, 2010
JOB No: 09-1365-1004	REVISION No: 0		Figure 8.I-1
OFFICE: GOLD - SAS	DRAWN: TAH	CHECK: JF	



LEGEND

Existing Ground Contours
5m Index - 1m Intermediate

Bathymetry Contours
5m Index - 1m Intermediate

CP Collection Pond

Winter Road

Marsh Area

Scrub

Sub-watershed Boundary

Drainage Flow Direction

Discharge Pipeline

Coarse PK

Drained Area

Fine PK

Flooded Areas

Lake/Pond

Mine Rock

Submerged PK

NOTES
Base data source: EBA Figure 4.8 - Stage 5 - Water Management During Mine Operation Year 6 (2020)

GAHCHO KUÉ PROJECT

Location of the Gahcho Kue Mine Site Facilities

PROJECTION: UTM Zone 12	DATUM: NAD83
SCALE 500 0 500 METRES	DE BEERS CANADA
FILE No: E-SWQ-006-CAD	DATE: December 16, 2010
JOB No: 09-1365-1004	REVISION No: 0
OFFICE: GOLD - SAS	DRAWN: TAH CHECK: JF

Figure 8.I-2

8.I.2.2 KENNADY LAKE WATER BALANCE

A water management strategy for Kennady Lake is described in technical memoranda in Attachment 8.I.1 for the construction and operations phases and Attachment 8.I.2 for the closure phase. Respecting the constraints and considerations listed in Attachments 8.I.1 and 8.I.2, the key objectives of the water management plan are to:

- minimize the amount of water requiring discharge to downstream receptors during the initial dewatering period;
- manage mine water during the closure period to minimize water quality impacts within the WMP during the closure and post-closure periods; and
- manage waters within the Kennady Lake catchment area until the water quality is suitable for release, marking the transition to the post-closure period.

The water management plan described in these technical memoranda formed the basis for evaluating the water quality at the Project. Details of the Water Management Plan with emphasis on the water quality considerations are provided in the Project Description (Section 3) and Section 8.4 (Water Management Plan).

8.I.2.3 CONCEPTUAL MODEL

To facilitate mining of the kimberlite pipes, the upper watersheds will be temporarily diverted to an adjacent watershed, and Kennady Lake will be dewatered and divided into separate areas during the construction and operations phases of the Project. The remaining lake area will be closed-circuited, and will function as a WMP. At closure, the diverted upper watersheds will be restored, and lake will be refilled by natural watershed inflows and by importing water from nearby Lake N11. Details regarding water management during all phases of the Project are included in Section 8.4.

The Kennady Lake water quality model was developed to predict concentrations in Kennady Lake during the construction, operations, and closure phases. A deterministic water quality model was developed for Kennady Lake using GoldSim version 9.6. GoldSim is a graphical, object-oriented mathematical model where all input parameters and functions are defined by the user and are built as individual objects or elements linked together by mathematical expressions. The object-based nature of the model is designed to facilitate understanding of the various factors, which control an engineered or natural system and predict the future performance of the system.

In general, the Kennady Lake water quality model is a flow and mass-balance model that was set up to account for all inputs and processes described in Section 8.4.3. The spatial modelling domain includes the portion of Kennady Lake (i.e., Areas 2 to 7) that is planned to be hydraulically isolated from the surrounding environment during mining operations. Within the closed-circuited areas of Kennady Lake, the lake is planned to be divided by dykes into five basins (i.e., Area 2, Areas 3 and 5, Area 4, Area 6 and Area 7) during the operations phase (Section 8.4.3). Each of these basins was treated as a distinct reservoir within the model.

Within each reservoir, volumes and concentrations were calculated on a monthly time step from Year -2, which corresponds to the start of construction, to Year 121, which is 100 years after the reconnection of the upper areas of Kennady Lake with Area 8 and the downstream watershed (i.e., the post-closure period). Inflow volumes and concentrations were included as inputs to each reservoir to account for loadings from natural areas, disturbed areas, mine rock runoff, fine and coarse PK runoff and groundwater discharge.

The model assumed complete mixing within each basin at each timestep while the dykes are operational. At closure, when the dykes are planned to be breached, the model reports fully mixed conditions in Areas 3 to 7 (Area 2 becomes incorporated into the Fine PKC Facility). No chemical reactions or sinks were assumed to occur in the model, except where volumes of water are sequestered in mine rock pore space.

The water quality model predicted concentrations for a range of water quality parameters at the following key nodes, for specific Project phases:

- Areas 3 and 5 (WMP) during operations, because this water is discharged to Lake N11 (Section 9.8);
- Kennady Lake Areas 3 to 7, at the end of the closure period; and
- Kennady Lake Areas 3 to 7, 100 years into the post-closure period.

Model predictions were made on a monthly basis under average climate conditions (i.e., 1:2 year wet [median] conditions). Model predictions were based on average climate conditions for three reasons. First, as a lake-dominated system, water quality is less susceptible to inter-annual fluctuations in precipitation and temperature. Second, the majority of changes in water quality parameter concentration due to the Project are large in terms of relative change compared to baseline conditions (see Section 8.8.4.1 of the environmental impact statement [EIS]), so natural variability would be a relatively small contributor to overall change. Finally, using mean conditions allows for a straightforward assessment of incremental changes due to the Project.

Modelled changes in water quality resulting from the Project are the difference between the measured background concentrations and the modelled water quality at the key nodes. The model used average background concentrations and conservative estimates of mass loadings from the Project to simulate changes in water quality. The model results are projections that are suitable for the assessment of effects; however, the model does not account for natural variability, and therefore, model results should not be viewed as predictions or forecasts of future conditions.

8.I.2.4 MODEL INPUTS

8.I.2.4.1 Kennady Lake and Receiving Environment Water Quality

Background water quality data in the Kennady Lake watershed was collected between 1995 and 2010. The data were collected by various consultants during open water and under-ice conditions (see Section 8.3). For the purposes of the Kennady Lake and downstream lakes water quality assessments, data collected from the sources presented in Table 8.I-2 were used.

Table 8.I-2 Water Quality Studies Used in the Assessment of Kennady Lake and Downstream Lakes, 1995 to 2010

Report Author(s)	Publication Date	Report Title	Applied to	
			Kennady	Downstream
JWEL	July 1998	Water Quality Assessment of Kennady Lake, 1998 Final Report. Project No. BCV50016. Submitted to Monopros Limited, Yellowknife, NWT	✓	✓
JWEL	October 14, 1999	Results of Water Sampling Program for Kennady Lake July 1999 Survey. Project No. BCV50016. Submitted to Monopros Limited, Yellowknife, NWT	✓	✓
JWEL	1999	Trip Report #1 and Data Assessment for Kennady Lake Water Quality - 1999 Survey Program. Submitted to Monopros Limited, Yellowknife, NWT	✓	
EBA & JWEL	2001	Gahcho Kué (Kennady Lake) Environmental Baseline Investigations (2000) Submitted to De Beers Canada Exploration Ltd., Yellowknife, NWT	✓	✓
JWEL	March 4, 2002	Baseline Limnology Program (2001) Gahcho Kué (Kennady Lake). Project No. 50091. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT	✓	

Table 8.I-2 Water Quality Studies Used in the Assessment of Kennady Lake and Downstream Lakes, 1995 to 2010 (continued)

Report Author(s)	Publication Date	Report Title	Applied to	
			Kennady	Downstream
JWEL	April 29, 2002	Data Compilation (1995-2001) and Trends Analysis Gahcho Kué (Kennady Lake). Project No. ABC50310. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT	✓	✓
EBA	2002	Gahcho Kué Winter 2001 Water Quality Sampling Program, Gahcho Kué, NWT. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT	✓	
EBA	2003	Kennady Lake Winter 2002 Water Quality Sampling Programme Kennady Lake, NWT. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT	✓	
JWEL	June 4, 2003	Gahcho Kué (Kennady Lake) Limnological Survey of Potentially Affected Bodies of Water (2002). Project No. NTY71008. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT	✓	✓
JWEL	June 4, 2003	Baseline Limnology Program (2002) Gahcho Kue (Kennady Lake). Project No. NTY71008. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT	✓	
JWEL	January 20, 2004	Baseline Limnology Program (2003) Gahcho Kué (Kennady Lake). Project No. NTY71037. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT	✓	✓
EBA	2004	Kennady Lake Winter 2003 Water Quality Sampling Program. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT	✓	
EBA	2004	Faraday Lake Winter 2003 Water Quality Sampling Program. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT	✓	✓
EBA	2004	Kelvin Lake Winter 2003 Water Quality Sampling Program. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT	✓	✓
EBA	2004	Kennady Lake (Winter 2004) Water Quality Sampling Program. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT	✓	
AMEC	2004-2005	Unpublished water chemistry and field data collected in Kennady Lake and surrounding watersheds.	✓	✓
Sections 8.3 and 9.3	2010	Additional baseline data collected in support of this application	✓	✓

JWEL = Jacques Whitford Environment Ltd.; EBA = EBA Environmental Consultants Ltd.; AMEC = AMEC Earth & Environmental.

Because the systems being modelled are lake-dominated, and therefore less prone to fluctuations, mean chemistries were chosen to represent baseline conditions. Long-term means were calculated by deriving long-term time series that fit probability distributions for each constituent. To do so, unique probability distributions were assigned to each water quality constituent modelled. Available water quality data were compiled and used to characterize the source waters. The following standardized screening process was used to develop a probability distribution for each constituent:

- Step 1 - remove outliers from the measured data;
- Step 2 - fit suitable probability distributions to the remaining data;
- Step 3 - assess the goodness of fit for all applicable distributions to determine the most appropriate distribution type;
- Step 4 – generate a long-term timeseries according to the chosen distribution; and
- Step 5 – calculate the mean from the timeseries.

Input concentrations for Kennady Lake and the downstream lakes are provided in Table 8.I-3.

Table 8.I-3 Baseline Input Water Quality

Parameters	Units	Kennady Lake	Downstream Lakes
Conventional			
Total Dissolved Solids	mg/L	11	16
Total Suspended Solids		1.0	1.3
Major Ions			
Calcium	mg/L	1.3	1.1
Chloride	mg/L	0.64	0.49
Magnesium	mg/L	0.54	0.43
Potassium	mg/L	0.47	0.39
Sodium	mg/L	0.75	0.78
Sulphate	mg/L	0.89	0.88
Nutrients			
Ammonia	mg/L	0.018	0.019
Nitrate	mg/L	0.035	0.019
Total Nitrogen	mg/L	0.33	0.12
Phosphorus, dissolved	mg/L	0.0048	0.0030
Phosphorus, total	mg/L	0.0048	0.0048
Dissolved Metals			
Aluminum	mg/L	0.0057	0.017
Antimony	mg/L	0.000093	0.000053
Arsenic	mg/L	0.00013	0.0001
Barium	mg/L	0.0024	0.002
Beryllium	mg/L	0.000048	0.000064
Boron	mg/L	0.002	0.0017
Cadmium	mg/L	0.000014	0.000019
Chromium	mg/L	0.00012	0.00016
Cobalt	mg/L	0.000083	0.00019
Copper	mg/L	0.00069	0.00099
Iron	mg/L	0.018	0.045
Lead	mg/L	0.000029	0.000027
Manganese	mg/L	0.0091	0.004
Mercury	mg/L	0.0000051	0.0000051
Molybdenum	mg/L	0.000059	0.000014
Nickel	mg/L	0.00033	0.00039
Selenium	mg/L	0.000025	0.000032

Table 8.I-3 Baseline Input Water Quality (continued)

Parameters	Units	Kennady Lake	Downstream Lakes
Silver	mg/L	0.000043	0.0000025
Strontium	mg/L	0.0082	0.0069
Thallium	mg/L	0.000017	0.0000012
Uranium	mg/L	0.000024	0.000011
Vanadium	mg/L	0.000025	0.000039
Zinc	mg/L	0.0028	0.0024
Total Metals			
Aluminum	mg/L	0.0094	0.019
Antimony	mg/L	0.00014	0.000062
Arsenic	mg/L	0.00013	0.00012
Barium	mg/L	0.0026	0.0027
Beryllium	mg/L	0.000048	0.000064
Boron	mg/L	0.002	0.0017
Cadmium	mg/L	0.000023	0.000019
Chromium	mg/L	0.00021	0.00016
Cobalt	mg/L	0.000085	0.00019
Copper	mg/L	0.0013	0.0013
Iron	mg/L	0.042	0.059
Lead	mg/L	0.000039	0.000061
Manganese	mg/L	0.0091	0.0057
Mercury	mg/L	0.0000066	0.0000051
Molybdenum	mg/L	0.000059	0.00003
Nickel	mg/L	0.00048	0.00047
Selenium	mg/L	0.000025	0.000032
Silver	mg/L	0.000043	0.0000081
Strontium	mg/L	0.0082	0.0069
Thallium	mg/L	0.000022	0.000014
Uranium	mg/L	0.000024	0.000016
Vanadium	mg/L	0.00021	0.000094
Zinc	mg/L	0.0028	0.0024

mg/L = milligrams per litre

8.I.2.4.2 Mine Rock Piles

Mine rock will be produced from mining of the three kimberlite pipes (5034, Hearne and Tuzo) at the Project. These materials will be placed in the West and South Mine Rock Piles (Figure 8.I-2). The following mine rock units are expected to be mined at the Project:

- granite;
- altered granite;
- granodiorite;
- altered granodiorite;

- diorite; and
- diabase.

Approximately 95 percent (%) of the mine rock to be produced at the Project is expected to be granite. Geochemical baseline testing indicates that a small fraction of the granitic mine rock will be acid generating (Appendix 8.II). When normalized to 100% of the total mine rock to be produced, 91% of the total granite was assumed to be non-potentially acid generating (PAG) and the remaining 4% was considered PAG granite. Relative proportions of the remaining mine rock lithologies were unknown and equal amounts of these units were assumed to represent the remaining 5% of the mine rock.

The drainage quality from the mine rock piles will be a function of the seasonality at the Project. During the freshet period (i.e., June), fresh oxidation products and readily soluble salts from mine rock placed in the piles during the winter months will be flushed from the mine rock piles. Following the initial flushing of these materials, the runoff is expected to obtain a more constant (“steady-state”) water quality for the remaining runoff months.

Concentrations observed during humidity cell testing were selected to represent the input water quality in the Kennady Lake water quality model. The maximum concentration observed in the first five weeks of the humidity cell tests of each lithology was selected to represent the freshet runoff water quality. The maximum concentration reported during the last five weeks of testing was considered to be representative of the expected steady-state water quality from each rock unit. In GoldSim, these qualities were mixed in their relative proportions to simulate the drainage water quality from the mine rock piles at each month. The model input water quality selected for each lithology, with the exception of phosphorus is presented in Table 8.I-4. Detailed humidity cell test results, forming the basis for the water quality inputs are provided in Appendix 8.II. The derivation of the phosphorus input concentration for mine rock is provided in Attachment 8.I.3).

Table 8.I-4 Kennady Lake Model Geochemical Inputs

Parameter	Units	Process Water	Kimberlite		Coarse PK		Fine PK		Mine Rock													
									Granite (non-PAG)		Granite (PAG)		Altered Granite		Granodiorite		Altered granodiorite		Diorite		Diabase	
			First Flush	Steady State	First Flush	Steady State	First Flush	Steady State	First Flush	Steady State	First Flush	Steady State	First Flush	Steady State	First Flush	Steady State	First Flush	Steady State	First Flush	Steady State	First Flush	Steady State
Conventional																						
Total Dissolved Solids (TDS)	mg/L	117	175	0	390	116	524	50	143	37	274	16	274	16	176	24	176	24	176	24	176	24
Major Ions																						
Calcium (Ca)	mg/L	30	30	11	55	93	59	35	30	4.0	44	0.28	44	0.28	30	11	30	11	30	11	30	11
Chloride (Cl)	mg/L	5.5	-	-	126	390	145	26	4.7	4.7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Magnesium (Mg)	mg/L	-	12	8.7	15	36	13	10.0	2.4	1.2	16	0.37	16	0.37	12	8.7	12	8.7	12	8.7	12	8.7
Potassium (K)	mg/L	-	20	7.8	32	34	30	14	4.6	0.45	9.6	0.29	9.6	0.29	20	7.8	20	7.8	20	7.8	20	7.8
Sodium (Na)	mg/L	-	31	11	57	92	59	15	6.2	0.15	3.6	0.06	3.6	0.06	31	11	31	11	31	11	31	11
Sulphate (SO_4)	mg/L	23	45	8.0	41	30	137	11	82	3.0	195	3.0	195	3.0	45	8.0	45	8.0	45	8.0	45	8.0
Dissolved Metals																						
Aluminum (Al)	mg/L	0.043	0.12	1.7	0.014	0.02	0.12	0.068	0.16	0.3	0.13	0.024	0.13	0.024	0.13	1.7	0.13	1.7	0.13	1.7	0.13	1.7
Antimony (Sb)	mg/L	0.0095	0.0031	0.0005	0.0005	0.0006	0.0083	0.0055	0.006	0.001	0.008	0.0002	0.008	0.0002	0.004	0.0005	0.004	0.0005	0.004	0.0005	0.004	0.0005
Arsenic (As)	mg/L	0.0016	0.002	0.001	0.009	0.0033	0.01	0.001	0.025	0.003	0.0005	0.0001	0.0005	0.0001	0.002	0.001	0.002	0.001	0.002	0.001	0.002	0.001
Barium (Ba)	mg/L	0.051	0.44	0.27	0.45	0.39	0.83	0.83	0.021	0.028	0.058	0.0028	0.058	0.0028	0.44	0.27	0.44	0.27	0.44	0.27	0.44	0.27
Beryllium (Be)	mg/L	0.00001	0.0005	0.0005	0.0005	0.0001	0.0005	0.0001	0.0005	0.0005	0.0005	0.0001	0.0005	0.0001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Boron (B)	mg/L	0.082	2.7	0.85	1.7	3.1	2.8	2.3	0.14	0.025	0.025	0.005	0.025	0.005	2.7	0.85	2.7	0.85	2.7	0.85	2.7	0.85
Cadmium (Cd)	mg/L	0.0000015	0.0001	0.0001	0.0001	0.00002	0.0001	0.00002	0.0001	0.0001	0.0002	0.00002	0.0002	0.00002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Chromium (Cr)	mg/L	0.0041	0.003	0.02	0.0042	0.006	0.003	0.0022	0.0005	0.0005	0.0005	0.0001	0.0005	0.0001	0.003	0.02	0.003	0.02	0.003	0.02	0.003	0.02
Cobalt (Co)	mg/L	0.00011	0.001	0.0005	0.0005	0.00013	0.0005	0.00014	0.0005	0.0005	0.01	0.0005	0.01	0.0005	0.001	0.008	0.001	0.008	0.001	0.008	0.001	0.008
Copper (Cu)	mg/L	0.0024	0.002	0.0005	0.005	0.0032	0.0041	0.0048	0.004	0.015	0.003	0.0067	0.003	0.0067	0.002	0.0048	0.002	0.0048	0.002	0.0048	0.002	0.0048
Iron (Fe)	mg/L	0.012	0.14	2.1	0.025	0.03	0.15	0.1	0.08	0.44	1.6	0.005	1.6	0.005	0.14	2.1	0.14	2.1	0.14	2.1	0.14	2.1
Lead (Pb)	mg/L	0.00008	0.0005	0.0005	0.0005	0.00012	0.0005	0.00014	0.0005	0.0023	0.011	0.0007	0.011	0.0007	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Manganese (Mn)	mg/L	0.0075	0.042	0.016	0.0084	0.0091	0.014	0.014	0.072	0.013	0.69	0.037	0.69	0.037	0.083	0.016	0.083	0.016	0.083	0.016	0.083	0.016
Mercury (Hg)	mg/L	0.00003	0.00001	0.00001	0.00001	0.00002	0.00002	0.00002	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Molybdenum (Mo)	mg/L	0.0038	0.073	0.00025	0.013	0.0059	0.074	0.019	0.029	0.0012	0.0013	0.00005	0.0013	0.00005	0.073	0.0011	0.073	0.0011	0.073	0.0011	0.073	0.0011
Nickel (Ni)	mg/L	0.0021	0.006	0.078	0.008	0.003	0.006	0.0036	0.0005	0.0005	0.033	0.0011	0.033	0.0011	0.006	0.078	0.006	0.078	0.006	0.078	0.006	0.078
Selenium (Se)	mg/L	0.00019	0.0005	0.0005	0.002	0.0076	0.00092	0.0006	0.001	0.0005	0.001	0.0001	0.001	0.0001	0.003	0.0005	0.003	0.0005	0.003	0.0005	0.003	0.0005
Silver (Ag)	mg/L	0.00014	0.00013	0.00013	0.00013	0.00006	0.00013	0.00003	0.00013	0.00013	0.00013	0.000025	0.00013	0.000025	0.00013	0.00013	0.00013	0.00013	0.00013	0.00013	0.00013	0.00013
Strontium (Sr)	mg/L	0.16	0.21	0.078	0.98	1.2	1.0	0.41	0.29	0.018	0.29	0.002	0.29	0.002	0.21	0.078	0.21	0.078	0.21	0.078	0.21	0.078
Thallium (Tl)	mg/L	0.0001	0.00005	0.00005	0.0001	0.00001	0.0001	0.00001	0.00005	0.00005	0.00005	0.00001	0.00005	0.00001	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Uranium (U)	mg/L	0.00023	0.026	0.0047	0.00025	0.00005	0.00031	0.00026	0.02	0.0008	0.00025	0.00005	0.00025	0.00005	0.026	0.0047	0.026	0.0047	0.026	0.0047	0.026	0.0047
Vanadium (V)	mg/L	0.0096	0.031	0.029	0.0039	0.0032	0.014	0.0075	0.004	0.0006	0.0011	0.0001	0.0011	0.0001	0.031	0.029	0.031	0.029	0.031	0.029	0.031	0.029
Zinc (Zn)	mg/L	0.0005	0.0025	0.0025	0.002	0.002	0.013	0.002	0.005	0.007	0.16	0.007	0.16	0.007	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025

mg/L = milligrams per litre; PAG = potentially acid-generating

Humidity cell testing was conducted on 14 mine rock samples collected from the Project (Appendix 8.II). For water quality modelling purposes, only one sample out of the 14 tests was considered not to be representative of granitic mine rock. The 13 granite humidity cell samples were selected to represent the drainage quality from water in contact with granite in the mine rock piles. A small percentage of granite samples (approximately 5%) are expected to be acid generating. Granite mine rock samples with neutralization potential ratios (NPR) less than two were selected to represent these materials. Granite samples with NPRs greater than 2 were assumed to be non-acid generating. The PAG granite water quality was also selected to represent altered granite units. Additional detail regarding the static geochemical properties and results from each humidity cell sample in the kinetic test program at the Project are provided in Appendix 8.II.

Approximately 5% of the mine rock generated at the Project will be other minor lithologies (e.g. diorite, granodiorite). In addition, it is expected that some kimberlite will be deposited in the mine rock piles from mine rock extracted near the margins of the kimberlite pipe. The maximum observed concentrations in the first and last five weeks of the kimberlite and diorite humidity cell tests were selected to represent the freshet and steady-state drainage water quality, respectively. This water quality was applied to the following units in the Kennady Lake water quality model: granodiorite, altered granodiorite, diorite and diabase (Table 8.I-4).

8.I.2.4.3 Coarse Processed Kimberlite Pile

Coarse PK will be deposited in the Coarse PK Pile (Figure 8.I-2). Three coarse PK samples were submitted for humidity cell testing as part of the 2008 EIS (AMEC 2008). In addition, as part of the current EIS, supplemental testing of coarse PK materials was conducted. This test work is ongoing and consisted of an additional humidity cell sample and a submerged column test containing coarse PK. Details of the geochemical test work and results are provided in Appendix 8.II.

Similar to the mine rock piles, it is expected that drainage from the Coarse PK Pile will result in a spring freshet and expected steady-state water quality. The maximum concentration reported in the first five weeks of testing in the AMEC (2008) and Golder (2010) coarse PK test programs was selected to represent the drainage water quality from coarse PK materials during freshet.

Only five weeks of humidity cell test results were available to be included in the model from the ongoing supplemental coarse PK sample at the time of the current assessment. It is unknown if these first-flush results are representative of the expected long-term steady state conditions that could be realized in the humidity cell sample; however, the water collected from the bottom of the submerged column tests is considered representative of the quality of water in contact with coarse PK (see Appendix 8.II). The expected steady-state water quality for coarse PK was calculated as the maximum concentration reported in the last five weeks of testing from the AMEC (2008) humidity cell tests and the concentrations reported in the bottom water of the submerged column test. Coarse PK input concentrations are presented in Table 8.I-4.

8.I.2.4.4 Fine Processed Kimberlite Containment Facility

Fine PK will be deposited in the Fine PKC Facility located in Area 1 and 2 of Kennady Lake (Figure 8.I-2). Fine PK will initially be placed in Area 1, and deposition will progress into Area 2 as the facility footprint increases. Deposition of fine PK in Area 1 will result in water being displaced to Area 2 as Area 1 becomes inundated. Since all of the water from Area 1 will eventually be displaced to Area 2, these areas were treated as one entity in the Kennady Lake water quality model.

The Fine PKC Facility will be separated from the WMP by Filter Dyke L. During operations, a pond will be consistently maintained between the toe of the Fine PKC Facility and Filter Dyke L (Figure 8.I-2). Water will be lost from the Fine PKC Facility to the WMP through the dyke. The quality of the water reporting to the WMP from the Fine PKC Facility will be a function of natural runoff, fine PK bleed water and fine PK runoff and seepage.

As part of the 2008 EIS (AMEC 2008), three fine PK samples were submitted for humidity cell testing. In addition, as part of the current EIS, supplemental testing of fine PK materials was conducted. This test work is ongoing and consisted of an additional humidity cell sample and a submerged column test containing fine PK. Details of the geochemical test work and results are provided in Appendix 8.II.

Runoff and seepage from the fine PK stored in the Fine PKC Facility will fluctuate as a result of seasonality. Similar to the mine rock piles and the Coarse PK Pile, an initial flush will occur during the freshet month until steady-state conditions are achieved in subsequent months. The maximum concentration reported in the first five weeks of testing in the Appendix 8.II) and Appendix 8.IV) fine PK test programs was selected to represent the drainage water quality from fine PK materials during freshet. At the time of modelling, only five weeks of humidity cell test results were available from the ongoing supplemental fine PK humidity cell sample. Based on the available results, it was difficult to ascertain if steady-state conditions had been realized. As such, to determine the expected long-term concentration in the humidity cell tests, the 2008 fine PK humidity cell tests were compared to the water collected from the bottom of the submerged fine PK column tests. The expected steady-state water quality for fine PK was calculated as the maximum concentration reported in the last five weeks of testing from the AMEC (2008) humidity cell tests and the maximum concentration reported in the bottom water of the submerged column test. Fine PK input concentrations, with the exception of phosphorus, are presented in Table 8.I-4. The derivation of the phosphorus input concentration for fine PK material is provided in Attachment 8.I.3).

There will also be a small amount of seepage from Lake A3 to the Fine PKC Facility through Dyke C (Figure 8.I-2). Natural runoff and seepage from Lake A3 was assigned the baseline water quality for Kennady Lake (Table 8.I-3).

Process water liberated from settled fine PK will also report to Area 2. The initial quality of the process water was assigned the process water quality based on the results of baseline geochemical test work (Table 8.I-4). The WMP is the primary source of the process plant reclaim and the concentrations in the process plant effluent are expected to fluctuate as mining advances. To account for increases in chemical constituents in the WMP, the process water quality was assigned the maximum concentration of the geochemical process water testing and simulated concentrations in the WMP.

During operations, when water is maintained in Area 2 downstream of the Fine PKC Facility, it is expected that a component of fine PK will be submerged in Area 2. Supplemental geochemical testing indicated that diffusive fluxes from submerged PK materials could influence the quality of overlying water (Appendix 8.II). To add an additional level of conservatism into the Kennady Lake model, the water quality in Area 2 was set to be the maximum of the simulated Area 2 water quality and simulated process water quality to account for diffusive fluxes into the pond.

8.I.2.4.4.1 Fine Processed Kimberlite Containment Facility Closure

Following the cessation of mining in the Hearne Pit in Year 7, fine PK will be deposited in the mined out Hearne Pit and progressive reclamation of the Fine PKC Facility will commence. The Project Description (Section 3) indicates that fine PK will be covered with a one meter layer of coarse PK and an overlying meter of non-PAG mine rock. The cover materials have the potential to influence the water quality draining from the Fine PKC Facility during the closure period; however, the water quality simulations assumed that the majority of the precipitation would seep through the facility and acquire the simulated fine PK water quality (Table 8.I-4). In essence, the modelled scenario assumed the Fine PKC Facility cover had a negligible effect on the drainage water quality to Kennady Lake during the closure phases.

At closure, any impounded water remaining at the toe of the Fine PKC Facility footprint and Filter Dyke L (Figure 8.I-2) will be backfilled by mine rock and the water will be gradually displaced to the WMP. Following backfilling of this area, the water quality reporting to the WMP from the Fine PKC Facility will be a function of natural runoff, mine rock runoff, fine PK facility runoff and seepage. During this phase of mining, submerged fine PK will be covered with mine rock and diffusive fluxes were assumed to be negligible. The drainage water quality from the Fine PKC Facility during this period was simulated based on the relative proportions of natural runoff, mine rock backfill runoff and seepage, and fine PK runoff and seepage.

8.I.2.4.5 Open Pit Water Quality

Kimberlite will be mined from the following three pits at the Project: 5034, Hearne and Tuzo. As the pits are developed, the following water sources have the potential to influence the water quality in each of the pit sumps being dewatered to the WMP:

- pit wall rock runoff;
- groundwater inflow; and
- blasting residue.

8.I.2.4.5.1 Pit Wall Rock Runoff Water Quality

Lithological units in the exposed wall rocks of the open pits will influence the pit sump water quality. In the Kennady Lake water quality model, pit wall rock runoff in contact with these units was assigned the mine rock unit water quality (Table 8.I-4). Details regarding the relative proportions of each lithology in the exposed wall rock were not available for the current assessment. As such, the proportions of mine rock in the mine rock piles were selected to represent the relative proportion of the exposed lithologies. This is considered reasonable since 95% of the mine rock at the Project is granite.

8.I.2.4.5.2 Groundwater Quality

Groundwater reporting to the open pits during operations represents the greatest flow component, and will be the primary control on pit sump water quality. Groundwater reporting to the open pits will be a function of the following two sources:

- shallow groundwater from Kennady Lake resulting from the dewatering cone of depression; and
- deeper saline connate water.

The results of groundwater quality monitoring presented in Section 11.6, Subject of Note: Permafrost, Groundwater, and Hydrogeology, were used to estimate the composition of groundwater that could passively inflow into the open pits during operations. Depth profiles were developed to evaluate the variability of groundwater composition with depth. Total dissolved solids (TDS) is known to vary with depth in groundwater in the Canadian Shield. The purpose of the depth profiles was to identify parameters that correlate with TDS relative to depth. Metals that correlated with TDS, and which vary by depth, included major ions (e.g., calcium, chloride, potassium, magnesium, sodium and sulphate) and trace metals (e.g., arsenic, boron, copper, nickel and selenium). Slopes, intercepts and regression coefficients for each of these parameters are provided in Table 8.I-5. The slopes and intercepts were used to derive groundwater concentrations of these major ions and trace metals.

Additional groundwater modelling (Section 11.6, Appendices 11.6.I and 11.6.II) provided a profile of the TDS concentrations reporting to each pit from deeper connate water with time. In addition, this modelling provided an estimate of the percentage of lake water contributing load to the groundwater. TDS will fluctuate in the lake as a result of mining activities and site water management. As such, the simulated TDS concentration in the WMP was mixed with the TDS concentration of expected connate water to determine a TDS concentration for groundwater reporting to each pit, according to the proportions indicated by hydrogeological model results.

Table 8.I-5 Attributes of Correlated Parameters

Parameter	Slope	Intercept	r^2
Calcium (Ca)	0.19	13	0.99
Chloride (Cl)	0.59	- 71.81	1.0
Magnesium (Mg)	0.021	16	0.87
Potassium (K)	0.0014	6.9	0.6
Sodium (Na)	0.13	- 28.07	0.99
Sulphate (SO_4)	0.065	12	0.78
Arsenic (As)	0.0000081	- 0.00133	0.81
Boron (B)	0.000067	0.073	0.77
Copper (Cu)	0.00000034	0.0017	0.22
Nickel (Ni)	0.0000026	0.0011	0.58
Selenium (Se)	0.00001	- 0.00524	0.73

r^2 = correlation of determination

Parameters that did not exhibit a relationship with TDS in the groundwater quality database were estimated based on the range of results in the groundwater dataset. The groundwater quality dataset was used to develop input concentrations for groundwater inflows to the Hearne Pit and 5034 Pit. Input concentrations are equal to the maximum concentration measured in groundwater samples from each pit. Groundwater quality data were not available for the Tuzo Pit; therefore, groundwater reporting to this pit was assigned the maximum concentration of all of the groundwater samples. Groundwater quality concentrations for parameters not correlated with TDS are presented in Table 8.I-6.

The approach of assigning groundwater concentrations to each pit was developed based on a detailed review of the groundwater quality dataset. This approach is considered somewhat conservative because of the high variability in metal concentrations with depth, and by location. Furthermore, the review of the results of groundwater quality monitoring identified concentrations of some parameters, such as chromium, that were anomalously elevated in select samples. These concentrations were not excluded from the statistical used to define groundwater input water quality; however, the input concentrations will be re-visited after supplemental groundwater samples are collected from the groundwater monitoring wells at the Project in 2011.

Table 8.I-6 Groundwater Quality Inputs (mg/L)

Parameter	Units of Measure	5034	Hearne	Tuzo
Ammonia (NH_4)	mg/L	2.2	1.6	2.2
Total Kjeldahl Nitrogen (TKN)	mg/L	1.2	0	1.2
Total Phosphorus	mg/L	0.02	0.02	0.03
Dissolved Phosphorus	mg/L	0.02	0.005	0.04
Aluminum (Al)	mg/L	0.02	0.013	0.06
Antimony (Sb)	mg/L	0.002	0.0001	0.002
Barium (Ba)	mg/L	0.41	0.12	0.41
Beryllium (Be)	mg/L	0.00005	0.00005	0.00005
Cadmium (Cd)	mg/L	0.0003	0.00005	0.0003
Chromium (Cr)	mg/L	0.048	0.01	0.048
Cobalt (Co)	mg/L	0.001	0.0021	0.0022
Iron (Fe)	mg/L	2.1	4.3	4.3
Lead (Pb)	mg/L	0.002	0.00085	0.002
Manganese (Mn)	mg/L	0.42	0.3	0.42
Mercury (Hg)	mg/L	0.00005	0.00005	0.00005
Molybdenum (Mo)	mg/L	0.008	0.01	0.083
Silver (Ag)	mg/L	0.00013	0.00013	0.00013
Thallium (Tl)	mg/L	0.002	0.00002	0.002
Uranium (U)	mg/L	0.01	0.0064	0.032
Vanadium (V)	mg/L	0.01	0.0027	0.01
Zinc (Zn)	mg/L	0.031	0.14	0.14

mg/L = milligrams per litre

Groundwater samples available for the current assessment reported more dissolved than total s results. Differences in the sample populations resulted in a maximum dissolved phosphorus concentration slightly greater than maximum total concentrations.

8.I.2.4.5.3 Explosives Usage

Open pit mining at the Project will require the use of both ammonium nitrate/fuel oil (ANFO) and emulsion explosives. Chemical loading of sodium and nitrogen species (e.g., nitrate and ammonium) are often associated with explosive usage at mine sites. Explosive usage assumptions for the mine site water quality model, used to estimate the chemical load release from explosives, are provided in Table 8.I-7.

Table 8.I-7 Summary of Assumptions for Explosives Usage

Assumption	ANFO	Emulsion
percent of total explosives	70 %	30 %
tonnage of explosives	94,196	40,470
fraction of residues	5 %	5 %
composition	94 % ANFO, 6 % Fuel Oil	63 % ANFO, 18 % $NaNO_3$, 9 % water, 6 % fuel oil, 4 % microballoons

ANFO = ammonium nitrate/fuel oil; "%" = percent

The total life-of-mine explosives tonnages formed the basis for determining chemical loadings. The total mass of explosive was assumed to be released linearly over the mine life to develop estimates of nitrogen-species concentrations from blasting activities. Water reporting to active open pits is expected to mobilize the majority of explosives residues, and the mass of explosives released during each month was added to the WMP.

8.I.2.4.5.4 Other Open Pit Water Quality Influences

In addition to the above sources, the Water Management Plan for the Project includes use of the mined out pits for additional water and mine rock storage. As such, water pumped from other areas of Kennady Lake to the mined out pits will influence the pit water quality during these periods. A chemical load to each pit from the various sources was simply calculated based on the simulated water quality for that area multiplied by the flow (EBA 2010b,c). The Water Management Plan provided in Section 8.4 and the Project Description (Section 3) details all of the flows that could influence the water quality in each pit.

Following the completion of mining in each of the three open pits, water will also be lost from the system as a result of entrainment in void spaces in mine material backfill or from water density differences resulting from pit lake development. The water losses are unique for each open pit and are discussed separately in the following subsections.

8.I.2.4.5.4.1 5034 Pit

Mine rock will be placed in the 5034 Pit once mining is complete in Year 6 (January 2020). The total capacity of the mined out open pit below 300 metres above sea level (masl) is 13.5 million cubic metres (Mm^3) (EBA 2010b). Backfilling to elevation 300 masl will be complete in Year 8 (June 2022). The void space in the mine rock placed below 300 masl has a water storage capacity of 3.1 Mm^3.

At closure, an additional 30 Mm^3 of mine rock will be placed over the mined out 5034 Pit above elevation 300 masl. This will result an additional 6.9 Mm^3 of pore space available to entrain water flowing to Kennady Lake. Following completion of the mine rock backfill in the 5034 Pit, approximately 10 Mm^3 of water will be entrained in the mine rock pore space.

8.I.2.4.5.4.2 Hearne Pit

Following the cessation of mining in the Hearne Pit in Year 8 (July 2022), fine PK slurry will be deposited in the mined out open pit. The following assumptions were used in the Kennady Lake water quality model to determine the fine PK pore space available in Hearne Pit:

- Fine PK specific gravity of 2.7;
- Fine PK slurry deposited at 30% weight-weight (w/w); and
- Fine PK slurry settles to 50% w/w.

Once mining is complete in the Hearne Pit, the total void space will be approximately 15.7 Mm^3. Between Year 8 and Year 11, approximately 6.4 Mm^3 of fine PK will be placed in Hearne Pit. Once the fine PK settles, the pore volume will be approximately 3.3 Mm^3.

Although the water in fine PK pore space will be locked up, supplemental submerged column testing of fine PK indicates diffusive flux can influence overlying water quality. As such, it is expected that fine PK in the backfilled Hearne Pit will provide a diffusive flux to Area 6 (Figure 8.I-1) in Kennady Lake.

In the Kennady Lake water quality model, when simulated concentrations in Area 6 were less than the maximum concentrations observed in the overlying water in the fine PK submerged column tests, a diffusive load was released to Area 6. The flux was calculated as the mass transfer observed during the first week in the submerged column tests prorated from the area of the test cell (12.5 square inches) to the proposed footprint area of the Hearne Pit (≈

0.17 square kilometres [km^2]). This represents a conservative approach since pristine water initially overlies the submerged fine PK at the onset of the column testing, resulting in a higher concentration gradient than would be observed in the bottom of Hearne Pit.

8.I.2.4.5.4.3 Tuzo Pit

The Tuzo Pit will not be backfilled with mine rock. Instead, a pit lake will form during the closure phase of the Project. Hydrodynamic modelling (Section 8.I.4) of the pit lake indicated that a pycnocline would form, isolating deeper saline water from the lower density, overlying water that would mix with the lake surface water. Following refilling of the Tuzo Pit, it is expected that the hypoliminion would isolate 16.4 Mm^3 of water from Kennady Lake. Over a 100 year modelled timeframe, it was indicated that pycnocline could migrate downwards, ultimately isolating approximately 9.2 Mm^3 of deeper water in the Tuzo Pit.

In the GoldSim model, the deeper water was tracked and released to the surface according to these volumes. Excess water was allowed to migrate into the upper portion of the pit where it was considered to be fully mixed with Kennady Lake. Any water and chemical load stored in the deeper portion of the Tuzo Pit at the end of the 100 year timeframe was treated as a loss from the system.

8.I.2.4.6 Water Management Pond (Areas 3 and 5)

The WMP will receive water from several mine sources during the operation of the mine. As such, the water quality in the WMP will vary with time. A chemical load was calculated for each source reporting to the WMP and mixed in the simulated volume (EBA 2010b) to determine the pond water quality. Details of all the water sources that have the potential to influence the WMP water quality are provided in the Water Management Plan (Section 8.4, and the Project Description [Section 3]).

8.I.2.4.7 Particulate Matter

The Kennady Lake water quality model tracked the concentrations of dissolved and particulate species separately, then summed the two fractions to arrive at total concentrations. In general, loadings from geochemical sources and groundwater contributed only dissolved parameter species. The sources of particulate loading were existing (background) waters and dust.

Background particulate parameter concentrations were calculated as the difference between total and dissolved parameter concentrations in Table 8.I-3. The particulate fraction of metals in the background water was assumed to remain in the water column and never settle out.

The principal source of aerially-deposited material to Kennady Lake during operations was expected to be fugitive dust from fleet and milling activities. Because this dust will be composed of finely-ground rock, it is anticipated that some, or all, of it will settle out during the eight to nine year closure period while Kennady Lake is being refilled. The settling of dust was modelled using the hydrodynamic model (Section 8.I.4), and it was predicted that <1 mg/L of these solids would remain in suspension. Therefore, 1 mg/L of particulate matter was added to the water column. The parameter concentrations of this particulate matter were based on the average analytical data collected as part of the baseline geochemical assessment (Appendix 8.II). The solid composition of fine PK was selected to represent the aerially-deposited particulate matter in Kennady Lake.

8.I.2.4.8 Kennady Lake Refilling Inputs

At the end of operations, Tuzo Pit and Kennady Lake will be refilled using passive and active inflows. Several water management strategies will be employed to expedite the filling of Kennady Lake back to its natural elevation of 420.7 masl. These include:

- pumping supplemental freshwater from Lake N11 to Areas 3 and 5;
- breaching of Dyke E to allow watershed B to recharge Kennady Lake in Areas 3 and 5;
- ceasing the diversion of D2 to N14 to reconnect the D watershed to Kennady Lake in Areas 3 and 5; and
- breaching Dyke G to re-establish E watershed recharge to Kennady Lake Area 6.

During construction and operations, water will be pumped from the WMP to Lake N11. As such, the quality of Lake N11 will deviate from background concentrations (Table 8.I-3) as a function of the chemical loading from the WMP. During the refilling period, water from Lake N11 will be pumped to Kennady Lake to expedite the refilling period. This water was assigned the simulated Lake N11 water quality from the downstream water quality model (Section 8.I.3). Water flowing to Kennady Lake from the B, D and E watersheds was assigned the Kennady Lake baseline water quality (Table 8.I-3).

8.I.3 DOWNSTREAM WATER QUALITY MODEL

8.I.3.1 CONCEPTUAL MODEL

A downstream (receiving environment) water quality model was developed in GoldSim to assess the effects the Project would have on the downstream lakes during the construction, operation and closure phases. During the dewatering phase, water will be pumped from Kennady Lake to Area 8, and to Lake N11. In addition, while the water quality in Areas 3 and 5 is suitable for discharge, additional water will be pumped to Lake N11 to provide additional storage capacity in Kennady Lake during operations. In the post-closure period (after 2035), the original flow path of Kennady Lake will be re-established, and Area 8 will receive flows from the refilled portion of Kennady Lake. Therefore, Area 8 was included in the downstream water quality model.

Although presently part of Kennady Lake, Area 8 is proposed to be hydraulically isolated from the rest of the lake during the construction and operations, and closure phases of the Project. During these phases, runoff from natural areas within the Area 8 sub-watershed are expected to be sufficient for maintaining water quality within this basin, as described in Section 8.7. Therefore, water quality was not assessed in Area 8 during these phases of the Project.

The downstream water quality model was developed to predict concentrations in Area 8, the Interlakes (i.e., the L and M watersheds), the N watershed, and Lake 410. At each location, average simulated Kennady Lake outflow concentrations were mixed with background parameter concentrations in their relative proportions based on downstream flows provided in the hydrological assessment (Section 9.7.1).

8.I.3.2 MODEL INPUTS

Water quality was simulated in several lakes in the L and M watersheds, Lake N11, Area 8 and in Lake 410, downstream of Kennady Lake. The downstream water quality model predicted concentrations during the construction and operations, and closure phases. The model assumed fully mixed conditions within each lake at each timestep.

Within each watershed, water quality profiles were assigned to natural inflows as baseline chemistry (Table 8.I-3). Throughout the construction and operations, and closure phases of the Project, the downstream watershed was assumed to behave according to baseline conditions, with the following exceptions, which are included in the model:

- water will be discharged from the WMP to Lake N11 during the construction and operations phases;
- water will be drawn from Lake N11 to refill Kennady Lake during the closure phase;
- the flow path from Area 7 to Area 8 will be disconnected during the operations and closure phases; and
- the flow path from Area 7 to Area 8 will be reconnected after Kennady Lake has refilled (i.e., the post-closure period).

Based on these flows, the only inputs to the downstream water quality model were the baseline concentrations and dynamic inputs from the Kennady Lake water quality model (Section 8.I.2).

It is expected that downstream of the mine site, settling of particulates may occur in the receiving environment; however, the model did not include a sink term for settling. This approach provides a conservative estimate of downstream concentrations.

8.I.4 HYDRODYNAMIC MODEL

8.I.4.1 CONCEPTUAL MODEL

The water quality in the Tuzo Pit basin (Tuzo Pit) and in the restored Kennady Lake will be influenced by several input sources. During the initial phase of refilling, water quality will be primarily influenced by groundwater inflows and the sources used to fill the pit, namely, water from the WMP and Lake N11 (Section 8.4.3). After Kennady Lake is filled, water quality in Tuzo Pit will be determined by surface runoff to Kennady Lake and surface – groundwater interaction in the Tuzo Pit.

The stability of stratification in Tuzo Pit was analyzed using two methods:

- hydrodynamic modelling of the first 100 years after refilling, using CE-QUAL-W2; and
- mass balance calculations over 15,000 years using a vertical slice spreadsheet model.

The CE-QUAL-W2 (W2) model (Cole and Wells 2008) was used to compute TDS, temperature and density at 1 to 3 metre (m) intervals in Tuzo Pit. The W2 model is a two-dimensional, laterally averaged, hydrodynamic and water quality model. The model is public domain software maintained and supported by the U.S. Army Corp. of Engineers Waterways Experiment Station. The model has established a well-recognized reputation as an effective and practical modelling tool for lake and reservoir hydrodynamics and water quality.

The hydrodynamic, temperature and water quality modules of the model simulate interactions of physical and chemical processes, including flow, thermal and substance mass loading regimes, meteorological forcing conditions (e.g., air temperature, wind, solar radiation, precipitation, evaporation, etc.) and lake-bottom interactions. The W2 model also includes a module to simulate ice-cover in the winter. The formation of a complete ice-cover prevents re-aeration, provides complete wind sheltering and results in reduced thermal inputs via solar radiation. The model has been extensively used to simulate the potential performance of natural and constructed lakes, including mine pit lakes (Cole and Wells 2008, Castendyk and Eary 2009).

8.I.4.1.1 W2 Model Inputs

The W2 model includes several hydrodynamic coefficients that may be used to calibrate the model to observed conditions. Because Tuzo Pit has not been constructed, this model cannot be calibrated to this system. Therefore, default values were used for coefficients in the hydrodynamic simulation.

The spatial extent of the model was Kennady Lake and Tuzo Pit. A model grid was developed based on GIS shapefiles of these connected waterbodies. The grid was optimized to account for the full fetch of the lake with higher resolution near the pit.

The model also requires meteorological forcing data to drive currents and thermal behaviour in the lake. Meteorological data were obtained from weather stations at Snap Lake and the Yellowknife Airport. Data were selected preferentially from the Snap Lake station because this station is closer to the Project, and data gaps were filled in using data from Yellowknife Airport. The required meteorological data were air temperature, dew point, wind speed and direction and solar radiation.

In a hydrodynamic simulation, TDS and temperature of the lake water must be known to initialize density throughout the water column. Initial concentrations in the pit were determined by concentrations in Kennady Lake at closure. The 16.3 Mm^3 of water in the bottom of the pit was set equal to the concentration in Kennady Lake prior to refilling, because this volume will be drawn from the surface to fill the pit until Kennady Lake is lowered to 417 masl. Kennady Lake will not be drawn below this level to ensure that bed sediment does not become suspended. 1.2 Mm^3 of groundwater is predicted to flow into the pit during the refilling period, so this was added as well, at time-varying concentrations predicted by the hydrogeological model (Section 11.6, Appendix 11.6.II). The upper portion of the lake was assumed to have a TDS concentration that was equal to the refilled Kennady Lake.

It is recognized that these layers will not form a sharp boundary due to turbulence caused by refilling and other factors. Therefore, the gradient was assumed to span a vertical transition depth of 40 m, and concentrations were calculated for the upper and lower portions respecting the mass of TDS in both layers and within the gradient.

It is not known exactly when the pit will be filled in terms of months of the year. Therefore, an average temperature of Kennady Lake was calculated based on samples that were skewed toward summer sampling events. The resulting average temperature (5 degrees Celsius [ºC]) is anticipated to be reasonable, because refilling activities are also expected to be most intense during open water periods. The uniform temperature of 5ºC was used to initialize the pit water column. It should be noted that the temperature profile could be manipulated somewhat to increase the stability in the pit, but that manipulation was not examined as part of this modelling.

Once the model was initialized, it was run for 100 years to predict the change in elevation of the pycnocline, and therefore the volume of water that will essentially be isolated from Kennady Lake. Inputs during the simulation included natural inflows, which were the same as those for the Kennady Lake model (Section 8.I.2) and groundwater inputs. Groundwater discharge from the hydrogeological model was input to the hydrodynamic model at several vertical points according to time-varying volumes and concentrations throughout the modelled time frame. Groundwater modelling is presented in Section 11.6, Appendix 11.6.II.

The W2 model includes an inorganic suspended solids compartment to model the settling and resuspension of particulate matter. This compartment was used to model the deposition of dust from fleet traffic on the lake. The model was run such that 5 mg/L of particulate matter measuring 2.5 microns or less ($PM_{2.5}$) dust composed of fine PK was instantaneously deposited on the lake at the end of mining operations. During the refilling period, the particulate matter was allowed to settle in the model, and maximum concentrations were tracked during periods of wind-driven turbulence. The model predicted that nearly all particulate matter would settle within the first winter, and suspended sediment would never exceed 1 mg/L thereafter. A value of 1 mg/L was conservatively assumed to represent dust at the end of the refilling period for the Kennady Lake model (Section 8.I.2).

8.I.4.2 LONG-TERM VERTICAL SLICE SPREADSHEET MODEL

To estimate the long-term stability of Tuzo Pit, long-term TDS profiles were calculated using a vertical slice spreadsheet model. A spreadsheet model was used because it was not feasible to run a hydrodynamic model for this length of time due to the computational limitations. The vertical slice spreadsheet model incorporated long-term inflows that were predicted by the hydrogeological model (Section 11.6 Subject of Note: Permafrost, Hydrogeology and Groundwater) to simulate TDS profiles over 15,000 years at 25 m vertical intervals in Tuzo Pit.

The main inputs used in the mass balance calculation were initial conditions in Tuzo Pit, which were the same as those used for the Hydrodynamic model, and long-term groundwater inflows and outflows. Groundwater inflow volumes and concentrations and outflow volumes were predicted for the first 1,000 years after Tuzo Pit is filled. After 1,000 years, the inflows were assumed to continue at constant volumes and concentrations.

To complete the calculations, inflow volumes and concentrations were directed to the appropriate 25 m interval within the pit. Within each interval, a mass-balance calculation was performed, and excess water (difference between inflow and outflow) was directed upwards to the next segment.

The vertical slice spreadsheet model generated annual time series at 25 m intervals over a 15,000 year timeframe. Vertical TDS profiles for select time snapshots are shown in Section 8.8.4.2.

8.I.5 MODEL ASSUMPTIONS AND LIMITATIONS

Water quality modelling requires many assumptions due to the uncertainty related to determining the physical and geochemical characteristics of a complex system. The prediction of water quality is based on several inputs (i.e., surface flows, groundwater flows and seepage, background water quality and geochemical characterization), all of which have inherent variability and uncertainty. The water quality model has attempted to incorporate natural processes and mineral weathering of mine materials, and combine them with flows to develop predictions for water quality, all for a mine that has not yet been developed. Water quality results predicted herein are based on our current understanding of the Project Water Management Plan and provide a reasonable estimate of the expected conditions in Kennady Lake. Given all of the inherent uncertainties, the results of the water quality model should be used as a tool to aid in the design of monitoring programs, and mine planning, to develop mitigation strategies and to outline potential risks rather than to predict absolute concentrations.

The following key assumptions have been made in the water quality modelling:

- there is complete mixing of masses in simulated site concentrations in the various areas of Kennady Lake;
- there are no seepage losses from the site to the downstream receptors;
- development of permafrost conditions in the mine rock and PK storage facilities were not considered in the assessment scenario;
- measured water quality parameters that were less than the analytical detection limit have been assumed to be equal to the detection limit for geochemical sources and half the detection limit for background water quality; and
- expected long-term water quality estimates are based only on laboratory data as no site data of mine materials (i.e., fine PK) currently exist. It is assumed that laboratory data are representative of the material that will be generated. This issue can be addressed through on-site monitoring programs of expected mining materials and periodic re-evaluation of predictions.

Care was taken to incorporate known processes as understood during model development. However, in natural systems and complex man-made systems, observed conditions, particularly on a daily basis, will almost certainly vary with respect to estimated conditions.

The data and approach used to estimate future water quality are currently believed to provide a reasonable approximation of the system as currently understood, within the context of the assumptions used in the model. Changes in Project site conditions, input data, or assumptions regarding Project site conditions will necessarily result in changes to water quality predictions.

Due to the factors listed above, even the best of models cannot be expected to match operational monitoring data. It is the goal of modelling to conservatively predict concentrations, so monitored data are anticipated to be less than predicted concentrations. Once the Project is operational, monitoring of water quality and periodic re-assessment of effects predictions and/or remedial measures will be required.

8.I.6 REFERENCES

8.I.6.1 LITERATURE CITED

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8.I.7 ACRONYMS AND ABBREVIATIONS

8.I.7.1 ACRONYMS

AMEC	AMEC Earth & Environmental
ANFO	ammonium nitrate/fuel oil
De Beers	De Beers Canada Inc.
EBA	EBA Environmental Consultants Ltd.
EIS	environmental impact statement
ICP	inductively coupled mass-spectrometry
JWEL	Jacques Whitford Environment Ltd.
masl	metres above sea level
NPR	neutralization potential ratios
NWT	Northwest Territories
PAG	potentially acid generating
PK	Processed Kimberlite
PKC	Processed Kimberlite Containment
$PM_{2.5}$	particulate matter measuring 2.5 microns or less
Project	Gahcho Kué Project
TDS	Total dissolved solids
WMP.	Water Management Pond

8.I.7.2 UNITS OF MEASURE

%	percent
km^2	square kilometres
km	kilometre
m	metre
mg/L	milligrams per litre
Mm^3	million cubic metres
ºC	degrees Celsius

ATTACHMENT 8.I.1

UPDATED SUMMARY OF WATER MANAGEMENT AND BALANCE DURING MINE OPERATION FOR FEASIBILITY STUDY OF GAHCHO KUÉ PROJECT

TECHNICAL MEMO

CREATING AND DELIVERING BETTER SOLUTIONS

www.eba.ca

TO:	Wayne Corso, JDS Energy and Mining Inc.	DATE:	May 14, 2010
C:	Jerry Vandenberg, Golder Associates Ltd. Graeme Swinnerton, Golder Associates Ltd.	MEMO NO:	006 (Updated)
FROM:	Gordon Zhang	FILE:	E14101046.001
SUBJECT:	**Updated Summary of Water Management and Balance during Mine Operation for Feasibility Study of Gahcho Kué Project**		

1.0 GENERAL

This memo is an update of EBA's previous Memo 006 dated February 25, 2010. The water management plan summarized in this memo will be finalized and documented in EBA's water and waste management report that is being prepared by EBA.

The purpose of this study was to develop a water management plan for the Gahcho Kué Project that is both practical and economical for the new mine plan. A number of water management schemes have been considered during the course of this study. The water management plan presented herein represents a practical plan that meets various project requirements and constraints. The key project requirements and constraints include the following:

- Limit the initial lake dewatering to a single year;
- Avoid using a costly water treatment plant that was recommended in the previous studies;
- Minimize the environmental impacts by placing all mine waste materials within the catchment area of the original Kennady Lake;
- Minimize the environmental impacts by limiting net loss of fish habitats;
- Manage the site runoff water, mine process water, and expected saline water from pits;
- Store the water within the internal basins when the water quality does not meet the discharge criteria;
- Facilitate refilling the drained lake basins and mined-out pits for mine closure and reclamation; and
- Limit the initial construction requirements for water management.

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2.0 DESIGN BASIS

2.1 MINE PRODUCTION PLAN

Table 1 summarizes the mine production plan used in this study, which was provided by JDS Energy and Mining Inc. (JDS) in an email to EBA on December 11, 2009. A uniform monthly production rate of 250,000 tonnes of dry ore was assumed for the water and waste management in this study, which resulted in a mine production period of March 2015 to August 2025.

TABLE 1 SUMMARY OF MINE PRODUCTION PLAN

Year	Calendar Year	Pit	Production (tonnes of dry ore)
-3	2012		Pre-disturbance
-2	2013	5034	Initial Lake Dewatering
-1	2014	5034	Pre-stripping 5034
1	2015	5034	2,500,000
2	2016	5034	3,000,000
3	2017	5034	3,000,000
4	2018	5034/Hearne	3,000,000
5	2019	5034/Hearne/Tuzo	3,000,000
6	2020	Hearne/Tuzo	3,000,000
7	2021	Hearne/Tuzo	3,000,000
8	2022	Tuzo	3,000,000
9	2023	Tuzo	3,000,000
10	2024	Tuzo	3,000,000
11	2025	Tuzo	1,800,000
Total			31,300,000

2.2 PIT DEVELOPMENT PLAN

Table 2 summarizes the yearly pit development plan that was received from SRK in an email to EBA on December 13, 2009. The pit bottom depths with time were obtained from a set of yearly pit development drawings received from SRK. No data for pit start and completion months were provided, so the pit start and completion months for each of the three pits were roughly estimated and listed in Table 3.

TABLE 2 YEARLY PIT DEVELOPMENT PLAN

Calendar Year	Bottom Elevation of 5034 Pit (m)	Mine Waste and Ore from 5034 Pit (M tonnes)			Bottom Elevation of Hearne Pit (m)	Mine Waste and Ore from Hearne Pit (M tonnes)			Bottom Elevation of Tuzo Pit (m)	Mine Waste and Ore from Tuzo Pit (M tonnes)		
		Overburden	Waste Rock	Ore		Overburden	Waste Rock	Ore		Overburden	Waste Rock	Ore
2013	421	0.46	1.56									
2014	373	0.26	15.95									
2015	349	2.21	27.19	2.5								
2016	301		24.71	3.0								
2017	253		17.74	3.0								
2018	181		10.51	3.0	409	1.24	1.89					
2019	121		2.92	1.7	361	0.74	10.01	1.2	397	1.86	11.63	0.1
2020					301		11.85	2.5	361	0.36	13.30	0.5
2021					217		3.56	1.8	325	0.21	27.16	1.2
2022									253		31.49	3.0
2023									193		9.89	3.0
2024									157		4.03	3.0
2025									121		0.96	1.8
Total		2.93	100.58	13.2		1.98	27.31	5.5		2.43	98.46	12.6

TABLE 3: SUMMARY OF ASSUMED PIT START AND COMPLETION MONTHS

Pit	5034	Hearne	Tuzo
Start	October 2013	September 2018	September 2019
Completion	June 2019	June 2021	August 2025

2.3 PRECIPITATION, SURFACE RUNOFF AND LAKE SURFACE EVAPORATION

Inconsistent values for precipitation, surface runoff, and lake surface evaporation parameters have been reported in various documents for the previous studies (AMEC 2005; De Beers 2008) for the Gahcho Kué project. The values adopted in this study generally refer to those reported in the draft Environmental Impact Statement (De Beers 2008). These values are slightly conservative when compared to those in the 2005 site water balance study (AMEC 2005). Table 4 summarizes the key parameters used for the water balance and management in this study.

TABLE 4: PRECIPITATION, RUNOFF AND LAKE SURFACE EVAPORATION PARAMETERS

Parameter	
Annual total precipitation for a mean year (1/2 return period)	328 mm
Net annual unit runoff for open water surface for a mean year	- 8 mm
Net annual unit runoff for vegetated natural land surfaces for a mean year	210 mm
Net annual unit runoff for disturbed land surfaces for a mean year	249 mm
Net annual unit runoff for waste rock dump surface during active waste rock placement period for a mean year	105 mm
Net annual unit runoff for inactive waste rock dump surface after completion of final waste rock placement for a mean year	210 mm
Monthly runoff distribution	7.7% in May 55.6% in June 19.6% in July 7.4% in August 7.2% in September 2.5% in October
Annual total lake surface evaporation for a mean year	285 mm
Monthly distribution of lake surface evaporation	13% in June 38% in July 29% in August 20% in September
Annual total precipitation for a wet year with a 1/10 return period	428 mm
Annual total precipitation for a wet year with a 1/100 return period	553 mm
1-hour extreme rainfall with a 1/100 return period	28 mm
1-day extreme rainfall with a 1/100 return period	56 mm
30-day extreme rainfall with a 1/100 return period	152 mm
Spring snowpack snow water equivalent for a mean year (1/2 return period)	120 mm
Extreme spring snowpack snow water equivalent in wet condition with a 1/100 return period	162 mm

2.4 PK PARAMETERS

The following parameters were used in the water and waste management in this study.

- Natural moisture content of ore: 6% (from JDS/Hatch);
- Specific gravity of ore and PK: 2.7 (AMEC 2005);
- Average ratio of dry fine PK over total PK by weight: 25% (assumed based on the discussions at the kick-off meeting with JDS on August 25, 2009);
- Cut-off (maximum) size of fine PK: 0.5 (mm) (preliminary value to be finalized by Hatch);
- Moisture content of coarse PK: 18% (from EKATI Mine);
- Dry density of compacted on-land coarse PK: 2.0 tonnes/m^3 (AMEC 2008);
- Solid content of slurry fine PK at discharge points: 30% (assumed based on the discussions at the kick-off meeting with JDS on August 25, 2009);
- Dry density of settled fine PK (no entrained ice): 1.0 tonnes/m^3 (assumed based on experience at EKATI and Jericho);
- Average dry density of in-place fine PK (with entrained ice): 0.77 tonnes/m^3 (assumed based on experience at EKATI and Jericho);
- Beach slope of fine PK surface: 2% (assumed).

2.5 PASSIVE INFLOW TO PIT

HCI (2005) conducted a detailed study with three-dimensional modelling to predict hydraulic effects of developing the Gahcho Kué diamond project. The study was based on the previous mine development plan, which was different from that for the current study. Daily rates of passive inflow to pits were predicted in that study. No similar hydraulic study has been conducted for the current study. Therefore, the daily rates of the passive inflow to pits were roughly estimated based on the values reported in HCI (2005), pit depths with time for both previous and new mine development plans, and engineering judgement. Table 5 summarizes the estimated values used in the water balance and management in this study.

TABLE 5: SUMMARY OF ESTIMATED RATES OF PASSIVE INFLOW TO PITS DURING MINE OPERATION			
Calendar Year	Estimated Passive Inflow to Pit (m^3/day)		
	5034 Pit	Hearne Pit	Tuzo Pit
2014	1260		
2015	1040		
2016	880		
2017	1210		
2018	1230		
2019	1200	620	340
2020	1100	590	340
2021	1100	850	790
2022	550	1100	1880
2023	550	550	1660
2024	550	280	1440
2025	550	280	690

3.0 MAJOR ASSUMPTIONS AND CONSIDERATIONS

The following assumptions have been adopted in developing the water management and balance.

- The basin in Areas 3 to 5 will become a polishing pond during the early years of mine operation.
- A water quality assessment using a simple mixing model indicates that the water in the basin will meet discharge criteria during the first four years (2014 to 2017) of mine operation; therefore, it is planned to discharge water from the polishing pond to Lake N11 during that period for the current water management plan. The actual discharge period can be extended beyond 2017 if the water quality in the basin still meets the discharge criteria after 2017, and the water management plan can be updated at that time.
- No water will be discharged from the basins of Areas 1 to 7 when the water quality no longer meets the discharge criteria. After that time, all the water flowing into the basins will be stored in the basins and/or mined-out pits when available.
- The maximum lake level drawdown in the basin is limited to 2.0 m from the original lake level during the first three years to avoid disturbing the lakebed sediments below the normal wave action zone along the lake shoreline in Areas 3 to 5. The planned maximum lake level drawdown can be increased to 2.5 m for the fourth year to increase the water storage capacity in the basin, which will accommodate more water during the following no-discharge period. It may be possible to further draw down the water level

in the basin based on the empirical approach of discharging 50% of lake volume without treatment. Nevertheless, the latter approach was not adopted in the current water management plan to leave some conservatism and flexibility. Site performance observation and monitoring are required to determine the final value of the maximum drawdown during mine operation.

- Mine waste (waste rock, coarse PK, and fine PK slurry) is planned not to be directly placed in the polishing pond during the first four years of mine operation so that the clean water in the polishing pond can be discharged annually during the period.
- A filter dyke will be constructed across the pond between Area 2 and Area 3 to retain the excess suspended solids in the water flowing into Area 2 from Area 1, where the fine PK slurry is planned to be deposited during the discharge period. Past experience with filter dykes at several northern mines suggests that the filter dyke will sufficiently remove the excess suspended solids in the water released from the settled fine PK slurry. The filter dyke will be constructed before any fine PK slurry is placed in Area 1.
- An in-line treatment system will be used for both the runoff water and pit water pumped into the polishing pond to lower the suspended solid concentration in the water.
- Waste rock will be placed in the mined-out 5034 Pit. The maximum water storage capacity in the mined-out 5034 Pit while mining Tuzo Pit will be limited to the total volume of the voids within the waste rock placed below the elevation of the sill between the 5034 and Tuzo pits.
- Fine PK slurry will be placed in the mined-out Hearne Pit after the total volume of the fine PK placed in Areas 1 and 2 reaches the design capacity of the areas. No waste rock is planned to be placed in the mined-out Hearne Pit.
- Water required for processing ore will be reclaimed solely from the pond in Area 3 during the early stage of mine operation before fine PK slurry is deposited into the mined-out Hearne Pit. Pit water from the active Tuzo Pit will be used as a portion of reclaim water in the process plant after the fine PK is directed into the mined-out Hearne Pit. The balance of reclaim water for ore processing will come from Area 3.

4.0 WATER MANAGEMENT PLAN DURING MINE OPERATION

Water management during the mine operation period (2014 to 2025) can be divided into the following eight stages. A total of eighteen dykes (Dykes A to N, N14, E1, A3, and N10) are required for the water management.

Stage 1: Year -1 (2014)

- Pump water from 5034 Pit through an in-line treatment system to Area 5;

- Pump runoff water collected in various collection ponds in Areas 6 and 7 through an in-line treatment system to Area 5;
- Discharge treated sewage water from sewage treatment plant into Area 3;
- Divert runoff water from the catchment area of Lakes A3 and A4 by constructing Dyke C (the water level in Lake A3 will rise to about 425.0 m by the end of 2014);
- Divert runoff water from the catchment area of Lakes D1 to D10 by constructing Dyke F (the water level in Lakes D2 and D3 will rise to about 426.5 m by the end of 2014);
- Divert runoff water from the catchment area of Lakes E1 to E3 by constructing Dyke G (the water level in Lake E1 will rise to about 426.0 m by the end of 2014 and extra runoff will flow into Lake N14 and then Lake N17);
- Allow runoff water from the catchment area of Lakes B1 to B4 flowing into Area 3 by deferring the construction of Dyke E to alleviate the dyke construction requirements before the freshet of 2014; and
- Discharge water from Area 3 to Lake N11 during June to November to lower the water elevation in Areas 3 to 5 to a minimum of about 418.7 m by end of November.

Stage 2: Years 1 to 3 (2015 to 2017)

- Same as Stage 1 except for the following additions and changes;
- Divert runoff water from the catchment area of Lakes B1 to B4 by constructing Dyke E (the runoff water will flow to Lake N8 and then Lake N6);
- Discharge fine PK slurry together with treated sewage water into Area 1;
- Complete Dyke L before the start of depositing fine PK in Area 1 so that the free water released from the settled fine PK in Area 1 and the contact runoff water into Areas 1 and 2 can be filtered through the filter dyke before the mixed water flows into Area 3;
- Reclaim water from Area 3 to process plant for ore processing;
- Construct Dykes N14 and E1 to allow raising the water level to 428.0 m in the area enclosed by Dykes F, G, E1, and N14 to create new fish habitat; pump water from Area 5 to reduce the time required to raise the water level in the area; and
- Construct Dykes A3 and N10 to allow raising the water level to 427.5 m in the area enclosed by Dykes C, N10 and A3 to create new fish habitat and force the extra water from the area to flow into the watershed of L lakes; pump water from Area 3 (from Areas 1 or 2 if the water quality meets the requirements) to reduce the time required to raise the water level in the area.

Stage 3: Year 4 (2018)

- Same as Stage 2 except for the following additions and changes;

- Pump pit water from both 5034 Pit and Hearne Pit to Area 5;
- Pump runoff water collected in collection ponds in Areas 6 and 7 to Area 5;
- Water replaced by waste rock placed below the water in the south portion of the basin in Area 5 (or Area 5B);
- Extra water from Raised D-E-N (the area enclosed by Dykes F, G, E1, and N14) to flow to Lake N18;
- Extra water from Raised A3 (the area enclosed by Dykes C, N10 and A3) to flow to Lake L18;
- Assume no discharge from Area 3 to Lake N11 for the current plan; annual discharge may continue depending on the actual water quality in Area 3.

Stage 4: Year 5 (2019)

- Same as Stage 3 except for the following additions and changes;
- Start to discharge fine PK slurry together with treated sewage water into Area 2;
- Stop pumping pit water from 5034 Pit to Area 5 after July of Year 5 (start backfilling mined-out 5034 Pit in August);
- Dyke B completed by July of Year 5 to separate Area 4 from Area 5;
- Siphon water from Area 4 to mined-out 5034 Pit to drain Area 4 in August and September of Year 8;
- Pump pit water from Hearne Pit to Area 5; and
- Pump pit water from Tuzo Pit to Area 5 after September of Year 5.

Stage 5: Year 6 (2020)

- Same as Stage 4 except for the following additions and changes;
- Pump runoff water collected in collection pond CP6 in Area 4 to Area 3;
- Stop pumping runoff water collected in collection ponds CP1 to CP5 in Areas 6 and 7 to Area 5;
- Pump runoff water collected in collection ponds CP2 to CP5 in Area 6 to Area 7;
- Start raising water level in Area 7 by complete Dyke K; and
- Pump pit water from both Hearne and Tuzo pits to Area 5.

Stage 6: Year 7 (2021)

- Same as Stage 5 except for the following changes;

- Pump runoff water collected in collection ponds CP1 to CP5 to Area 7 before and during June of Year 7 and water collected in collection ponds CP2 to CP4 into mined-out Hearne Pit after June of Year 7; and
- Stop pumping pit water from Hearne Pit to Area 5 after June of Year 7 when Hearne Pit is mined-out.

Stage 7: Year 8 (2022)

- Same as Stage 6 except for the following additions and changes;
- Stop placing fine PK slurry into Area 2 after June of Year 8;
- Start placing fine PK slurry into mined-out Hearne Pit after June of Year 8;
- Stop pumping pit water from Tuzo Pit to Area 5 after June of Year 8;
- Pump pit water from Tuzo Pit to process plant as a portion of the reclaim water after June of Year 8 to promote locking the chloride/TDS in the Tuzo pit water in the fine PK slurry placed in the bottom portion of Hearne Pit;
- Pump the remaining reclaim water required for ore processing from Area 3; and
- Start pumping extra water cumulated in the mined-out 5034 Pit into the mined-out Hearne Pit after February of Year 8.

Stage 8: Years 9 to 11 (2023 to 2025)

- Same as Stage 7 except for the following addition and change;
- Start pumping extra water in Area 7 into the mined-out Hearne Pit to limit the maximum water level in Area 7 to 420.7 m; and
- Construct Dyke N to increase water storage capacity in the west portion of Area 6 containing the mined-out Hearne Pit.

5.0 WATER STORAGE CURVES AND CATCHMENT AREAS

The water storage capacities with depths for various additional areas used in water management and balance during the mine operation stage are summarized in Table 6.

TABLE 6 WATER STORAGE CAPACITY FOR SOME AREAS DURING MINE OPERATION					
Water Elevation (m)	Areas 1 and 2 after Final Deposition of Fine PK in Areas 1 and 2 (Mm³)	Areas 3 and 5 after Construction of Dykes L and B and Final Placement of Waste Rock in Area 5B * (Mm³)	Area 4 after Construction of Dyke B (Mm³)	Mined-out 5034 Pit below the Sill between 5034 Pit and Tuzo Pit (Mm³)	West of Dyke N in Area 6 Including Mined-out Hearne Pit (Mm³)
200				2.06	
225				3.83	
250				6.28	
275				9.57	1.00
300				13.53	
350					5.47
410		0.44	0.14		12.42
411		0.72	0.22		12.58
412		1.38	0.37		12.74
413		2.04	0.52		12.92
414		3.14	0.75		13.09
415		4.24	1.01		13.32
416		5.75	1.36		13.56
417		7.26	1.71		13.85
418		9.09	2.14		14.14
419	0.00	10.93	2.64		14.52
420	0.07	13.01	3.23		14.91
421	0.24	15.08	3.89		15.50
422	0.69	17.42	4.65		16.08
423	1.13	19.77	5.41		
424	1.87				

*The volume includes the voids within the submerged portion of the waste rock placed in south portion of Area 5. An average porosity of 0.23 was used for the submerged waste rock.

The total catchment areas for various additional areas used in water management and balance during the mine operation stage are summarized in Table 7.

TABLE 7: SUMMARY OF CATCHMENT AREAS FOR VARIOUS ADDITIONAL AREAS DURING MINE OPERATIO	
Area	Total Catchment Area Including Water Surface (km^2)
5034 Pit including surrounding areas where runoff water directly flows into 5034 Pit after surface water diversion and collection	0.50
Hearne Pit including surrounding areas where runoff water directly flows into Hearne Pit after surface water diversion and collection	0.53
Tuzo Pit including surrounding areas where runoff water directly flows into Tuzo Pit after surface water diversion and collection	0.80
West portion of Area 6 after construction of Dyke N	1.63
Final waste rock pile surface in Area 6	0.78
Final waste rock pile surface in Area 5	0.74
Final coarse PK pile surface in Area 4	0.32
Final settled fine PK surface in Areas 1 and 2	1.41

6.0 WATER BALANCE DURING MINE OPERATION

Monthly water balance was conducted for the basins in Areas 1 to 7 and mined-out 5034 and Hearne pits during the mine operation under mean precipitation years. Table 8 summarizes the major sources of water inputs and outputs for each of the basins and pits for the water balance.

TABLE 8: SUMMARY OF SOURCES OF WATER INPUTS AND OUTPUTS FOR WATER BALANCE		
Basin or Pit	Water Inputs	Water Outputs
Basin in Area 1	a) Net runoff into catchment area of Area 1; b) Inflow from Lake A3 into Area 1 before Dyke C is constructed or seepage through Dyke C into Area 1 after Dyke C is constructed; c) Free water released from settled fine PK deposited in Area 1.	a) Water flowing from Area 1 to Area 2.
Basin in Area 2	a) Net runoff into catchment area of Area 2; b) Free water released from settled fine PK deposited in Area 2; c) Water flowing from Area 1 to Area 2.	a) Water flowing from Area 2 to Area 3 before Dyke L is constructed or seepage water through the filter dyke (Dyke L) from Area 2 to Area 3.

TABLE 8: SUMMARY OF SOURCES OF WATER INPUTS AND OUTPUTS FOR WATER BALANCE		
Basin or Pit	**Water Inputs**	**Water Outputs**
Basin in Areas 3&5	a) Net runoff into catchment area of Areas 3&5; b) Inflow from Lake B1 into Area 3 before Dyke E is constructed or seepage through Dyke E into Area 3 after Dyke E is constructed; c) Inflow from Lake D2 into Area 5 before Dyke F is constructed or seepage through Dyke F into Area 5 after Dyke F is constructed; d) Water flowing from Area 2 to Area 3 before Dyke L is constructed or seepage water through the filter dyke (Dyke L) from Area 2 to Area 3; e) Pit water in active pits pumped to Area 5; f) Water flowing from Area 4 to Area 3 before Dyke B is constructed or water pumped from collection ponds in Area 4 to Areas 3&5 after Dyke B is constructed; g) Water pumped from collection ponds in Area 6 to Area 5; h) Water pumped from collection ponds in Area 7 to Area 5.	a) Water discharged from Area 3 to Lake N11; b) Water reclaimed from Area 3 to process plant; c) Seepage water through internal Dykes B and M into Area 4; d) Seepage water through internal Dykes H and I into Area 6.
Basin in Area 4	a) Net runoff into catchment area of Area 4; b) Seepage water through internal Dykes B and M into Area 4; c) Seepage from bottom of drained lake in Area 4.	a) Water pumped from Area 4 to Area 3; b) Seepage water through internal Dyke J into Area 6; c) Water pumped from Area 4 to mined-out 5034 Pit.
Basin in Area 6	a) Net runoff into catchment area of Area 6; b) Inflow from Lake E1 into Area 6 before Dyke G is constructed or seepage through Dyke G into Area 6 after Dyke G is constructed; c) Seepage water through internal Dykes H, I, J, K, and N into Area 6; d) Seepage from bottom of drained lake in Area 6.	a) Water flowing from Area 6 to Area 7 during initial lake dewatering and water pumped from Area 6 to Area 7 after Dyke K is constructed; b) Water pumped from Area 6 to Area 3; c) Water flowing from Area 6 into mined-out 5034 Pit; d) Water pumped from Area 6 to mined-out Hearne Pit.

TABLE 8: SUMMARY OF SOURCES OF WATER INPUTS AND OUTPUTS FOR WATER BALANCE		
Basin or Pit	**Water Inputs**	**Water Outputs**
Basin in Area 7	a) Net runoff into catchment area of Area 7; b) Water flowing from Area 6 to Area 7 during initial lake dewatering and water pumped from Area 6 to Area 7 after Dyke K is constructed; c) Seepage water through Dyke A in Area 7; d) Seepage from bottom of drained lake in Area 7.	a) Water discharged from Area 7 to Lake K5; b) Water pumped from Area 7 to Area 5; c) Water pumped from Area 7 to mined-out Hearne Pit.
Mined-out 5034 Pit	a) Net runoff into catchment area of mined-out 5034 Pit; b) Water pumped from Area 4 to mined-out 5034 Pit; c) Underground seepage through bottom and walls of inactive mined-out 5034 Pit into the pit.	a) Water pumped from mined-out 5034 Pit to mined-out Hearne Pit.
West Portion (Area 6A) of Area 6 including Mined-out Hearne Pit	a) Net runoff into catchment area of Area 6A; b) Water pumped from the remaining area (Area 6B) of Area 6 into Area 6A; c) Seepage through Dyke G and drained lakebed into Area 6A; d) Water pumped from Area 7 to Area 6A; e) Underground seepage through bottom and walls of inactive mined-out Hearne Pit into the pit; f) Fine PK slurry deposited into mined-out Hearne Pit; g) Water pumped from mined-out 5034 Pit to mined-out Hearne Pit.	a) Seepage water though internal Dyke N from the west of Area 6 to the east of Area 6.

The volume of net runoff water in a given catchment area was calculated based on sub-areas of various surface types including vegetated land surface, open water surface, disturbed land surface, active waste rock surface, and inactive waste rock surface. The net unit runoff value for each of the surface types is summarized in Table 4.

The seepage volume through the filter dyke (Dyke L) was calculated using a macro built into the spreadsheets for the water balance. Similar macros were previously developed and used for water balance for other mining projects. The seepage values calculated from these macros were compared to the values determined using a finite element method, SEEP/W.

Good agreement between these values was obtained, which provides solid basis for using the macro in this study.

Filter dykes similar to Dyke L have been successfully constructed and operated in several mines in northern Canada. The performance of the filter dykes was monitored. The hydraulic conductivity of the unblocked filter material was back-calculated based on actual operational data for a mine and estimated to be 9.7E-05 m/s. This value was used for the filter material in Dyke L for seepage estimations in this study. Seepage paths could be blocked in the upper filter zone due to ice formation in winter periods and in the lower filter zone below the potential fluffy fine PK zone due to infiltration of the silty particles into the filter material. These factors were considered in the macro for estimating seepage volumes through the filter dyke.

Seepage volumes through the perimeter dykes (Dykes A, C, D, E, F, and G) around Areas 1 to 7 were explicitly considered in the water balance model. The month seepage volumes through Dyke A were estimated in seepage analyses using SEEP/W. The seepage volumes though the other perimeter dykes are expected to be none or minor because these dykes have been designed to have a liner system keyed into top of saturated permafrost or bedrock. Nominal values of the seepage volumes through the dykes were assumed in the water balance model.

Seepage through internal water retention dykes (Dykes B, H, I, J, K, M, and N) will be collected in water collection ponds and pumped back to the source reservoirs. Therefore, the monthly seepage values through these dykes were not shown in the water balance spreadsheets.

Estimated passive inflow rates to pits are summarized in Table 5. There values were used in the water balance model.

Seepage volumes from bottom of the drained basins were estimated using a three-dimensional analysis model in HCI (2005) for the previous studies. Similar modelling was not conducted for the current study. Seepage volumes from bottom of the drained basins used in the current water balance model were adjusted from those reported in HCL (2005) based on the overall areas of the drained basins.

ATTACHMENT 8.I.2

UPDATED SUMMARY OF PRELIMINARY WATER AND WASTE MANAGEMENT CLOSURE PLAN FOR FEASIBILITY STUDY OF GAHCHO KUÉ PROJECT

TECHNICAL MEMO

CREATING AND DELIVERING BETTER SOLUTIONS

www.eba.ca

TO:	Wayne Corso, JDS Energy and Mining Inc.	DATE:	May 14, 2010
C:	Jerry Vandenberg, Golder Associates Ltd. Graeme Swinnerton, Golder Associates Ltd.	MEMO NO:	007 (Updated)
FROM:	Gordon Zhang	FILE:	E14101046.001
SUBJECT:	**Updated Summary of Preliminary Water and Waste Management Closure Plan for Feasibility Study of Gahcho Kué Project**		

1.0 GENERAL

This memo is an update of EBA's previous Memo 007 dated March 19, 2010. This memo describes the updated mine closure and reclamation plans associated with the water and mine waste management for the Gahcho Kué project at this stage. This includes the water storage areas with dykes and berms, fine PK storage area, coarse PK disposal area, and waste rock piles. The closure plans for other components of the mine site are not addressed in this memo.

This plan may be updated later based on findings and recommendations from the ongoing environmental impact assessment that Golder is conducting for this project.

The water and waste management closure plan will be finalized and summarized in the water and waste management report that is being prepared by EBA.

2.0 WATER MANAGEMENT DURING MINE CLOSURE

2.1 ANNUAL WATER INPUTS DURING MINE CLOSURE

Water from various sources will flow into the water storage system after the end of mine life during mine closure. Table 1 presents the estimated annual volume of water from each of the water sources.

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TABLE 1 ESTIMATED ANNUAL VOLUME OF WATER FOR VARIOUS SOURCES DURING MINE CLOSURE		
Water Source	Estimated Average Annual Volume of Water Flowing into Areas 1 to 7 during Mine Closure (Mm^3)	Comments
Net runoff from Area 1	0.349	Dyke C remains in place
Net runoff from Area 2	0.293	Dyke D remains in place
Net runoff from catchment area of Lakes B1 to B4 after breach of Dyke E	0.224	Dyke E is breached
Net runoff from Areas 3 and 5	0.517	Dyke F remains in place
Net runoff from Areas 4 and 6, not including west of Dyke N	0.828	
Net runoff from the area west of Dyke N within Area 6	0.233	Dyke G remains in place
Net runoff from Areas 7	0.620	Dyke A remains in place
Underground inflows to mined-out Pits	0.110	Assumed 300 m^3/day of underground inflow from mined-out pit bottoms
Net runoff from the west flooded area (Raised D-E-N) after its lake elevation is raised to 429.0 m	0.613	After construction of Dyke N18; Dykes F, G, E1, and N14 remain in place; it is estimated to take about 4 years after the end of mine operation to raise the lake elevation of Raised D-E-N from 428.0 m to 429.0 m from natural runoff accumulation.
Total (without net runoff from Raised D-E-N)	3.174	All above but without runoff from Raised D-E-N
Total (with net runoff from Raised D-E-N)	3.787	All above with runoff from Raised D-E-N

2.2 STAGE STORAGE CURVES

Table 2 summarizes the stage storage data for various areas. These data will be used to estimate the volume of water required to fill the mined-out pits and restore the drained basins in Section 2.3.

TABLE 2 STAGE STORAGE CURVES FOR WATER MANAGEMENT DURING MINE CLOSURE						
Elevation (m)	Stage Storage Curves at End of Mine Operation (2025) (M m^3)					
	a)	b)	c)	d) = a) - b) - c)	e)	f) = d) + e)
250	14.501	6.420		8.081	0	8.081
300	28.309	13.677		14.632	0	14.632
350	48.785	24.351		24.434	2.455	26.889
410	84.341	40.894		43.447	6.260	49.707
414	87.700	42.147	0.134	45.419	6.579	51.998
418	94.352	43.407	1.187	49.758	7.111	56.869
420	98.172	43.407	2.069	52.695	7.314	60.009
422	102.606	43.407	3.140	56.058	7.560	63.618

Note:

a) Area 4 and east portion of Area 6 enclosed by Dykes B, M, I, N and K and Area 1 Till Berm 1; no waste rock in mined-out 5034 Pit; no waste rock in south of Area 6; and no coarse PK pile in Area 4.
b) Waste rock placed in the mined-out 5034 Pit.
c) Waste rock placed in the south waste rock pile in Area 6.
d) The enclosed area in a) minus volumes occupied by waste rock in the mined-out 5034 Pit and south waste rock pile. It was assumed that negligible volume of coarse PK placed below the elevation of 422 m in Area 4.
e) Voids in all the waste rock placed above water; 23% of porosity of in-place waste rock was assumed. It was assumed that water has filled in the voids in the waste rock placed below the elevation of 300 m in the mined-out 5034 Pit by the end of the mine operation.
f) Volume of water required to fill in the enclosed area for mine closure.

2.3 PIT REFILLING AND RESTORING DRAINED LAKE BASINS

The total estimated volume of water required to raise the water elevation in the entire area, including Areas 1 to 7 and the mined-out pits, to the original Kennady Lake elevation of 420.7 m is 56.0 Mm^3. Table 3 summarizes the water volumes and estimated times required for two closure water management options.

TABLE 3 WATER VOLUMES AND FILLING TIMES REQUIRED FOR TWO CLOSURE WATER MANAGEMENT OPTIONS		
Item	Value	Comments
Estimated volume of water required to fill in the basins in Area 4 and east portion of Area 6 to the original lake elevation of 420.7 m after end of mine operation	61.3 (Mm^3)	Volume including the voids in the waste rock between elevations of 300 m and 418 m in the mined-out 5034 Pit and in the waste rock below 420.7 m in the west waste rock pile
Volume of water stored above the original lake elevation of 420.7 m in Areas 1 to 7 by end of mine operation	5.3 (Mm^3)	Lower water elevations in Areas 1, 2, and 3&5 to 420.7 m or lower during mine closure
Additional volume of water required to raise the water elevations in Areas 1 to 7 to the original lake elevation of 420.7 m	56.0 (Mm^3)	Volume needed for filling in the pits and restoring the drained lake basins
Estimated time required for raising the water elevations in Areas 1 to 7 to the original lake elevation of 420.7 m by natural runoff but without pumping water from external water sources	15.5 years	Assuming that natural runoff water from all water sources in Table 1 is used.
Assumed average yearly volume of water pumped from Lake N11 to Area 3 after 2024	3.7 (Mm^3/year)	Value from De Beers (2008)
Estimated time required for raising the water elevations in Areas 1 to 7 to the original lake elevation of 420.7 m by both natural runoff water and annually pumping water from Lake N11 to Area 3 after 2025	7.8 years	Assuming that natural runoff water from all water sources in Table 1 is used; annual pumping of water of 3.7 Mm^3/year from Lake N11 to Area 3

If pumping water from an external source, namely from Lake N11, is adopted for a closure water management plan, the average annual volume of water that can be pumped from Lake N11 is 3.7 million cubic metres per year based on the previous draft environmental impact statement report for this project (De Beers 2008). The following information is quoted from the report:

To expedite the refilling of Kennady Lake, water will be pumped from Lake N11. Pumping will occur during the early, high water season. It will typically begin in June and end in July, although pumping may extend into August in wet years. Flow forecasts, based on snow pack conditions and seasonal precipitation trends, will be used to estimate annual water yield from Lake N11. Planned pumping rates will be set accordingly to ensure that the total annual outflow from Lake N11 does not drop below the 1 in 5-year dry condition. During the pumping season, pumping rates will be adjusted, as required, to meet this objective. In years where the Lake N11 outflow is forecast to naturally fall below the 5-year dry condition, no pumping will occur.

The total annual average diversion from Lake N11 will be in the order of 3.7 million cubic metres per year, which represents no more than 20% of the normal annual flow to Lake N11. The 20% cutoff will be used to ensure that sufficient water remains in, and flows out of, Lake N11 to support downstream aquatic systems in the N watershed.

The value of 3.7 Mm^3/y represents the difference between the flow reporting to Lake N11 under median/normal flow conditions and that which occurs under 1 in 5-year dry conditions. Based on a six-week pumping period, the average pumping rate will be in the order of 88,100 m^3/d. It is anticipated that more water will be withdrawn during wet years, up to a maximum of 175,200 m^3/d. In drier years, less water will be withdrawn. At no time will the diversion result in outflow from Lake N11 dropping below that which occurs under 1 in 5-year dry conditions.

2.4 WATER MANAGEMENT PLAN DURING MINE CLOSURE

The following closure water management plan is adopted in consideration of various factors and after discussions with JDS. The plan requires annually pumping water from Lake N11 to Area 3 to reduce the overall time for the closure process. The required filling time is estimated to be approximately 8 years of both pumping from Lake N11 and natural runoff accumulation (or 7 years of pumping from Lake N11 and 9 years of natural runoff accumulation).

Major steps for the closure water management plan

- Lower the water elevations in all water storage areas within Area 1 to 7 to 417.0 m by siphoning the water from Area 3&5, west of Area 6, and Area 7 to the mined-out Tuzo Pit after the end of mine life.
- Breach sections of Dykes B, N, and K to an elevation of 417.0 m, flatten the downstream slope, and place 1 m thick erosion protection material over the excavated dyke crests and flattened downstream slopes.
- Place erosion protection materials over the downstream natural channels (or engineered channel when required) to limit erosion along the flow paths to the mined-out Tuzo Pit.
- Breach a section of Dyke E to allow the runoff water from the catchment area of Lakes B1 to B4 to flow into Area 3.
- Pump water from Lake N11 to Area 3 at an average annual volume of 3.7 Mm^3/y for 8 consecutive years.
- Allow the extra runoff water from Area 3&5, west of Area 6, and Area 7 to flow over the breached sections of Dykes B, N, and K.
- Construct Dyke N18 to raise the water elevation in Raised D-E-N from 428.0 m to 429.0 m and to allow extra runoff water from Raised D-E-N to flow into Lake D1 then Area 5 after its water elevation reaches 429.0 m; it is estimated to take four years to raise the water elevation in Raised D-E-N from 428.0 m to 429.0 m.
- Monitor water quality and adjust the closure water management plan if required.
- Raise the water elevation in the entire basin to the original lake elevation of 420.7 m in 8 years after end of the mine operation.

- Breach Dyke A to connect the refilled basin to Lake K5, when the water quality meets the discharge criteria.
- End of mine closure.

This plan has the following major advantages:

- Reduce the overall time and associated costs to fill in the mined-out pits and drained basins.
- Improve the water quality in Areas 3&5 and west of Area 6 by siphoning/pumping the potential saline water down to the bottom of the mined-out Tuzo Pit.
- No need to excavate spillway channels to discharge the extra water from Areas 3&5 and west of Area 6
- Reduce water depth over the lower portion of the final PK in Area 2 and facilitate reclamation the fine PK surfaces.
- Less requirements for maintenance of Dykes B, K, and N.
- Create additional fish habitat in the Raised D-E-N by raising its water elevation.

Table 4 summarizes the estimated total volume of the water pumped from each of the areas to lower the water elevation down to 417.0 m after the end of mine life.

TABLE 4 ESTIMATED VOLUMES OF WATER TO LOWER WATER ELEVATION TO 417.0 m

Area	Volume of Water to be Pumped (Mm^3)
Areas 1 and 2	0.69
Areas 3 and 5	11.52
West of Dyke N in Area 6	2.09
Area 7	2.70
Total	**17.00**

2.5 WATER QUALITY AFTER END OF MINE OPERATION

It is understood that the prediction of the water quality in Areas 1 to 7 after the end of mine operation (2025) will be conducted by Golder as a part of the environmental impact assessment for this project. General considerations and comments regarding the water quality are briefly described below.

High chloride concentrations of up to 300 mg/L in Areas 3&5 and up to 740 mg/L in the west of Area 6 by the end of mine operation were predicted using a simple mixing model. It is planned to siphon the water in these areas down to an elevation of 417.0 m into the mined-out Tuzo Pit. This will improve the water quality with time in these areas during the mine closure period when more fresh runoff water is flowing into the areas.

The water siphoned from Area 3&5, west of Area 6, and Area 7 into the mined-out Tuzo Pit after the end of mine life will raise the water elevation in Tuzo Pit from the pit bottom elevation of 121 m to approximately 310 m. The higher water elevation in the pit will reduce the rate of the potential underground saline seepage through the pit bottom into the pit, which will also help to improve the overall water quality in the pit.

The water elevations in Area 3&5, west of Area 6, and Area 7 will be maintained at 417.0 m or higher to limit potential disturbance of the lakebeds during the mine closure.

Water quality will be monitored during the mine closure stage so the closure water management plan can be evaluated or adjusted if required.

3.0 PK AND WASTE ROCK AREAS

3.1 FINE PK STORAGE AREA

The fine PK storage area in Areas 1 and 2 will be progressively reclaimed during the mine operation since fine PK will not be deposited in the area after July 2022 before the end of mine life in 2025. After that time, the fine PK will be placed into the bottom of the mined-out Herne Pit.

The fine PK surface will be progressively covered with a layer of coarse PK and then a layer of NAG waste rock to limit surface erosion from runoff and eliminate potential dust production over dry surfaces during the mine life and closure. The waste rock layer thickness will depend on actual fine PK properties, local conditions, and equipment used for waste rock placement. A minimum of 1 m is required. A layer of coarse PK will be placed over the fine PK surface before the waste rock layer is placed to improve equipment trafficability and prevent squeezing up of the underlying fine PK. The final geometry of the cover layer will be graded to limit ponding of water over the waste rock covered fine PK areas.

The settled fine PK placed in the mined-out Hearne Pit will have a final top elevation of approximately 300 m, which is well below the final lake elevation of 420.7 m after mine closure. No action is required for the fine PK placed in the pit..

3.2 COARSE PK PILE

The coarse PK pile will be progressively reclaimed during the mine life. The final closure plan for the coarse PK pile includes placing a waste rock cover of a minimum of 1 m to limit surface erosion.

3.3 WASTE ROCK PILES

Closure of the waste rock piles will involve contouring and re-grading. The piles will not be covered or vegetated, consistent with the approaches in place at other northern diamond mines, such as EKATI, Diavik, and Jericho diamond mines. Thermistors may be installed within the waste rock pile to monitor the progression of permafrost development.

The waste rock pile placed in the mined-out 5034 Pit will be submerged with a minimum water cover of 2.7 m when the water level in the drained basins is raised to the original lake elevation of 420.7 m.

4.0 DYKES AND BERMS

After the end of mine life, the water elevations in all water storage areas within Area 1 to 7 will be lowered to 417.0 m by siphoning the water from Area 3&5, west of Area 6, and Area 7 to the mined-out Tuzo Pit. After the water elevations are lowered, a portion of the dyke crest for each of Dykes B, N, and K will be excavated down to an elevation of 417.0 m to create a temporary spillway for extra runoff water flowing from the upstream side to the downstream side during early years of mine closure when the water elevations in the drained basins are below 417.0 m. The downstream slopes around the excavated sections will be flattened to a tentative slope of 10(H):1(V). A layer of 1 m thick erosion protection material will be placed over both the excavated dyke crests and flattened downstream slopes. The excavated section width will depend on hydraulic requirements and other considerations such as creating fish habitats. Tentative minimum widths of 50 m, 100 m, and 150 m were selected at this stage for Dykes N, K, and B, respectively. The remaining portions of Dykes B, N, and K will be lowered to a top crest elevation of 418.0 m to limit net fish habitat losses.

Dyke E will be breached after end of mine life to allow the runoff water from the catchment area of Lakes B1 to B4 to flow into Area 3.

Dykes C, F, G, E1, N14, A3 and N10 will become permanent water diversion structures to maintain the established fish habitats upstream of these dykes. The downstream of Dyke C will be covered with a wide zone of the settled fine PK during early stage of mine operation. It is expected that permafrost will be developed over the fine PK area with time. Therefore, excess seepage from Lake A3 to Area 1 through Dyke L is not expected. Additional till fill materials can be placed on the downstream side of Dykes F and G during late stage of mine operation or early mine closure to limit potential excess seepage through the dykes if thermal evaluations during the final design stage indicate that the permafrost below the key trench will be thawed under extreme climate change (global warming) scenarios. Long-term maintenance and monitoring may be required for these dykes. The dyke performance during the mine operation and early closure stage will be evaluated to address any potential issues and to minimize the requirements of long-term maintenance and monitoring.

A section (100 m width) of Dyke L crest close the northwest abutment will be lowered down to an elevation of 421.0 m to create a drainage path across the dyke. The fine PK surface will be covered with a minimum of 1 m waste rock material after mine closure. The final PK surface elevations at the locations close to the lowered section will be around 416.0 m, which is about 5 m below the lowered dyke crest. Therefore, it will be less likely that any fine PK will flow over to Area 3.

Dyke J will be lowered to a top crest elevation of 418.0 m to limit net fish habitat losses.

Dykes D, H, I, and M are not technically required once the water elevations in Area 2 and Areas 3&5 are lowered to 417.0 m after the end of mine life. The berms for water collection ponds will not be needed after the end of mine life and will be completely submerged below water under the water elevation of 420.7 m in the restored basins. These dykes/berms can remain in place after mine closure.

Dyke A will be the last dyke to be breached during mine closure once the water quality in the restored lake basins in Areas 1 to 7 meets the discharge criteria.

The till berms around Area 1 and the waste rock berms around and in Area 1 will remain in place after mine closure. Waste rock cover may be placed over the till berms to reduce potential surface erosion.

ATTACHMENT 8.I.3

EVALUATION OF PHOSPHORUS CONCENTRATIONS IN ON-GOING GEOCHEMICAL TEST LEACHATES AND WATER QUALITY MODELLING

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1. OVERVIEW

Geochemical characterization of mine rock and processed kimberlite (PK) was carried out as a component of the Metal Leaching and Acid Rock Drainage (ML/ARD) assessment for the Environmental Impact Statement (EIS) for the Gahcho Kué Project (Project). The results of geochemical characterization of PK and mine rock were used as inputs to the water quality modeling for the Project. The water quality modeling work simulated solute transport in water that comes into contact with mine rock and PK during operations and following closure. The results of the water quality projections indicated that long-term concentrations of phosphorus in Kennady Lake could be in concentrations that may affect overwintering habitat to some species of fish.

In 2011, the water quality assessment for the Project has been carried out iteratively based on the results of on-going geochemical testing. The objective of this memorandum is to provide an update with respect to ongoing work that has been completed in support of the evaluation of post-closure phosphorus concentrations in Kennady Lake.

2. GEOCHEMICAL CHARACTERIZATION OF PROCESSED KIMBERLITE AND MINE ROCK

Geochemical characterization of PK and mine rock has taken place in several stages (Table 1). The objective of the initial stage of the geochemical characterization program carried out prior to 2008 was to define the ML/ARD characteristics of mine rock and PK that could be generated at the Project. A second phase of testing was initiated in 2010 to evaluate the characteristics of PK in the range of saturated and unsaturated conditions that could be realized in the Fine Processed Kimberlite Containment (PKC) Facility. In addition, a supplemental geochemical testing program was initiated in 2011. The objective of this supplemental testing program is to expand, and possibly refine, the knowledge of the geochemical characteristics of PK and mine rock, particularly with respect to the evaluation of phosphorus leaching.

Table 1 Summary of Geochemical Testing for the Gahcho Kué Project

Year of Testing Program	1996[1]	2002[1]	2008[1]						2010[1]					2011[2]					
Geochemical Test[3]	**ABA and Metals**	**ABA and Metals**	**ABA**	**Metals**	**Mineralogy**	**Short-Term Leach**	**HCT**	**Column**	**ABA and Metals**	**Mineralogy**	**Short-Term Leach**	**HCT**	**SCT**	**ABA and Metals**	**Short-Term Leach**	**Mineralogy**	**HCT**	**SCT**	**Evaluation of Water from Exploration Drill Chip Samples**
Kimberlite	10	10	508	200	4	27	7	5	0	0	0	0	0	0	0	0	0	0	0
Coarse Processed Kimberlite	0	0	23	20	1	11	7	1	11	1	11	1	1	9	9	3	3	3	31
Fine Processed Kimberlite	0	0	38	11	13	10	1	1	10	1	10	1	1	9	9	3	3	5	0
Mine Rock	10	3	1,235	893	3	34	18	5	0	0	0	0	0	6	6	0	3	3	0
Total Number of Samples	**20**	**13**	**1,804**	**1,124**	**21**	**82**	**33**	**12**	**21**	**2**	**21**	**2**	**2**	**24**	**24**	**6**	**9**	**11**	**31**

Notes:
1. Testing as described in Appendix 8.II
2. Ongoing geochemical testing program initiated in 2011
3. Geochemical tests, including: ABA = acid base accounting; HCT = humidity cell testing; SCT = saturated column tests.

The methods used for testing the ML/ARD potential of PK and mine rock include static and kinetic laboratory tests, as recommended in guidance documents including "Guidelines for Acid Rock Drainage Prediction in the North." (DIAND 2002), "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. MEND Report 1.20.1." (MEND 2009), and "Global Acid Rock Drainage Guide (GARD Guide)" (INAP 2009). The level of effort presented in these guidelines is generally accepted by Canadian and international regulatory jurisdictions.

Static tests are one-time tests that are used to perform a screening level evaluation of a material's potential for ML/ARD. Kinetic tests are longer term, repetitive leach tests. The objective of kinetic testing is to verify whether the ML/ARD potentials indicated by the results of static testing will be realized over time, and if so, what the associated mineral reaction rates and mechanisms of mineral reaction are (e.g., sulphide oxidation, depletion of neutralization potential, mineral dissolution). The goal of kinetic testing is to evaluate what the potential composition of long-term release rates contributing to solute transport in mine discharges will be.

The kinetic testing component of the geochemical characterization program included two test methods:

- Humidity Cell Testing (HCT), according to ASTM D5744-99 (Standard Test Method for Accelerated Weathering of Solid Materials Using a Modified Humidity Cell [ASTM 2001]), was used to simulate the long-term leachate composition of a material under partially flooded conditions and atmospheric exposure.
- Saturated column testing (SCT) was used to simulate the effect of inundating fine PK and coarse PK in the Fine PKC Facility.

The results of kinetic testing were evaluated with respect to the acid generation potential, and metal and phosphorus leaching potential from PK and mine rock. Source term inputs to the EIS water quality model for the Project were then defined based on the evaluation of the results of kinetic testing. The laboratory test methods in the geochemical characterization program were selected for the purpose of simulating the range of conditions that could be realized in the various mine waste management facilities during the life of the Project. Laboratory scale tests are not capable of simulating the site-specific, temporal factors that could influence the rate of mine waste weathering, including climate, channelization of flow, or grain size distribution owing to mine waste deposition methods. The application of the results of laboratory scale geochemical tests to represent geochemical processes that will occur during operations and closure is conservative. Assumptions made based on the use of such data must be confirmed with monitoring during the mine life.

3. PHOSPHORUS CONCENTRATIONS IN ON-GOING GEOCHEMICAL TESTS

The primary source of the results of geochemical characterization of PK and mine rock is Appendix 8.II of the EIS, which includes a summary of the results of static and kinetic laboratory tests completed during the initial phase of geochemical testing in 2008, and the preliminary results of geochemical tests initiated in 2010 using composite samples of coarse PK and fine PK from pilot plant testing.

The 2010 PK kinetic tests were on-going at the time of submission of the EIS; however, the results of the evaluation of phosphorus concentration trends in the ongoing kinetic tests have become a key component of the iterative updates to the water quality model that were carried out in 2011. Figure 1 presents the results of HCT and SCT of fine PK and coarse PK composite samples through to Week 46 of testing. Kinetic testing of these samples is on-going.

The results of HCT and SCT of the coarse PK composite sample have been relatively stable since the onset of the coarse PK composite kinetic tests. The range of results of HCT, which are considered representative of coarse PK exposed to “atmospheric” conditions, are similar to the range of results of the SCT. The results of kinetic testing of coarse PK, to date, suggest that geochemical mobility of phosphorus from coarse PK is similar in laboratory tests representative of atmospheric and fully saturated conditions.

In the atmospheric test conditions represented by the fine PK HCT, the range of phosphorus concentrations was similar to that measured in the coarse PK HCT. However, phosphorus concentration trends from fine PK SCTs are considerably different than the coarse PK SCT. After Week 10 of the fine PK SCT, phosphorus concentrations in leachate collected from the bottom of the fine PK SCT began to increase to a maximum of 0.755 mg/L in Week 26 of the SCT (Figure 1). Recent phosphorous concentrations in water collected from the bottom of the fine PK SCT have decreased to a range from 0.3 to 0.228 mg/L (Weeks 35 to 46).

Figure 1 Results of Kinetic Testing of Fine Processed Kimberlite and Coarse Processed Kimberlite Composite Samples through Week 46 of Testing

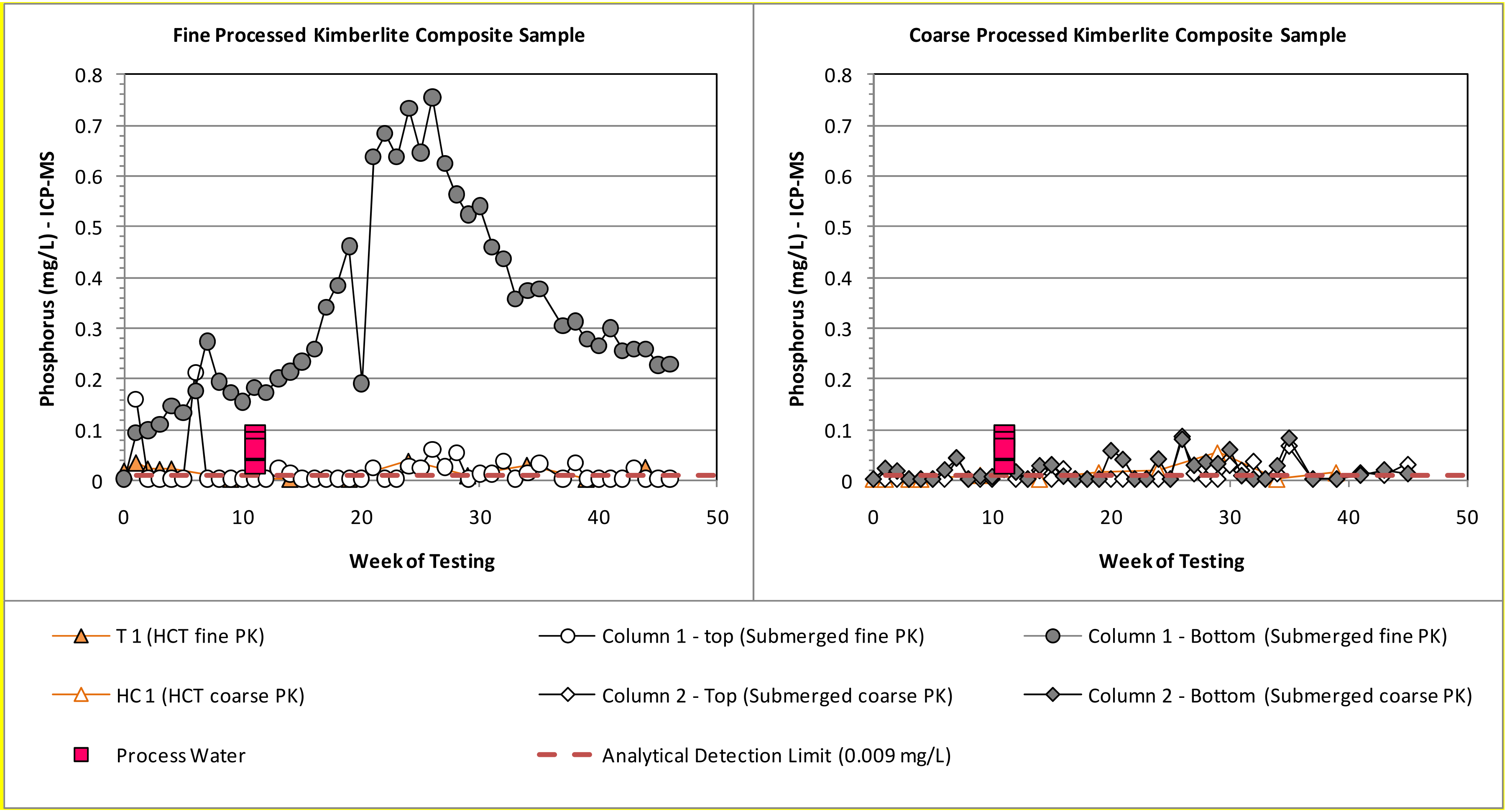

Figure 1 compares the phosphorus concentrations in the ongoing kinetic tests to the range of concentrations measured in recycled process water collected from the pilot plant. The results of process water analysis, as well the evaluation of the results of static testing discussed in Appendix 8.II of the EIS confirm that phosphorus is capable of mobilizing from PK. However, the results of the ongoing kinetic tests suggest that phosphorus concentrations may vary over time, and may be influenced by controls such as saturation and grain size. The evaluation of the ongoing results of kinetic testing formed the basis of updates to the water quality projections for the Project, as discussed in Section 4. Furthermore, the results of the on-going tests are in the process of being verified by supplemental geochemical testing, as discussed in Section 6.

4. APPLICATION OF RESULTS OF GEOCHEMICAL TESTING

The results of process water analysis, HCT, and SCT were used to define several source terms in the EIS water quality model. Unique assumptions were applied with respect to the derivation of phosphorus source terms for water that comes into contact with the various mine waste facilities. Table 2 provides a detailed overview of the results of geochemical testing that were used to define the source term inputs for the Fine PKC Facility, Coarse PK Pile, and mine rock pile.

The results of humidity cell testing have been applied to the water quality model for the Gahcho Kué Project as source term inputs for coarse grained mine waste materials (including coarse PK and mine rock) that are maintained in unsaturated conditions. The direct use of results of HCT as a source term input to water quality models is consistent with current industry practices and some regulatory guidance (e.g., Price 1997). The direct application of the results of HCT avoids the need for scaling of the kinetic test results to mine facilities (EPA 2003). Although the mine rock pile and coarse PK pile will contain a mixture of coarse grained material, the total surface area of the material in these facilities is dominated by their fines content, much as is the case in a humidity cell (Morin and Hutt 1997). Therefore, it is often reasonable and appropriate to use humidity cell leachate concentrations as a direct analogue for what could be expected in waters originating from certain mine facilities, such as mine rock dumps, despite their apparent differences in grain size (Morin and Hutt 1997).

The results of process water analysis are considered to be a direct analogue for the composition of water that will be discharged as a component of the fine PK slurry into the Fine PKC Facility because: the pilot plant was operated to be a smaller-scale representation of the process that will be used to extract diamonds during operations; and water was continually recycled through the pilot plant, as will be the case during operations.

Table 2 Summary of Geochemistry Source Term Inputs for Water Quality Modelling

Location	Input	Time	Flow	Condition	Phosphorus concentration (mg/L)	Description of data source
Fine PKC Facility	Fine PK	Operations / period of active discharge to the PKC (pre reclamation)	Process water in pond / infiltration from fine PK	Interflow - saturated conditions	0.089	Maximum concentration measured in process water analysis by ICP-MS (2010 specific data [see Appendix 8.II]).
		Reclamation / closure (post reclamation)	Infiltration through fine PK	Interflow - saturated conditions	0.290	Average concentrations of calculated measurements in "bottom" water collected from the Fine PK saturated column test during Weeks 37 to 42. Concentrations measured by ICP-MS (Supplemental testing data, 2011).
		Reclamation / closure (post reclamation)	Infiltration through fine PK	Interflow - Unsaturated flow	0.026	Concentration calculated based on measurements in "bottom" water collected from the Fine PK saturated column test. Concentrations measured by ICP-MS (Supplemental testing data, 2011).
	Coarse PK	Operations / reclamation / closure	Runoff from PKC - interflow through saturated coarse PK near Fine PK contact	Interflow - saturated flow	0.032	Concentration calculated based on measurements in "bottom" water collected from the coarse PK saturated column test. Concentrations measured by ICP-MS (Supplemental testing data, 2011).
		Operations / reclamation / closure	Runoff from PKC - flow through unsaturated coarse PK	Interflow - Unsaturated flow	0.017	Concentrations calculated using results of ICP-MS analysis of leachates in current humidity cell testing.
	Mine Rock	Operations / reclamation / closure	Runoff from mine rock in the PKC where water will not otherwise come into contact with PK	Unsaturated flow	0.01*	Concentrations calculated using the results of colorimetric analysis of HCT leachates collected between week 171 and 208 (2008 specific data [see Appendix 8.II]). Median concentrations based on entire colorimetric dataset for mine rock humidity cell tests (Wk 171 to Wk 208), assuming detection limit concentrations equal to 0.01 mg/L (one half the analytical detection limit). 95th percentile concentrations calculated with anomalous data points removed (Wk 179 HC9 (0.13 mg/L), Wk 179 HC 10 (0.73 mg/L), Wk 183 HC 12 (0.11 mg/L), Wk 175 HC 17 (0.2 mg/L)) due to single detect points for these cells over the 37 week program), and also assuming detection limit concentrations equal to 0.01 mg/L (i.e., one half the analytical detection limit).

Table 2 Summary of Geochemistry Source Term Inputs for Water Quality Modelling (continued)

Location	Input	Time	Flow	Condition	Phosphorus concentration (mg/L)	Description of data source
Coarse PK Pile	Coarse PK	Operations / reclamation / closure	Runoff / infiltration through the coarse PK pile	Unsaturated flow	0.015	Concentrations calculated using results of ICP-MS analysis of leachates in current humidity cell testing.
Mine Rock Piles	Mine Rock	Operations / reclamation / closure	Runoff / infiltration through the mine rock pile	Unsaturated flow	0.01	Concentrations calculated using the results of colorimetric analysis of HCT leachates collected between week 171 and 208 (2008 specific data [see Appendix 8.II]). Median concentrations based on entire colorimetric dataset for mine rock humidity cell tests (Wk 171 to Wk 208), assuming detection limit concentrations equal to 0.01 mg/L (one half the analytical detection limit). 95th percentile concentrations calculated with anomalous data points removed (Wk 179 HC9 (0.13 mg/L), Wk 179 HC 10 (0.73 mg/L), Wk 183 HC 12 (0.11 mg/L), Wk 175 HC 17 (0.2 mg/L)) due to single detect points for these cells over the 37 week program, and also assuming detection limit concentrations equal to 0.01 mg/L (one half the analytical detection limit).

Saturated column testing results were used to represent the composition of long-term infiltration from saturated PK in the Fine PKC Facility. The results of saturated column tests appear to be starting to move towards a steady-state composition with respect to phosphorus (Figure 1). Furthermore, the actual mechanisms of phosphorus leaching in saturated conditions must be considered in the context of the predicted flow paths from the Fine PKC Facility.

5. WATER QUALITY MODEL UPDATES

A water quality model was developed to simulate the expected conditions in Kennady Lake during the construction, operations, and closure phases as part of the 2010 EIS for the Gahcho Kué Project. Monthly water quality values were simulated deterministically using GoldSim version 9.6. GoldSim is a graphical, object-oriented mathematical model where all input parameters and functions are defined by the user and are built as individual objects or elements linked together by mathematical expressions. The object-based nature of the model is designed to facilitate understanding of the various factors, which control an engineered or natural system and predict the future performance of the system. In general, the Kennady Lake water quality model is a flow and mass-balance model that was set up to account for all inputs and processes described in Section 8.4.3 of the EIS. Details of the water quality model are provided in Appendix 8.I of the EIS.

Each flow contributing phosphorus to Kennady Lake, as detailed in the water management strategy, was assigned a source term for phosphorus based on existing and ongoing geochemical testwork as described in Section 4.. Input phosphorous source terms for each mine material are provided in Table 2.

For the updated water quality modelling, the following inputs were assigned to each material for the phosphorous water quality base case assessment:

Saturated Fine PK: Average concentrations of calculated measurements in "bottom" water collected from the Fine PK saturated column test during Weeks 37 to 42.

Unsaturated Coarse PK: 75th percentile concentration calculated based on ongoing humidity cell testing.

Saturated Coarse PK: 75th percentile concentrations calculated from observed values observed in SCT bottom water.

Mine Rock: 75th percentile concentration calculated from AMEC (2008) humidity cell testing.

In addition to the above source terms, the following key assumptions were also included in the base case water quality model as part of the total phosphorus water quality evaluation in Kennady Lake:

- maximum concentrations observed in process water quality samples were selected to represent the simulated water quality in the ponded area of the Fine PKC Facility during operations;
- all water in contact with coarse PK in the Fine PKC Facility was assigned a saturated source term for this material (Table 2); and
- the modelling assessment did not account for the development and persistence of permafrost conditions in operations and closure phases of the Project.

Trends in the phosphorus concentrations in leachates from the SCT resulted in a number of iterations to the water quality modelling due to variability with the source term used for saturated fine PK flows in the water quality modelling in 2011. For the EIS, data through to Week 10 were available, which did not include the sharp increase in mobilization of phosphorus through to a peak around Week 26. Following Week 26, phosphorus concentrations in leachates began to decrease (Figure 1) and have continued to decrease through to Week 46.

In addition to the on-going geochemistry testing, seepage analysis was also refined on an iterative basis in 2011. For the EIS, the total catchment runoff in Areas 1 and 2 (650,000 m^3/y) that infiltrated the ground surface in natural areas and the Fine PKC Facility were assumed to come into contact with fine PK. Current modeling indicates that the total runoff generated in Areas 1 and 2 will infiltrate into the following materials in the covered Fine PKC Facility during the closure/post-closure:

- Saturated fine PK (30% of the total runoff)
- Saturated coarse PK (56% of the total runoff)
- Mine Rock (14% of the total runoff)

Application of the above source term inputs and assumptions in the water quality model, including seepage flow proportioning, resulted in a simulated long-term steady state total phosphorus concentration of 0.030 mg/L in Kennady Lake. To evaluate the effects of reducing the volume of water in contact with fine PK on long-term Kennady Lake total phosphorus concentrations, additional sensitivity model runs were completed to test mitigation strategies of reducing infiltration into the Fine PKC Facility. If flow through fine PK is reduced to approximately 8.7% of the total annual flow from Areas 1 and 2, and all other inputs remain the same, model sensitivity analyses indicate that a long-term steady state total phosphorous concentration of 0.018 mg/L in Kennady Lake. De Beers is currently evaluating strategies to reduce seepage flow through saturated fine PK to mitigate expected long-term total phosphorus concentrations in Kennady Lake.

Three mitigation strategies are being considered for the Fine PKC Facility, since fine PK is the largest source of phosphorus to the lake. These strategies include:

- reducing the overall footprint area of fine PK in the facility;
- reducing the potential for overall infiltration of water into the facility; and
- reducing seepage contact with materials with the potential to release elevated concentrations of phosphorus.

6. ON-GOING WORK

Several scopes of work are on-going, which will support the continued phosphorus evaluation for the Project, long-term studies continuing through the mine life, and contribute to adaptive management plans (as appropriate):

- The long-term geochemical tests of composite samples of fine PK and coarse PK are being continued. The objective of these tests is to determine long-term trends in phosphorous mobilization.
- Additional geochemical characterization of PK has been initiated to confirm the trends observed in the supplemental kinetic tests. The ongoing work includes:
  - Kinetic testing of three samples of coarse PK and three samples of fine PK in saturated (SCT) and atmospheric (HCT) conditions. Samples were selected for testing based on solid phase phosphorous concentration and the kimberlite pipe which they originated from.
  - Samples of ground PK from Hearne and the East Lobe (Tuzo) have been submitted for kinetic testing. These samples have been crushed and ground, but were not run through the pilot plant. The results of testing of these samples will assist in determining whether leachate composition is affected by the processing of kimberlite.
  - Samples have been submitted for detailed mineralogical analysis to identify potential mineralogical hosts of phosphorous in fine PK and coarse PK, respectively. The mineralogical analysis will include an evaluation of whether phosphorous occurs in “liberated” mineral grains or “bound” mineral grains in coarse PK and fine PK, which will speak to the potential for phosphorous mobilization as a function of grain size.

7. REFERENCES

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