Gahcho Kué Project
Aquatics

December 1, 2011

EIS Sections Relevant to Aquatics

Section Number	Section Title
2	Project Alternatives
3	Project Description (Includes Appendix 3.II, Conceptual Compensation Plan)
8	**Key Line of Inquiry: Water Quality and Fish in Kennady Lake**
9	**Key Line of Inquiry: Downstream Water Effects**
10	**Key Line of Inquiry: Long-term Biophysical Effects, Closure, and Reclamation**
11.2	Subject of Note: Impacts on Great Slave Lake
11.6	Subject of Note: Permafrost, Groundwater, and Hydrogeology
13	Cumulative Effects Assessment
14	Summary and Conclusions
Annex G	Hydrogeology Baseline
Annex H / Addendum HH	Hydrology Baseline
Annex I / Addendum II	Water Quality Baseline
Annex J / Addendum JJ	Fisheries and Aquatic Resources Baseline

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KLOIs: Kennady Lake and Downstream Waters

- Terms of Reference:
  - the EIS must detail any effects on Kennady Lake and the downstream waters, as well as their significance and likelihood
    - "…detailed analysis of all impacts on fish abundance, health, and fitness for consumption including a comprehensive analysis of potential impacts on water quality…emphasis must be placed on the ability of the lake ecosystem, particularly fish and fish habitat, to recover …. "
    - "…where the analysis of 'water quality and fish in Kennady Lake' identifies potential impacts or where uncertainty exists, the EIS must provide an evaluation of the potential downstream effects and extent of impact…"

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Environmental Impact Statement

- Impacts from the Project will not have a significant negative influence on:
  - Suitability of water quality to support a viable aquatic ecosystem, and key fish species
  - Abundance and persistence of desired populations of key fish species
- Based on weight of evidence from analysis of primary pathways to effects on VCs
- The EIS was based on multiple assessment approaches and endpoints for key aquatics components
  - To meet Terms of Reference
  - Critical in reducing uncertainty in projections
- The EIS considered a suite of conservatisms throughout the assessment
  - Impacts should not be worse than predicted

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Aquatics Presentation Outline

- Introduction
  - Aquatics Team
  - Overview of Assessment
- KLOI: Water Quality and Fish in Kennady
- KLOI: Downstream Effects
  - Hydrogeology
  - Hydrology
  - Geochemistry
  - Water Quality
  - Fish and Fish Habitat
  - Kennady Lake Recovery
  - Assessment Conclusions
- SON: Great Slave Lake

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General Setting

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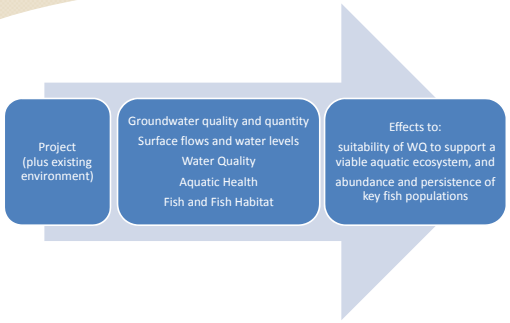
Conceptual Approach to Aquatics Effects Analysis



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Valued Components

- Consistent aquatic valued components used in each of the aquatic KLOIs and SON
  - Permafrost
  - Groundwater chemistry and quantity
  - Water flows and water levels
  - Water chemistry
  - Sediment chemistry
  - Fish habitat
  - Lower trophic organisms
  - Forage and large-bodied fish
- Water Quality and Fish in Kennady Lake (Section 8)
- Downstream Water Effects (Section 9)
- Long-term Biophysical Effects, Closure and Reclamation (Section 10)
- Impacts to Great Slave Lake (Section 11.2)

8

Suitability of Water Quality

- Water quality has both important ecological and a human health value
  - Changes to water quality may ultimately affect fish, wildlife, and human health
- Examples of key aquatic biophysical components within Project area that influence the suitability of water quality to support a viable aquatic ecosystem include:
  - Permafrost
  - Groundwater quality and quantity
  - Water levels and flows
  - Water chemistry
  - Sediment chemistry

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Abundance and Persistence of Fish Populations

- Fish are important to traditional and non-traditional land users, and also provide a direct link between potential effects to water quality and human health
- Examples of key aquatic biophysical components within Project area that influence the abundance and persistence of desired populations of key fish species include:
  - Water levels and flows
  - Water chemistry
  - Sediment chemistry
  - Lower trophic organisms
  - Fish habitat

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Highly Valued Fish Species

- Lake trout, Arctic grayling, and northern pike were selected as highly valued fish species for assessment endpoints for both KLOIs

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Pathways Analysis

Project activity → change to environment → effect on VC

- No detectable change and no residual effects to a VC
  - No Linkage Pathway
- A minor change, and negligible residual effect on a VC
  - Secondary Pathway
- A measurable change that could contribute to residual effects on a VC
  - Primary Pathway

No Linkage and Secondary pathways are described in Sections 8.6 and 9.6

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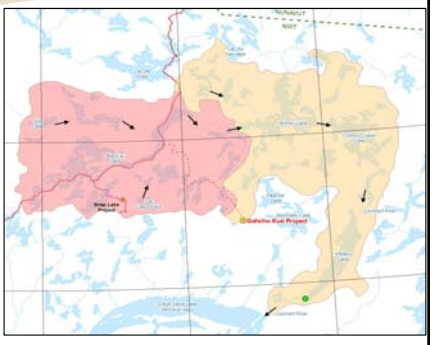
Aquatics Regional Study Area

- Project located in watershed of Kennady Lake, a small headwater lake within Lockhart River system
- Lockhart River drains into the east arm of Great Slave Lake



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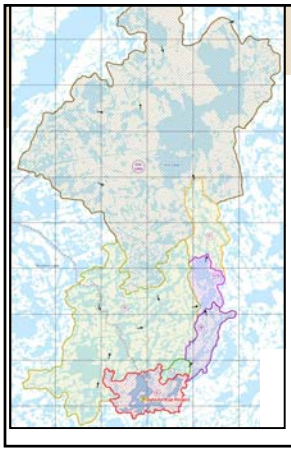

Local Study Area

- Drainage direction from Kennady Lake is northward, passing through number of small watersheds before entering Aylmer Lake
- LSA for Kennady Lake and its Watershed (Section 8) is drainage area to outlet of Kirk Lake
- LSA for Downstream Watershed (Section 9) is from outlet of Kennady Lake to outlet of Kirk Lake

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Aquatics Assessment Discipline Presentations

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Discipline Presentations

- Permafrost, Hydrogeology and Groundwater
- Hydrology
- Geochemistry
- Water Quality
- Aquatic Health
- Fish and Fish Habitat – Recovery of Kennady Lake

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Gahcho Kué Project

Permafrost, Hydrogeology and Groundwater

December 1, 2011

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Hydrogeology - Introduction

- The Project will result in temporary changes to the local groundwater regime. An understanding of these changes and the quality and quantity of groundwater inflow into the mine is required so that the Project can be developed to be protective of the environment
- The projections of groundwater inflow quality and quality are inputs, in addition to precipitation and surface water flow, into the development of the water management plan for the Project
- The purpose of the hydrogeological investigations and analyses, is to assess these changes and groundwater inflows

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Hydrogeology – Assessment Summary

- Conservative assumptions were built into our assessment to provide a high degree of confidence that effects on groundwater (quantity and quality), and surface water quality as a result of changes to the groundwater, have not been underestimated
- Mining will result in temporary changes to the local groundwater regime; however, no measurable differences in lake volumes outside of the immediate Kennady Lake area (controlled area) are projected to occur due to groundwater flow to the mines
- Following mining, groundwater levels and quality will return to conditions similar to those of the current /baseline

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Hydrogeology - Environmental Setting

Hydrogeology – Local Study Area

- The local study for groundwater is different than that for the surface water as it does not correspond to the surface water catchment area
- Includes sufficient number of large lakes to assess regional flow directions.

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Hydrogeology – Environment Setting

- The environmental setting is defined from available published work and various surveys and investigations
- Baseline studies in the Kennady Lake area:
  - Packer testing studies – 1996, 2004, 2005
  - Pressure profiling study – 2005
  - Geotechnical studies – 2004, 2005
  - Geothermal/permafrost study – 2004
  - Groundwater chemistry studies – 2004, and 2005

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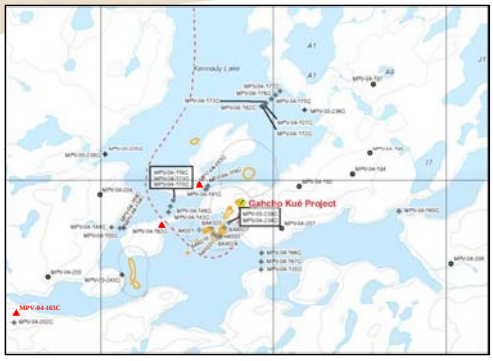
Hydrogeology – Testing and Monitoring Locations



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Hydrogeology – Groundwater Flow Regimes

- Hydrogeology controlled by permafrost characteristics, distribution, and spatial and temporal dynamics
- Two primary flow regimes
  - Shallow groundwater regime
    - "active layer" above the permanent permafrost up to 4 m thick
    - ephemeral system that is only unfrozen during summer
  - Deep Groundwater regime
    - Laterally continuous below the permafrost at ~300 m depth
    - Little hydraulic connection between the two regimes due to very low hydraulic conductivity of the permafrost
- Taliks
  - Unfrozen ground beneath lakes
  - Taliks beneath large and deep lakes extend through to the deep groundwater regime

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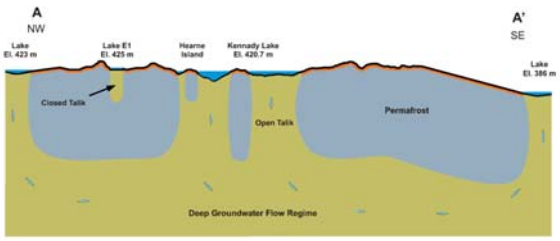
Hydrogeology - Shallow and Deep Groundwater Flow Regimes



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Hydrogeology - Groundwater Flow

- Shallow Groundwater
  - Seasonal flow generally parallels the topography within the ~ 4 m thick active layer above the permafrost
  - Shallow groundwater flows towards the nearest lakes, at rate generally in the order of a few cm/day
  - Shallow groundwater has low salinity
- Deep Groundwater
  - Located in bedrock below the permafrost (>300 mbgl)
  - Predominantly controlled by water levels in lakes with through taliks
  - Laterally continuous
  - Flow from high elevation to lower elevation lakes in an east to southeast direction, at a rate of generally less than 0.5 m per year

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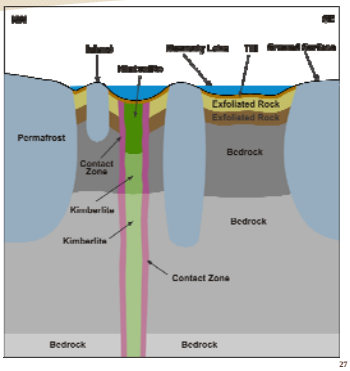
Hydrogeology - Hydrostratigraphy

- Comprises six hydrostratigraphic units:
  - Till
  - Shallow exfoliated rock
  - Deep competent rock
  - Kimberlite
  - Kimberlite contact zone
  - Structures



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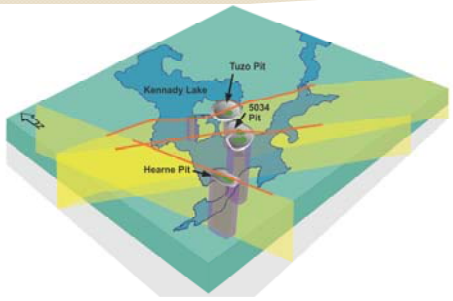
Hydrogeology – Structure (Faults)



- Primary and secondary structures identified by geophysics. Primary structures are interpreted to have continuous strike extensions greater than 10s of kms whereas secondary structures are developed locally

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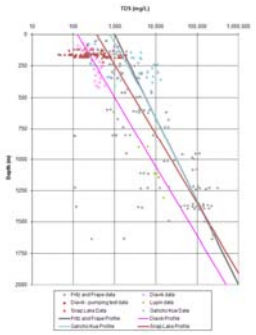
Groundwater Quality

- Shallow Groundwater Quality
  - Groundwater samples collected from monitoring wells in active layer were used to characterize chemistry of shallow groundwater; expected to be similar over most of LSA
- Deep Groundwater Quality
  - Quality of deeper groundwater determined using Project TDS profile established based on a best fit down to the maximum depth of site-specific data, then Fritz and Frappe Profile (most conservative) at greater depth
  - Relationships of other water quality constituents that change with depth were correlated to TDS



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Hydrogeology – Assessment Methods and Findings

Hydrogeology - Assessment Methods

- A groundwater quantity and quality model was developed using MODFLOW and MT3D to evaluate:
  - Effects to surrounding lake levels
  - Effects to surface water quality
- The groundwater model was designed to project the following:
  - Quantity of groundwater reporting to the pits during operations and - closure
  - Projected concentrations of TDS in the groundwater inflow
  - Projected contribution from lake water

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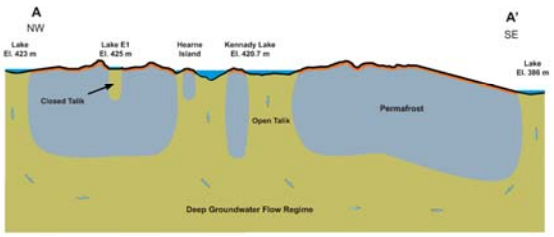
Hydrogeology - Assessment Methods

Groundwater Flow Prior to Mining



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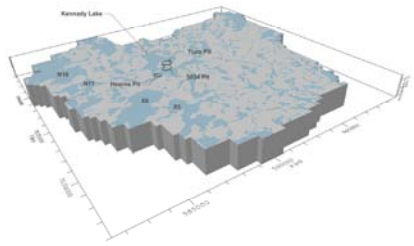
Hydrogeology - Assessment Methods



Elevations of lakes with through taliks, extent of permafrost, mine plan and hydrogeologic parameters assigned in the model

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Hydrogeology – Assessment Methods

- In assigning hydraulic conductivity (K) values, a conservative approach was undertaken with K values increased or selected at the high end of the range of test results. This included:
  - Increasing the geometric average of the hydraulic conductivity (K) of all units (except the potential permeability zones and exfoliated rock where the increase is greater) by a factor of three
  - Assume that bedrock structures identified in geophysics represent enhanced permeability zones that are hydraulically continuous over large areas and 30 m wide
  - Assign arithmetic average of K tests conducted in potential permeability zones and exfoliated rock (results in K at high end of range)
  - Assume K at depths below 500 m is the same down to bottom of model at 1500 m. Expect K to reduce with depth

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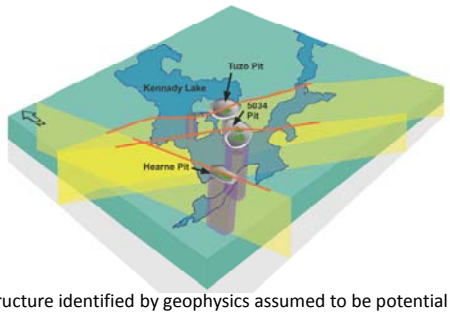
Hydrogeology – Potential Enhanced Permeability Zones



Structure identified by geophysics assumed to be potential enhanced permeability zone and 30 m wide

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Hydrogeology – Assessment Findings (Operations)

Mine Year	Inflow (m^3/d)			TDS (mg/L)			Lakewater Contribution (%)			Pit Elevation (masl)		
	5034	Hearne	Tuzo	5034	Hearne	Tuzo	5034	Hearne	Tuzo	5034	Hearne	Tuzo
-2	-	-	-	-	-	-	-	-	-	421	-	-
-1	2100	-	-	300	-	-	67	-	-	373	-	-
1	2300	-	-	1100	-	-	29	-	-	349	-	-
2	2100	-	-	2000	-	-	24	-	-	301	-	-
3	2400	-	-	2500	-	-	32	-	-	253	-	-
4	2600	400	-	3300	100	-	39	83	-	181	409	-
5	2500	800	600	4000	600	200	46	44	74	121	361	397
6	2200	1200	800	4000	1400	700	53	34	38	205[a]	301	361
7	1200	1400	1100	2500	1800	1100	71	42	32	300[a]	217	325
8	1400	700	1800	2600	1100	2000	70	70	29	300[a]	337[a]	253
9	1400	300	2100	2600	400	3100	72	89	35	300[a]	376[a]	193
10	1400	100	2200	2500	50	4000	74	90	40	300[a]	410[a]	157
11	1400	50	2400	2400	50	5200	75	90	43	300[a]	421[a]	121

Numerical Hydrogeological Model Predictions

Note: Predictions of groundwater inflows, TDS concentrations and percent lake water are used as input to overall water quality model (GoldSim Model)

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Hydrogeology – Assessment Findings
(Sensitivity)

- Undertook two sensitivities to assess further:
  - Sensitivity #1 – potential enhanced permeability zones that are assumed associated with Faults removed from model, but all other parameters (including TDS depth profile) remain the same as Base Case. This is considered a lower bound estimate of inflow and effects
  - Sensitivity #2 – the potential enhanced permeability zones were removed but the TDS profile was increased to twice that of the Base Case

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Hydrogeology – Assessment Findings
(Sensitivity)

- Model Sensitivity #1 – Predicts that the inflow are generally 40% less than the inflows predicted for the base case. Predicted groundwater quality is somewhat better (lower concentrations) than the base case
- Model Sensitivity #2 – Predicts TDS concentrations, on average, about 1.5 to 2 times greater than base case, but the inflows are lower. Therefore, the predicted overall TDS mass loadings to the pits are similar to the base case

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Hydrogeology – Assessment Findings
(Closure and Post-Closure)

- During mining, deep-seated higher TDS water will be induced to flow up into the Tuzo Pit
- At closure, the Tuzo Pit will gradually flood over a period of eight to nine years and hydraulic pressures will return to conditions that characterise the pre-mining groundwater regime
- These conditions will permit the development of density-driven flow system
- Intent of modelling study is to examine closure and post-closure effects of density-driven flow on the water quality of surface water
- Density-dependent model FEFLOW was used to simulate closure and post-closure effects.

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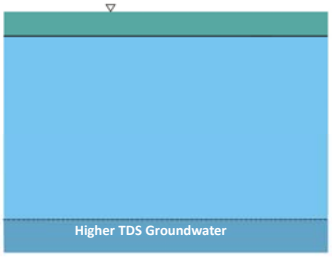
Conceptual Model – Tuzo Pit



Current Conditions

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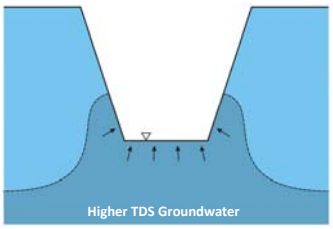
Conceptual Model – Tuzo Pit



During Mining

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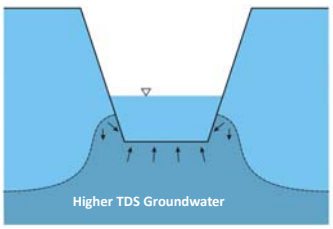
Conceptual Model – Tuzo Pit



During Closure

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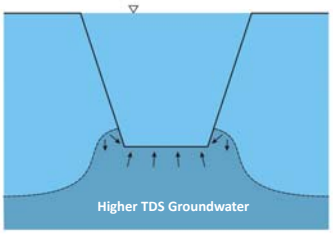
Conceptual Model – Tuzo Pit



Near end of Closure

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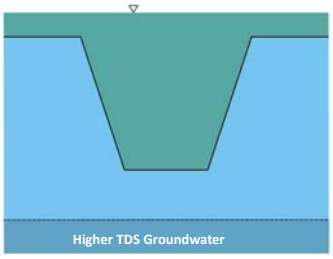
Conceptual Model – Tuzo Pit



Post- Closure

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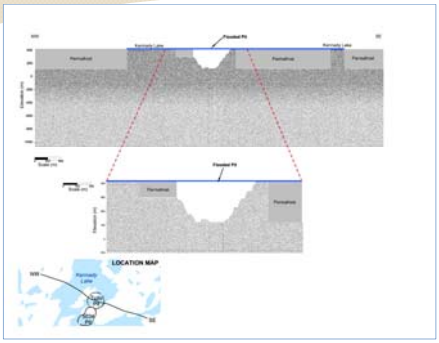
Hydrogeology – Assessment Findings



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Hydrogeology – Assessment Findings (Closure and Post Closure)

- During the first 100 years after Tuzo Pit is flooded:
  - Groundwater inflow rates to the flooded pit are predicted to range from 0.5 m^3/d to 3 m^3/d
  - Corresponding TDS flux into the flooded pit range from approximately 300 g/d to 4,500 g/d
  - Provides input to pit lake hydrodynamic model

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Hydrogeology – Summary

Hydrogeology – Assessment Summary

- The Project will have negligible effects on groundwater quantity
  - No measureable differences in lake water volumes outside of controlled area are projected
- Conservative assumptions were built into the model to provide high degree of confidence that effects on groundwater (quantity and quality), and surface water quality as a result of changes to the groundwater, have not been underestimated
  - i.e., upper bound values were selected for hydraulic conductivities
- Simulated groundwater inflow results and concentrations will be validated during operational monitoring

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Gahcho Kué Project
Hydrology

December 1, 2011

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Outline of Presentation

- Introduction
  - Terms of Reference, EIS Sections, Assessment Overview
- Environmental Setting
  - Study areas, baseline data collection, ongoing and future work
- Assessment Approach and Results (Kennady Lake & Downstream)
  - Approach
  - Activities
  - Effects on Water Level & Flow
  - Effects on Channel & Bank Stability

} Presented by Project Phase

- Summary of Results

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EIS Sections Relevant to Hydrology

- Based on the TOR, effects on hydrology were captured primarily in two Key Lines of Inquiry:
  - Water quality and fish in Kennady Lake (Section 8)
  - Downstream water effects (Section 9)
- Some TOR excerpts that guided the assessment included:
  - "Describe the … water balance for Kennady Lake…"
  - "Water balance calculations during present conditions and over time as the project proceeds is required to compare baseline conditions with future downstream effects"
  - "Include a detailed assessment of impacts on aquatic life that considers timing and levels of increased flows…"
- The hydrology assessment also serves as an input to Fish and Water Quality assessment

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EIS Summary

- The EIS identified residual effects to flows, water levels and channel and bank stability for waterbodies in the Kennady Lake and downstream watersheds
- These effects were used as inputs to the assessment of impacts on water quality and fish in Kennady Lake and downstream watersheds
- No significant adverse effects are anticipated, due to mitigation measures applied as part of the project

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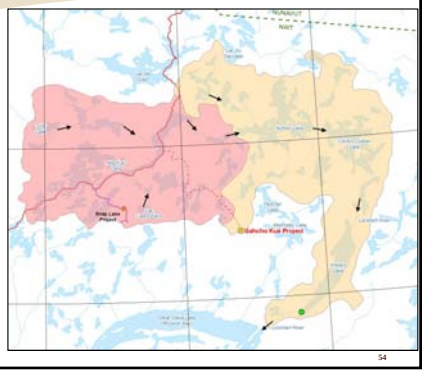
Hydrology – Environmental Setting

Aquatics Regional Study Area

- Project located in watershed of Kennady Lake, a small headwater lake within Lockhart River system
- Lockhart River drains into the east arm of Great Slave Lake



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Hydrology – Environmental Setting

- Hydrology baseline studies conducted in Kennady Lake area from 1996 to 2011
  - Climate data
  - Hydrometric data collection
  - Water level and discharge
  - Lake bathymetry
  - Stream and lake shoreline geomorphology data
  - Ice and winter flow information
- Additional regional data
  - Environment Canada
  - Water Survey of Canada

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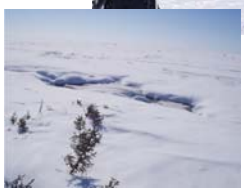
Hydrology – Environmental Setting

- During winter, when lakes are not frozen to bottom, ice thickness typically grows to about 1.8 m
- Small lake outlets are generally frozen to the bottom, though ice-covered flow has been observed at larger ones like Lake N1, N11 and Kirk Lake in early spring



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Hydrology – Environmental Setting

- Many lake shorelines in the study area are comprised of boulders and exposed bedrock

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Hydrology – Environmental Setting

- Outlet channels beds are typically armoured with an inerodible bedrock or boulder layer
- Channels at outlets of smaller, headwater lakes may be poorly defined and flow through organic substrates
- Channel banks often consist of vegetated mats of organic material

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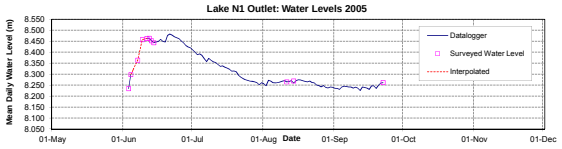
Hydrology – Environmental Setting

- Lake levels follow a predictable seasonal cycle:
  - Rapid spring rise occurs before loss of ice cover and before onset of discharge at lake outlet
  - Subsequent decline to lowest water levels typically in late August
  - Small increase in water levels from late August into September, due to an increase in rainfall during late summer and early fall



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Hydrology - Environmental Setting

- Current, Ongoing and Future Work
  - Bank and lakeshore surveys initiated in 2010 were continued in 2011 to augment the qualitative assessment presented in 2010 EIS
  - No additional major hydrometric or bank and lakeshore survey programs are anticipated
  - An operational monitoring program would also be required if the project proceeds

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Hydrology – Assessment Methods and Findings

Hydrology – Assessment Approach

- Water Balance Model
  - Model developed using GoldSim™ software
    - Calibrated and validated using flow and climate data from 2004, 2005 and 2007
    - Flows simulated on a daily time step, and based on long-term climate data from 1959 to 2005
  - Kennady Lake watershed, downstream, and adjacent watersheds divided into sub-watersheds
  - Water balance for each watershed considered the following:
    - Rainfall and snowmelt runoff
    - Inflow from upstream watersheds
    - Changes in lake storage
    - Lake evaporation
    - Outflow to downstream watersheds

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Hydrology – Assessment Approach

- Water Balance Model
  - The water balance model was used to model the effects of the Project during the following project phases:
    - Construction, operations, closure (refilling), and post-closure
  - Project activities (diversions, landscape modifications, consumptive water use) were incorporated into the model
  - The assessment focused on effects to the following key hydrological parameters:
    - Flows and water levels
    - Channel and bank stability

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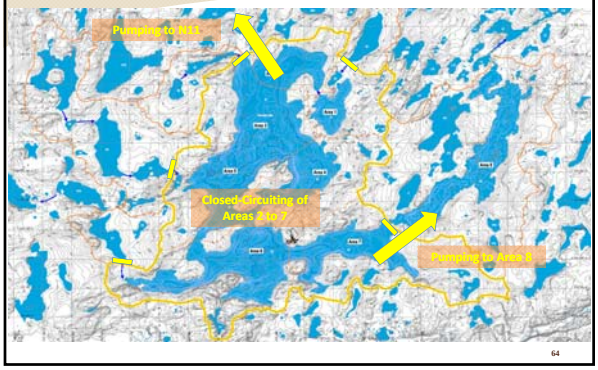
Hydrology – Assessment
(Construction Phase)



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Hydrology – Assessment
(Construction Phase)

- Water Level and Flow Assessment
  - Closed-Circuiting
    - A reduction in drainage area was applied in the model at Area 8
  - Dewatering
    - Pumping schedule was applied in the model at Area 8 and at N11
- Resulting water levels and flows at all modeled lakes in the Kennady Lake watershed and downstream watersheds were compared to baseline conditions

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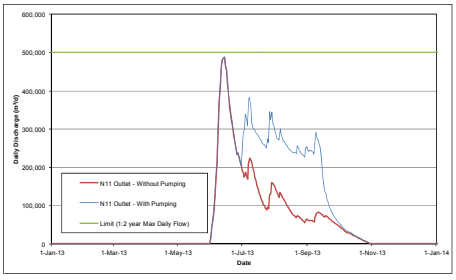
Hydrology – Assessment
(Construction Phase)

- Water Level and Flow Assessment
  - Dewatering



66

Hydrology – Assessment
(Construction Phase)

- Water Level and Flow Findings

Kennady Lake Watershed (Section 8)	Downstream Watershed (Section 9)
Mean monthly flows, low flows, are expected to increase in Area 8 and downstream watersheds. 2-year flood discharge, 100-year flood discharge are expected to decrease for these watersheds.	Mean monthly flows, 2-year flood discharge, 100-year flood discharge , low flows, are expected to increase from Lake N11 to Lake N1. These are also expected to increase from Lake 410 and downstream.
	In lakes located between Area 8 and 410, effects are expected to be similar to those at Area 8.

67

Hydrology – Assessment
(Construction Phase)

- Channel and Bank Stability Assessment
  - Because the resulting water levels and flows at all modeled lakes in the Kennady Lake watershed and downstream watersheds are comparable to the baseline conditions no effects are anticipated on the outlet channels
  - Sediment resuspension along the exposed shoreline may occur from lowering the water level

68

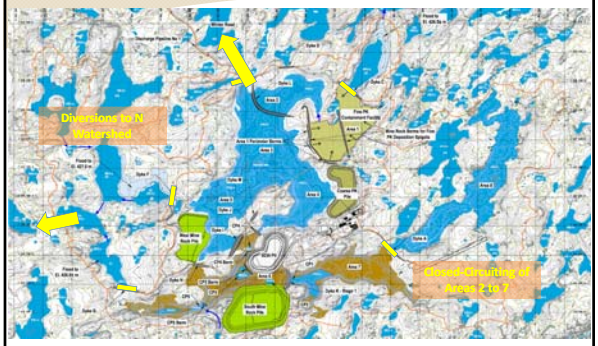
Hydrology – Assessment
(Construction Phase)

- Construction Phase – Channel and Bank Stability Findings

Kennady Lake Watershed (Section 8)	Downstream Watershed (Section 9)
Exposed lake-bed areas may be subject to sediment resuspension by runoff and wave action, depending on the type of substrate present.	No effects on channel or bank stability are anticipated because increase in flood magnitude in the N Watershed and downstream watersheds are small relative to the existing flood regime. Flood magnitudes from Area 8 to Lake 410 will not exceed baseline values.

69

Hydrology – Assessment
(Operations Phase)



Note: Footprint of Fine PKC Facility to be updated

70

Hydrology – Assessment
(Operations Phase)

- Water Level and Flow Assessment
  - Closed-Circuiting
    - A reduction in drainage area was applied in the model at Area 8
  - Diversions
    - Flows from A3 were treated as an input to N9
    - Flows from B1 were treated as an input to N8
    - Flows from D2 and E1 were treated as an input to N14

71

Hydrology – Assessment
(Operations Phase)

- Water Level and Flow Assessment
  - Water Level Augmentation
    - Changes in proportions of Lake to Land areas were reflected in the model
  - Pumping to Lake N11
    - Pumping schedule was applied in the model at Lake N11
- Resulting water levels and flows at all modeled lakes in the Kennady Lake watershed and downstream watersheds were compared to baseline conditions

72

Hydrology – Assessment
(Operations Phase)

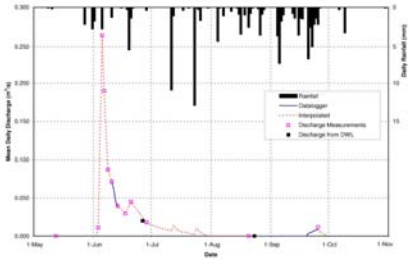
- Water Level and Flow Findings

Kennady Lake Watershed (Section 8)	Downstream Watershed (Section 9)
Annual outflows from raised lakes will be reduced somewhat from baseline due to increased evaporation from the lake water surfaces. The annual outflow from Lake D1 will be greatly reduced because of the upstream diversion.	Mean monthly flows, 2-year flood discharge, 100-year flood discharge , low flows, are expected to increase in the N Watershed and downstream watersheds. Effects diminish downstream of the N Watershed.
Annual variation in water levels in the raised lakes will be similar to pre-diversion values.	In lakes located between Area 8 and 410, effects are expected to be similar to those at Area 8.
Annual outflows from Area 8 will be reduced due to a decrease in drainage area.	

73

Hydrology – Assessment
(Operations Phase)

- Channel and Bank Stability
  - All channel diversions, with the exception of the Watershed D to N14 channel, are expected to be ephemeral, with flows mostly during the spring freshet.



74

Hydrology – Assessment
(Operations Phase)

•Operations Phase – Channel and Bank Stability

E1 outlet channel view downstream

- Kennady Lake tributary lakes that are going to be affected have small outlet channels with low flow velocities that flow through existing vegetation.
- Because of low flows most of the open water season erosion potential is expected to be minor.

E1 outlet channel survey

75

Hydrology – Assessment (Operations Phase)

- Channel and Bank Stability

– Outlet channels were surveyed during the 2011 baseline program to support a quantitative analysis

– Data collected included water level profiles, channel cross-sections, channel bed and bank material

B1 Lake Outlet Channel view downstream

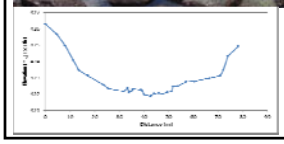
76

Hydrology – Assessment (Operations Phase)

- Channel and Bank Stability

N9 outlet channel view downstream

– Typical outlet channel in the study area



N9 outlet channel survey, view upstream

77

Hydrology – Assessment (Operations Phase)

- Channel and Bank Stability
  - In 2010 and 2011 existing and predicted shoreline elevations were surveyed and field data were collected including slope gradient, sediment types, wave exposure, aspect
    - Typical shoreline in the study area (Lake E1)

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Hydrology – Assessment
(Operations Phase)

- Channel and Bank Stability
  - Typical shoreline in the study area (Lake N9)

79

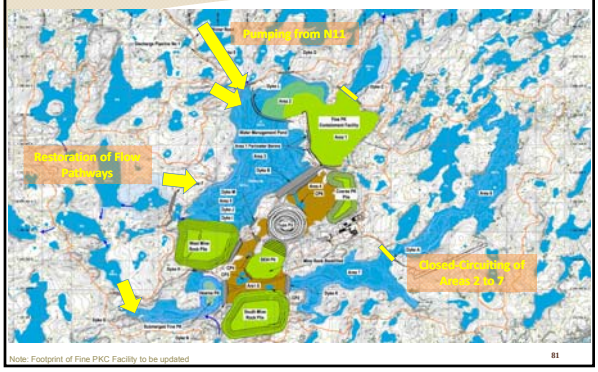
Hydrology – Assessment
(Operations Phase)

- Channel and Bank Stability Findings

Kennady Lake Watershed (Section 8)	Downstream Watershed (Section 9)
Raised lakes will be subject to erosion as new shorelines are established.	No effects on channel or bank stability are anticipated because increase in flood magnitude in the N Watershed and downstream watersheds are small relative to the existing flood regime.
	No effects on channel or bank stability are anticipated upstream of Lake 410 because flows and water levels decrease, and downstream of Lake 410 because flows and water level increases will be small.

80

Hydrology – Assessment
(Closure Phase)



Note: Footprint of Fine PKC Facility to be updated

81

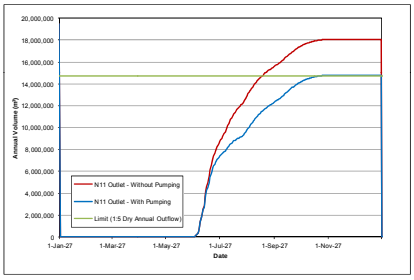
Hydrology – Assessment
(Closure Phase)

- Water Level and Flow Assessment
  - Closed-Circuiting
    - A reduction in drainage area at Area 8 was modeled
  - Refilling of Kennady Lake
    - Pumping schedule was applied in the model at Lake N11
    - Changes in proportions of Lake to Land areas were reflected in the model for lakes with restored flow pathway
  - Diversion
    - Flows from Lake A3 were treated as an input to Lake N9
- Changes in proportions of Lake to Land areas were also reflected in the model. Water levels and flows at all modeled lakes in the Kennady Lake and downstream watersheds were compared to baseline conditions.

82

Hydrology – Assessment
(Closure Phase)

- Water Level and Flow Assessment
  - Refilling of Kennady Lake



83

Hydrology – Assessment
(Closure Phase)

- Water Level and Flow Findings

Kennady Lake Watershed (Section 8)	Downstream Watershed (Section 9)
During Closure, all flow from Kennady Lake Area 3, 4, 5, 6 and 7 tributary watersheds will contribute to lake refilling. Diversion of water from Lake N11 during refilling will reduce the median refilling time from 17 years to approximately 8 or 9 years.	Mean monthly flows, 2-year flood discharge, 100-year flood discharge, low flows, are expected to decrease at Lake N11 and downstream, and increase slightly for lakes N9 to N2 from the diversion of Lake A3.
Annual outflows in watersheds B, D and E will be restored to baseline conditions	In lakes located between Area 8 and 410, effects are expected to be similar to those at Area 8.
Annual outflows from Area 8 will be reduced due to a decrease in drainage area.	

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Hydrology – Assessment
(Closure Phase)

- Channel and Bank Stability

- Outlet channels will return to the baseline conditions
- Lakes in D and E watersheds are going to return to their initial elevation
- Lake A3 is going to remain permanently diverted through N9

85

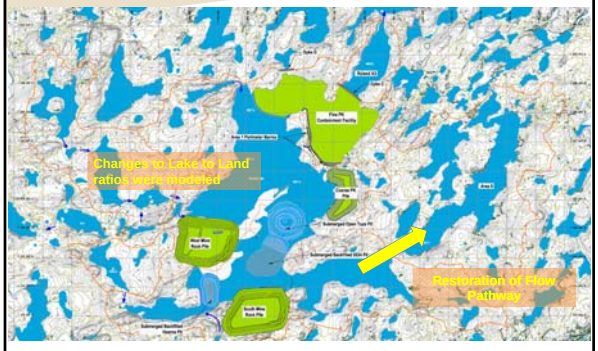
Hydrology – Assessment
(Closure Phase)

- Channel and Bank Stability Findings

Kennady Lake Watershed (Section 8)	Downstream Watershed (Section 9)
Water levels in the upstream Areas will not exceed the naturally armoured shoreline elevation. Therefore, no effects on channel or bank stability are anticipated.	For lakes where flows and water levels are expected to increase, no effects on channel or bank stability are anticipated because increase in flows and water levels are small relative to the existing flood regime.
	For lakes where flows and water levels are expected to decrease, no effects on channel or bank stability are anticipated because flows and water levels are expected to decrease.

86

Hydrology – Assessment
(Post-Closure Phase)



Note: Footprint of Fine PKC Facility to be updated

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Hydrology – Assessment
(Post-Closure Phase)

- Water Level and Flow Assessment
  - Diversion
    - Flows from A3 were treated as an input to N9, and changes in proportions of Lake to Land areas were reflected in the model
  - Infrastructure
    - Changes in proportions of Lake to Land areas were reflected in the model
- Resulting water levels and flows at all modeled lakes in the Kennady Lake watershed and downstream watersheds were compared to baseline conditions

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Hydrology – Assessment
(Post-Closure Phase)

- Water Level, Flow and Channel and Bank Stability Findings

Kennady Lake Watershed (Section 8)	Downstream Watershed (Section 9)
Permanent diversion, changes in land to lake ratio and changes to Kennady Lake surface area will result in an 8.9% increase in Kennady Lake mean annual water yield and 6.1% increase in mean annual discharge.	Because changes in hydrological regime of the Kennady Lake watershed are small, effects to downstream watersheds will be proportionately small and will diminish with distance downstream.
A net decrease in the water surface area of Kennady Lake. This will slightly reduce flood flow attenuation.	
Modest permanent changes to flow regime at Kennady Lake outlet, diminishing downstream, are not expected to affect channel and bank stability in any waterbodies.	

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Hydrology - Summary

Hydrology – Assessment Findings

- Short Term Effects (Construction, Operations and Closure):
  - Water management activities are intended to allow mine development while protecting the environment
  - Dewatering and refilling will affect magnitude and seasonal variability of flows and water levels
  - Diversions will reduce peak and annual flows and water levels on diverted waterbodies, and increase peak and annual flows on receiving environment
  - Water level augmentations will expose new shoreline soils to wave erosion
  - Shoreline erosion is expected to be limited by natural armouring
  - Mitigation measures will limit erosion during dyke removal
  - All effects diminish downstream of Kennady Lake

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Hydrology – Assessment Findings

- Long Term Effects (Post-Closure):
  - Long term effects are expected to be smaller in general than short term effects
  - 8.9% increase in mean annual water yield (mm) at Kennady Lake outlet
  - 6.1% increase in mean annual discharge (m^3/s) at Kennady Lake outlet
  - All effects diminishing downstream, with no effects in Watershed N
  - Slight increase in flood peak discharges and water levels
  - All effects diminish proportionally downstream of Kennady Lake, with no effects in Watershed N

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Gahcho Kué Project
Geochemistry

December 1, 2011

De Beers Canada

Outline – Geochemistry

- Objectives
- Test Program
  - Methods
  - Overall program at the location of the Gahcho Kué Project (# of samples for each main test type)
- Results
  - Majority (.98%) of Mine Rock is considered non-acid generating
  - Processed Kimberlite is non-acid generating with excess neutralization capacity
  - Leach test results carried forward to water quality assessment
- Supplemental Evaluation
  - Phosphorus

EIS Section: Appendix 8.II of the EIS

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Geochemistry – Objectives

- Objectives of geochemical testing and analysis
  - Provide understanding of influencing factors which control water quality
    - Rock/water interactions
    - Atmospheric interactions
    - Chemical reactions, migration and movement
  - Inform decisions related to design and mitigation measures for mine rock and processed kimberlite (PK) that will help protect the environment
    - Input to water quality estimates
    - Mitigation option determination
    - Release rates and implications for various options

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Geochemistry – Assessment Methods

- Geochemistry related guidance documents:
  - Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia (Price 1997)
  - Guidelines for Acid Rock Drainage Prediction in the North (Department of Indian and Northern Development - DIAND 1992)
  - Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. (Mine Environment Neutral Drainage - MEND Report 1.20.1 (MEND 2009)
  - Global Acid Rock Drainage Guide (GARD Guide).internet site http://www.gardguide.com/ (INAP 2009)

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Geochemistry – Testing Program Outline

- Sample Selection Considerations
  - Geological distribution / Cross Sections
  - Mine Plan / Tonnage / Rocktypes
  - Processing
- Static Testing
  - Solids - ABA; Bulk Chemical (Elemental) Analyses; Mineralogy
  - Short term leach testing (various types)
- Kinetic Testing
  - Humidity cells, Columns, Submerged columns
- Staged approach (supplemental evaluation for key parameters)
  - Phosphorus – more detailed mineralogy plus additional testing

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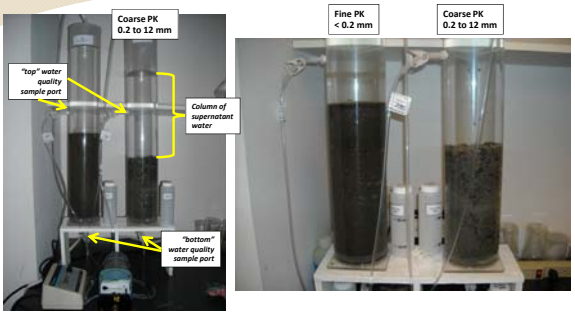
Geochemistry – Humidity Cell

98

Geochemistry – Saturated Columns



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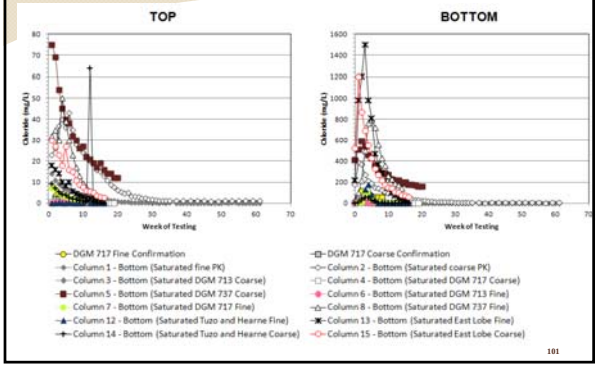
Geochemistry – Available Data - Kinetic Testing

Material Type	Static test (Solids)	Static tests (Short Term Leach)	Kinetic Tests (Humidity Cells and Subaqueous Columns)
Kimberlite			
Kimberlite	528	27	12
Total Kimberlite	**528**	**27**	**12**
Processed Kimberlite			
Fine Processed Kimberlite	47	35	20
Coarse Processed Kimberlite	59	31	14
Total Processed Kimberlite	**126**	**66**	**34**
Mine Rock			
Granodiorite	14	0	1
Altered Granodiorite	21	0	0
Granite	1188	40	22
Altered Granite	10	0	0
Gneissic Granite	9	0	0
Pre-leached Granite	4	0	4
Diabase	7	0	1
Diorite	1	0	1
Total Mine Rock	**1254**	**40**	**24**
TOTAL SAMPLES ANALYZED	**1908**	**133**	**75**

100

Geochemistry – Submerged Column Data - Chloride



101

Geochemistry – Assessment Findings

- Mine Rock (primarily granite)
  - Acid Base Accounting (ABA)
    - very little sulphide mineralization, low buffering capacity
    - generally non-acid generating (Non-AG) (more than 98% of samples)
    - humidity cell test samples containing less than 0.1% sulphide-sulphur are unlikely to generate acidity in the long-term
    - One humidity cell with a sulphur concentration of 0.1 wt% and NP of 4.3 kg $CaCO_3$/t was acid generating and leached metals at higher concentrations than the neutral pH humidity cell. The remaining 23 kinetic test samples were non-acid generating.
  - Elemental Analyses
    - Al, Si, primary elements
  - Leach tests (short term and Kinetic)
    - low potential for metal leaching

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Geochemistry – Assessment Findings

- Processed Kimberlite
  - Acid Base Accounting (ABA)
    - NP:AP ratios greater than three in all samples
    - Classified as non-AG according to the DIAND (1992) criteria
    - Excess buffering capacity present
  - Elemental Analyses
    - In general, metal concentrations were higher in fine PK than coarse PK samples
    - Parameters above typical values in the earths crust (continental rock) for a number of parameters, as would be expected for this type of rock

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Geochemistry – Assessment Findings

- Processed Kimberlite (Continued)
  - Leach tests and process water
    - Fine PK leachate concentrations were slightly higher than coarse PK leachate concentrations of select metals
    - Process water samples had a similar composition to PK short term leach sample concentrations
    - Phosphorus was identified as requiring follow-up

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Geochemistry – Supplemental Testing (Phosphorus)

- Iterative process
  - Change in deposition options resulted in additional geochemical testing (i.e. subaqueous testing)
- Based on initial geochemistry results and water quality modeling
  - Additional understanding of Phosphorus required
  - Additional mitigation for Phosphorus to be investigated
- Single set of submerged column test results showed elevated phosphorus values (relative to desired concentrations) but were conservatively carried forward in initial assessment
- Supplemental test program was undertaken to better understand geochemical influence on phosphorus (10 kinetic tests)

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Geochemistry – Assessment Findings

- A comprehensive geochemistry program was completed on representative samples
- Potential for Acid Rock Drainage (ARD) and Metal Leaching (ML) assessed
  - ARD is not expected to be an impact at this site
    - Monitoring will be conducted
    - Mitigation is possible if necessary
- Concentrations of metals, major ions and nutrients were evaluated and supplemental data collected to inform the water quality analyses and help with design decisions

Understanding the geochemical conditions contributes to sound decision making that will help protect the environment

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Gahcho Kué Project
Water Quality

December 1, 2011

De Beers Canada

Outline of Presentation

- Introduction
  - Terms of Reference, EIS Sections, Assessment Overview
- Environmental Setting
  - Study areas, baseline data collection, ongoing and future work
- Assessment Approach and Results (Kennady Lake & Downstream)
  - Project Air Emissions
  - Surface Water Quality
  - Tuzo Pit Lake Stability
  - Winter Oxygen Depletion Rate (WODR)
- Assessment Findings
- Water Quality Effects to Aquatic Health

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EIS Water Quality Sections

- Based on the TOR, effects on water quality were captured primarily in two Key Lines of Inquiry:
  - Water quality and fish in Kennady Lake (Section 8)
  - Downstream water effects (Section 9)
- Some TOR excerpts that guided the assessment included:
  - "The EIS must provide a detailed analysis of all impacts…including a comprehensive analysis of potential impacts on water quality of Kennady Lake as a result of possible contamination."
  - "…the EIS must provide an evaluation of the potential downstream effects and extent of impact."
- The water quality assessment also serves as an input to Aquatic Health and Fish assessment

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Water Quality – Environment Setting

Water Quality – Environmental Setting

- Existing Environment data for Water Quality and Sediment Quality collated from:
  - Historic data sources
    - Kennady Lake watershed
    - LSA
    - RSA
  - Field surveys
    - Kennady Lake watershed
    - LSA

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Water Quality – Environmental Setting

- Field Programs
  - Water quality surveys
    - 23 water quality sampling programs in LSA between 1995 and 2005, and 2010 and 2011
      - Emphasis on Kennady Lake watershed
    - Monitoring included:
      - Open water and under-ice conditions
      - Sampling for water chemistry data
      - Water column profile data
  - Sediment quality surveys in Kennady Lake in 2004 and 2005, and 2010 and 2011
    - Sampling for sediment properties and chemistry

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Water Quality – Environmental Setting

- Water quality is similar throughout Kennady Lake and other lakes in the LSA; seasonal variability is low
- Lakes exhibit seasonal physico-chemical characteristics
- Most lakes have low concentrations of total dissolved solids, alkalinity and hardness, and total suspended solids
- The lakes can be characterized as oligotrophic, and phosphorus-limited
- The lakes have low total organic carbon and dissolved organic carbon, but possess some colour
- Metal concentrations are generally low, but some metals (e.g., aluminum, cadmium, copper, iron and zinc) have been measured above aquatic life guideline concentrations

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Sediment Quality – Environmental Setting

- Sediments are mainly composed of sand (~70%), with low silt (~25%) and very low clay (~2%) content
- Low to moderate organic carbon content
- Concentrations of most metals in Kennady Lake bed sediments are below sediment quality guidelines, but arsenic, cadmium, chromium, copper and zinc have been measured above guideline concentrations

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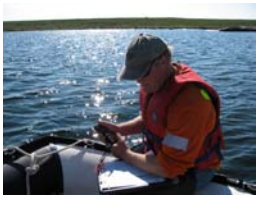
Ongoing and Future Work

- Seasonal water and sediment quality monitoring in targeted locations
  - Under ice and open water conditions, targeted freshet monitoring
    - Including in-situ monitoring of physico-chemical parameters and turbidity
  - Transition from baseline data collection to AEMP
  - Apply updated analytical techniques to measurement ultra-low metals, and nutrients (e.g., P) as appropriate
  - Include chlorophyll *a* sampling in association with nutrients
  - Improve sediment-nutrient data



115

Water Quality – Assessment Methods

Water Quality – Assessment Methods

- Project Air Emissions
  - An air quality dispersion model was developed to project the following:
    - Mass loadings of parameters to Kennady Lake and lakes in downstream watersheds
    - The potential for lake acidification as a result of deposition of acidifying air emissions

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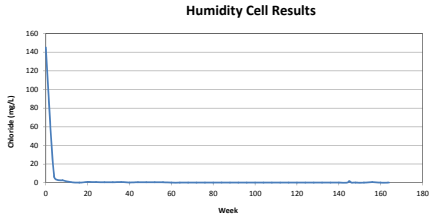
Water Quality – Assessment Methods

- Surface Water Quality Model
  - Effects to surface water quality were evaluated using a conservative mass balance model developed in the GoldSim™ modeling package
  - Water qualities were projected for the following:
    - Kennady Lake
    - Downstream Watersheds
  - In GoldSim™, inflow volumes to water bodies were assigned a water chemistry selected from baseline information or geochemical testing to account for loadings from natural areas, disturbed areas, mine rock runoff, fine and coarse PK runoff, and groundwater discharge

118

Water Quality – Assessment Methods

- Selection of Source Terms
  - Source terms were selected to provide a conservative representation of mine drainage

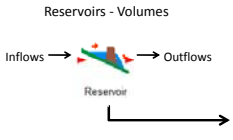


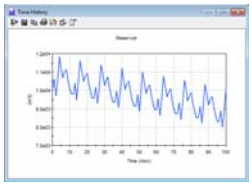
119

Water Quality – Assessment Methods

How is water quality calculated in GoldSim™?

GoldSim™ has elements designed to facilitate water quality modeling





For illustrative purposes only

- Reservoirs are used to track inflow and outflow rates to simulate the volume of a body of water

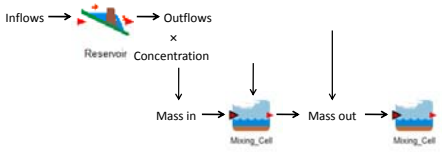
120

Water Quality – Assessment Methods

How is water quality calculated in GoldSim™?

GoldSim™ has elements designed to facilitate water quality modeling

Reservoirs - Volumes



Cell Pathways – Water Quality

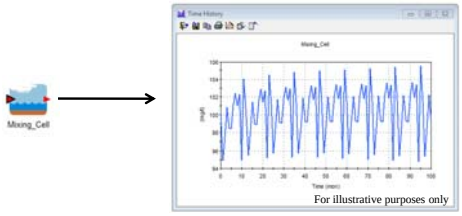
- Cell pathways are used to track mass inflow and outflow rates to simulate the water quality of a body of water

121

Water Quality – Assessment Methods

How is water quality calculated in GoldSim™?

GoldSim™ has elements designed to facilitate water quality modeling

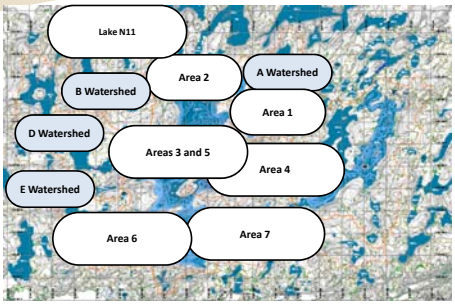


For illustrative purposes only

- Cell pathways are used to track mass inflow and outflow rates to simulate the water quality of a body of water

122

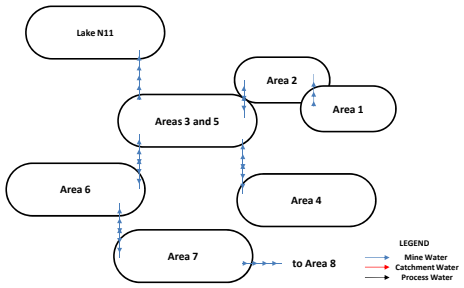
Water Quality – WQ Model Background



123

Water Quality – WQ Model Background

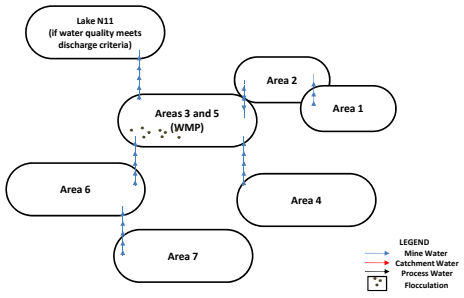
Dewatering: Mine Year -2



124

Water Quality – WQ Model Background

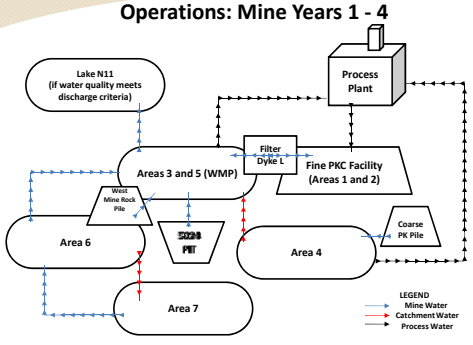
Dewatering: Mine Year -1



125

Water Quality – WQ Model Background

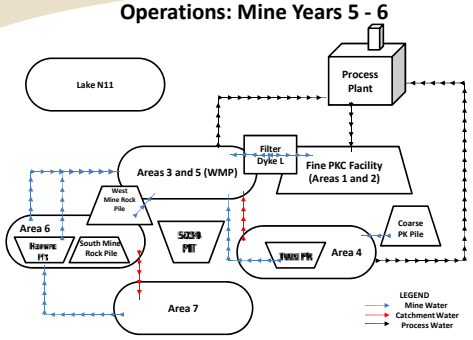
Operations: Mine Years 1 - 4



126

Water Quality – WQ Model Background

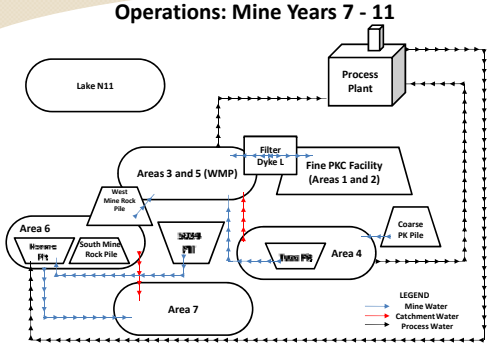
Operations: Mine Years 5 - 6



127

Water Quality – WQ Model Background

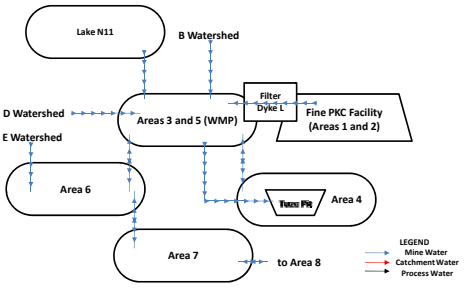
Operations: Mine Years 7 - 11



128

Water Quality – WQ Model Background

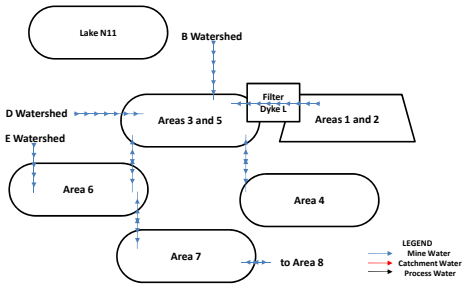
Closure (Refilling): Mine Years 12 - 20



129

Water Quality – WQ Model Background

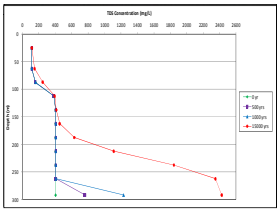
Closure (Post-Closure): Mine Years 21+



130

Water Quality – Assessment Methods

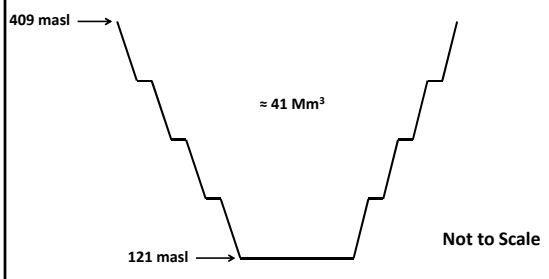
- ***Tuzo Pit Lake Stability***
  - Meromixis will develop as a consequence of the density gradient between high TDS bottom waters in the pit and the overlying low TDS water
  - Pycnocline movement and stability were evaluated using:
    - Hydrodynamic model (CE-QUAL-W2)
      - 100 years of closure
    - Mass balance model
      - 15,000 years of closure



131

Water Quality – Assessment Methods

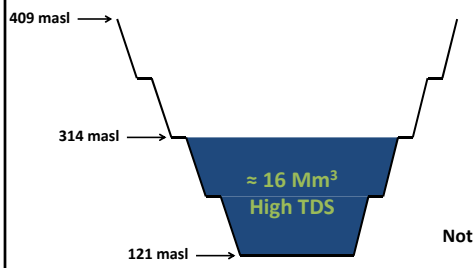
Tuzo Pit Lake Stability (Closure and Post-Closure)



132

Water Quality – Assessment Methods

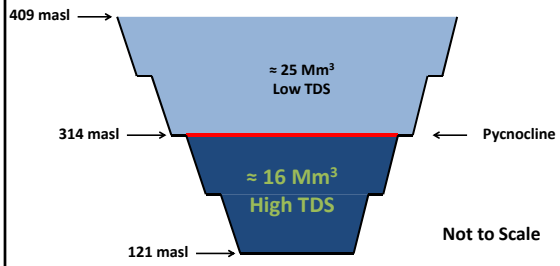
Tuzo Pit Lake Stability (Closure and Post-Closure)



132(a)

Water Quality – Assessment Methods

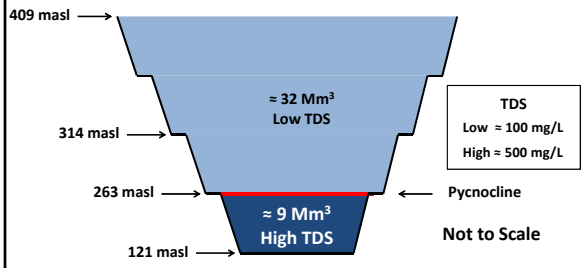
Tuzo Pit Lake Stability (Closure and Post-Closure)



132(b)

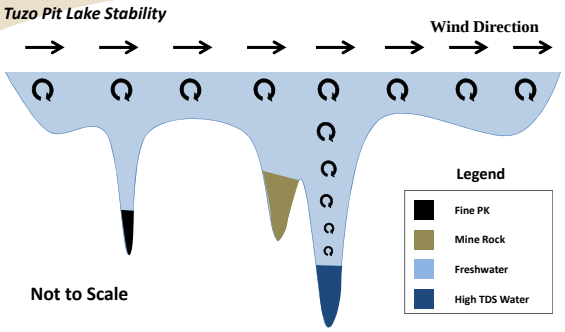
Water Quality – Assessment Methods

Tuzo Pit Lake Stability (Closure and Post-Closure)



132(c)

Water Quality – Assessment Methods



133

Water Quality – Assessment Methods

- Tuzo Pit Stability
  - Tuzo pit was incorporated into the GoldSim™ model as a Cell Pathway with a defined capacity
  - As the pycnocline moves deeper with time, additional water stored in the Tuzo pit will mix with Kennady Lake
  - The change in capacity resulting from pycnocline migration in Tuzo pit was included in the GoldSim™ model to account for release of deeper saline water stored in Tuzo during the closure period prior to stratification being established

134

Water Quality – Assessment Methods

- Winter Oxygen Depletion Rate (WODR)
  - A WODR model was developed to estimate DO depletion under ice conditions as a result of projected total phosphorus (TP) concentrations in Kennady Lake
  - Used three approaches based on North American Lakes:
    1. Vollenweider 1979 - annual rate of carbon productivity
    2. Mathias and Barica 1980 - sediment surface area to the lake volume
    3. Babin and Prepas 1985 - summer TP concentration in the euphotic zone
  - On-going modelling development underway to validate the projections

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Water Quality – Assessment Findings

Water Quality – Assessment Findings

- Changes to Water Quality from Project Air Emissions
  - Limited spatial and temporal extents of air emissions expected to result in minor changes to water chemistry in lakes within the Kennady Lake watershed
  - Projected net PAI values representing peak emissions were below critical loads for the 19 lakes studied
    - lake acidification not expected

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Water Quality – Assessment Findings

- Changes to Water Quality from Project Activities
  - Several parameters are projected to increase in Kennady Lake and the downstream watershed lakes after closure
    - TDS, major ions, nutrients and metals
    - Projected concentrations decrease downstream in the watershed relative to Kennady Lake
  - Metals projected to be higher than CCME Guidelines (Protection of Aquatic Life)
    - Kennady Lake: Cadmium (Cd), Chromium (Cr), Copper (Cu) and Iron (Fe)
    - Area 8: Cd and Cr
    - Lake N11: Cd and Cr
    - Lake 410: Cd
  - Impacts to water quality are expected to negligible at the Lake 410 outlet
  - Projected concentrations were evaluated as part of the Aquatic Health Assessment

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Water Quality – Assessment Findings

- Changes to Winter Oxygen Depletion Rate (WODR)
  - Additional depletion of oxygen under ice after closure is expected in Kennady Lake
  - Increased oxygen demands are likely to affect 22% of the water volume, mainly below 6 m depth and near the lake bed sediment
  - The surface zone (78% volume) is expected to maintain sufficient oxygen concentrations to support cold-water aquatic life (CCME Guideline >6.5 mg/L DO)

139

Water Quality – Assessment Findings

- Uncertainty
  - Water quality projections based on several inputs all of which have inherent variability and uncertainty
  - Water quality model incorporated conservative assumptions including the following:
    - groundwater inflows
    - geochemical source terms
    - no consideration of mass retention as a result of permafrost development
    - no attenuation of mass due to geochemical or biological reactions
  - On-going work to refine surface water quality projections

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Gahcho Kué Project
Aquatic Health

Aquatic Health – Assessment Methods

- Predicted changes to water quality on aquatic health evaluated through two exposure pathways:
  - Direct Exposure
    - Predicted water concentrations compared with chronic effects benchmarks (CEBs) to evaluate potential for aquatic health effects due to direct waterborne exposure
  - Indirect Effects
    - Predicted tissue concentrations compared with toxicological benchmarks to evaluate potential for aquatic health effects related to tissue concentrations

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Aquatic Health – Assessment Findings

- The proposed water management plan is designed to be protective of the environment and the Project is expected to have negligible effects on aquatic health in Kennady Lake and downstream watersheds:
  - Kennady Lake Watershed
    - Potential for adverse effects from dust and metals deposition during operations is minor
    - Changes to concentrations of all substances considered in the assessment predicted to result in negligible effects to aquatic health in Kennady Lake
  - Downstream Watershed
    - Changes to concentrations of all substances considered in the assessment predicted to result in negligible effects to aquatic health in water bodies downstream of Kennady Lake

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Gahcho Kué Project

Fish and Fish Habitat

December 1, 2011

De Beers Canada

Outline

- Environmental Setting
- Fish and Fish Habitat Assessment
  - Introduction
  - Methods
  - Results
  - Plan Forward for Fish Habitat Compensation
- Recovery of Kennady Lake

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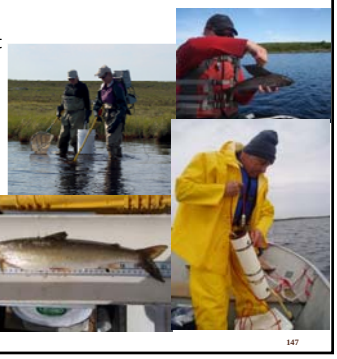
Fish and Fish Habitat - Environmental Setting

Fisheries and Aquatic Resources – Environmental Setting

- Baseline fish and fish habitat studies conducted between 1996 and 2011
- Focused on Kennady Lake, adjacent watersheds and downstream watersheds
- Components:
  - Aquatic Habitat
  - Limnology
  - Lower Trophic Levels
  - Fish Communities



147

Fisheries and Aquatic Resources – Environmental Setting

Studies	Purpose	Years
Lake & Stream Habitat	Overwintering, Spawning potential	1996, 1999, 2000-2005, 2007, 2010, 2011
Limnology	Characterize water quality	1996, 1999, 2001-2005, 2007, 2010, 2011
Sediment	Baseline sediment toxicity	2004, 2005
Lower Trophic Levels	Characterize existing communities	1996, 2001-2005, 2007, 2011
Gill Netting	Large-bodied fish sampling	1996,1999, 2004, 2005, 2007, 2010
Minnow Trapping and Electrofishing	Small-bodied & young fish sampling, littoral habitat utilization	1996,1999, 2004, 2005, 2007, 2010, 2011
Fish Fences	Spawning movements	2000, 2004, 2005
Lake Sampling	Fish bearing status, species composition, abundance	1996, 2002, 2003-2005, 2007, 2010, 2011
Stream Utilization Surveys	Fish use, species, abundance	1996, 2000, 2004, 2005, 2007, 2010, 2011
Spawning Studies	Identify habitat and confirm use	1996, 2001, 2004
Radio Telemetry	Large-bodied fish movements	2004, 2005
Mark/recapture & Acoustics	Population estimates, movements	1996, 2000, 2001, 2004, 2010
Fish Tissue Sampling	Baseline metal concentrations	1996,1999, 2004, 2005, 2007, 2011

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Fisheries and Aquatic Resources – Environmental Setting

- Aquatic Habitat - Lakes
  - Kennady Lake
    - Mean ~5 m and max depth ~18 m
    - Nearshore area mostly boulder/cobble with limited aquatic vegetation
    - Deeper offshore habitats mostly loose, fine sediments
  - Small lakes
    - Generally shallow depressions in tundra with low gradient shorelines and little vegetation
    - Few offer overwintering habitat as they freeze to bottom

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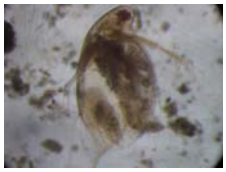
Fisheries and Aquatic Resources – Environmental Setting

- Aquatic Habitat - Streams
  - Majority of streams low gradient, boulder/cobble substrates with low-moderate fish habitat potential
  - In spring, some streams provide habitat for Arctic grayling spawning and northern pike spawning migrations
  - Flows reduced in summer with many streams becoming ephemeral and restricting large-bodied fish movement

150

Fisheries and Aquatic Resources – Environmental Setting

- Lower Trophic Levels
  - Phytoplankton, zooplankton and benthic invertebrate communities typical of sub-Arctic lakes on Canadian Shield with low abundance and high diversity



151

Fisheries and Aquatic Resources – Environmental Setting

- Fish Investigations - Lakes
  - Fish presence and distribution determined
    - Half of sampled lakes were non fish-bearing
  - 8 fish species in Kennady Lake
    - Lake trout and round whitefish most abundant large-bodied species
    - Arctic grayling, northern pike, burbot also present
    - Forage fish include lake chub, ninespine stickleback and slimy sculpin

152

Fisheries and Aquatic Resources – Environment Setting

- Fish Investigations - Streams
  - Arctic grayling most abundant species captured in streams
  - Other large-bodied and forage fish also captured
  - Arctic grayling and northern pike make extensive spawning migrations (spring)
  - Other species found to move into streams for feeding

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Fish and Fish Habitat - Assessment

Fish and Fish Habitat – Introduction

- Baseline information
  - Annex J and Addendum JJ
  - Sections 8.3.7 and 8.3.8 (KLOI: Water quality and fish in Kennady Lake)
  - Sections 9.3.4 and 9.3.5 (KLOI: Downstream water effects)
- Effects on fish and fish habitat
  - Section 8.10 (KLOI: Water quality and fish in Kennady Lake)
  - Section 9.10 (KLOI: Downstream water effects)
- Recovery of Kennady Lake
  - Section 8.11 (KLOI: Water quality and fish in Kennady Lake)
- Conceptual Compensation Plan (CCP)
  - Appendix 3.II (Appendix to the Project Description)

155

Fish and Fish Habitat – Assessment Methods

- Area of fish habitat lost quantified using GIS (overlaying Project footprint over habitat classification maps)
- Review of data and results from other components
  - Changes to flows, water levels, shoreline erosion and sedimentation from hydrology component
  - Changes in total suspended solids and winter oxygen demand from water quality component
  - Changes in aquatic health from aquatic health component
- Qualitative assessments based on anticipated changes, literature reviews, species life history and habitat use, and knowledge

156

Introduction – Assessment Findings

Projected impacts of the Project on abundance and persistence of desired populations of fish Valued Components considered to be not environmentally significant

157

Fish and Fish Habitat – Assessment Findings (Construction and Operations)

- Dewatering – Kennady Lake
  - Fish salvage to remove fish before and during dewatering
    - DFO General Fish-out Protocol will be used as a guide to develop Project-specific protocol prior to initiating the salvage
    - Designed and implemented in consultation with DFO and local communities
  - Dewatering will result in a temporary loss of fish habitat in Kennady Lake during the life of the mine
    - **However, habitat will recover and a self-sustaining fish community will be present in Kennady Lake after refilling**

158

Fish and Fish Habitat – Assessment Findings (Construction and Operations)

- Dewatering - Downstream
  - Flows augmented in downstream (N, and L and M) watersheds in summer
    - Pumping plan will mitigate adverse effects on fish and fish habitat
      - Most pumping occur after peak of spring freshet has occurred
      - Ramp up and ramp down will minimize flushing or stranding fish
  - Negligible effects on Arctic grayling spawning and rearing
  - May improve fish passage between lakes for some species
  - Small increases in lake water levels and areas may benefit fish through increased littoral area and summer rearing habitat

159

Fish and Fish Habitat - Assessment Findings (Construction and Operations)

- Watershed Diversions
  - Dykes will interrupt movement of fish between Kennady Lake and upstream waterbodies
    - Diversion watersheds will support self-sustaining fish populations e.g., Arctic grayling, northern pike, burbot, forage fish
  - Increased lake habitat area and depth will benefit fish residing in these lakes
    - Additional littoral habitat and increased overwintering habitat for resident fish
  - Watersheds will be reconnected at closure, allowing for fish migration

160

Fish and Fish Habitat – Assessment Findings (Construction and Operations)

- Changes to Fish Habitat from Project Footprint
  - Affected habitat areas include
    - Permanently lost areas; physically altered and re-submerged; dewatered and re-submerged areas
  - All lake and watercourse areas affected by the Project footprint are identified and quantified in the CCP
  - Habitat compensation plan will create new fish habitat to offset predicted habitat losses (no net loss of fish habitat)

161

Fish and Fish Habitat – Assessment Findings (Operations)

- Dust Deposition
  - Primarily associated with spring melt from dust accumulating on snow over winter from winter road use
    - Conservative, as assumes no natural mitigation
  - Effects localized to a small number of lakes close to Project site for a short period after freshet
    - Fish can tolerate high concentrations for short periods
    - Low potential for adverse effects to aquatic health

162

Fish and Fish Habitat - Assessment Findings (Operations)

- Kennady Lake - Isolation of Area 8
  - During operations, Area 8 will be isolated from Areas 2 to 7 of Kennady Lake, and upper watershed flow
  - A fish community will continue to be present in Area 8
    - e.g., Arctic grayling, northern pike, burbot and forage fish
  - Existing shallow depths in Area 8 may limit overwintering habitat in isolated basin for species such as lake trout and round whitefish

163

Fish and Fish Habitat – Assessment Findings (Operations)

- Downstream Flows
  - Flow reductions in L and M watershed during operations
    - Reduction in available habitat
    - Reduction in spring flows will negatively affect Arctic grayling spawning migrations and populations
    - However, flow mitigation plan being developed to mitigate fish habitat losses due to reduced flows; will focus on Arctic grayling spawning and rearing habitat
  - Flows return to near baseline during post-closure

164

Fish and Fish Habitat - Assessment Findings (Closure and Post-Closure)

- Refilled Kennady Lake
  - Increased nutrients will increase primary and secondary productivity in Kennady Lake
  - Due to increases in food base, likely will be increased growth and production in forage fish, as well as large-bodied fish species
  - Kennady Lake is expected to retain sufficient DO during winter to support fish; however, may be reduction in availability or suitability of overwintering habitat for cold-water fish species
- No effects to fish populations or communities in refilled Kennady Lake from changes in aquatic health (negligible)

165

Fish and Fish Habitat – Assessment Findings (Closure and Post-Closure)

- Downstream Watersheds
  - Increased nutrients along gradient downstream in L and M watersheds, which will increase primary and secondary productivity
  - Increased potential for growth and production of forage fish, as well as large-bodied fish
  - Potential for small changes in habitat availability or suitability, but not expected to affect fish populations or distribution
  - No effects to fish populations or communities downstream of Kennady Lake from changes in aquatic health (negligible)

166

Fish Habitat Compensation Plan

- De Beers will implement fish habitat compensation to offset losses to fish habitat to meet DFO's policy for no net loss
- Compensation options currently considered include:
  - Raising water levels in lakes west of Kennady Lake
  - Widening top bench of mine pits where they extend onto land
  - Construction of habitat enhancement features

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Fish Habitat Compensation Plan

- De Beers has had preliminary discussions with DFO and will continue engagement process throughout 2012 for input and to move forward with detailed compensation plan
  - Preferred compensation options, compensation ratio, quantification and validation, monitoring programs, etc.
- Finalization of compensation will be achieved through discussions with DFO and input from communities

168

Fish and Fish Resources – Ongoing and Future Work

- Transition baseline data to Aquatics Effects Monitoring Program (AEMP)
  - Conduct additional fish and fish habitat sampling at reference lakes
  - Develop program and collect monitoring data prior to development
  - Incorporate TK into monitoring program
- Develop compensation monitoring programs
  - Sample lakes identified as potential compensation habitat (D-E-N lakes), as well as other areas identified for compensation
  - Develop program and collect data prior to development
- Additional sampling for flow mitigation
  - Fish passage at barriers, measurements of physical habitat

169

Fish and Fish Habitat – Recovery of Kennady Lake

Recovery of Kennady Lake – Methods

- Evaluated and assessed how components of aquatic ecosystem may develop in Kennady Lake after refilling
  - Literature review
    - Reviewed published information relevant to recovery of lakes after flooding or refilling
    - Identified main drivers that control rate and direction of recovery
  - Evaluated how results of literature review applied to Kennady Lake, given location and physical characteristics
  - Projected how aquatic ecosystem in Kennady Lake will likely recover

171

Recovery of Kennady Lake

- A viable and self-sustaining aquatic ecosystem will develop after refilling and reconnection of basins
  - Mine rock piles, Fine PKC Facility, mine pits, in-lake roads reclaimed and in-lake compensation habitat constructed prior to refilling
  - After closure and reconnection, long-term hydrology of Kennady Lake expected to return to stable state similar to current conditions
  - Water quality expected to return to conditions suitable to support aquatic life (i.e., for all aquatic species)
    - Negligible effects predicted to aquatic health from changes to water quality in refilled Kennady Lake
    - Increased nutrient levels leading to more productive aquatic ecosystem

172

Recovery of Kennady Lake

- Some growth of terrestrial vegetation in dry lakebed during period of exposure
  - Slow vegetative growth currently occurs around margins of the lake in tundra region
  - Lakebed sediments may provide substrate suitable for the establishment of early successional plants species
  - Colonization by terrestrial species within dewatered lake bed will be reversible when re-flooded
  - Provides nutrient source for benthic colonization and development of phytoplankton in the refilled lake

173

Recovery of Kennady Lake

- With physical and chemical environment of Kennady Lake returning to stable conditions, aquatic ecosystem will develop
- Estimated time frame for recovery after refilling
  - Phytoplankton community ~5 yrs
  - Zooplankton within 5 to 10 yrs
  - Benthic invertebrate community ~10 yrs
  - Forage fish initially, then large-bodied species
    - Northern pike ~50 to 60 yrs
    - Lake trout ~60 to 75 yrs
- Increased nutrients will facilitate re-establishment and result in higher productivity of the resulting ecosystem

174

Recovery of Kennady Lake

- Fish community re-establishment dependent on species ability to re-colonize, habitat conditions, and how succession occurs
- Development of self-sustaining populations of small-bodied fish species in Kennady Lake will occur during refilling
- Migration of large-bodied species will occur from reconnected upper watersheds and from Area 8 once Dyke A removed
- Final fish community will consist of small-bodied forage fish community and large-bodied species
  - Expected to have same fish species assemblage as currently exists in Kennady Lake
- **Viable and self-sustaining aquatic ecosystem will develop**

175

Aquatics Assessment Summary

KLOIs: Assessment Summary – Hydrogeology

- The Project will have negligible effects on groundwater quantity
  - No measureable differences in lake water volumes outside of controlled area are projected
- Conservative assumptions were built into the model to provide high degree of confidence that effects on groundwater (quantity and quality), and surface water quality as a result of changes to the groundwater, have not been underestimated
  - i.e., upper bound values were selected for hydraulic conductivities
- Simulated groundwater inflow results and concentrations will be validated during operational monitoring

177

KLOIs: Assessment Summary – Hydrology (Construction, Operations and Closure)

- Water management activities are intended to allow mine development while protecting the environment
- Dewatering and refilling will affect magnitude and seasonal variability of flows and water levels
- Diversions will reduce peak and annual flows and water levels on diverted waterbodies, and increase peak and annual flows on receiving environment
- Water level augmentations will expose new shoreline soils to wave erosion
- Shoreline erosion is expected to be limited by natural armouring
- Mitigation measures will limit erosion during dyke removal
- All effects diminish downstream of Kennady Lake

178

KLOIs: Assessment Summary – Hydrology (Post-Closure)

- Long term effects are expected to be smaller in general than short term effects
- 8.9% increase in mean annual water yield (mm) at Kennady Lake outlet
- 6.1% increase in mean annual discharge (m^3/s) at Kennady Lake outlet
- All effects diminishing downstream, with no effects in Watershed N
- Slight increase in flood peak discharges and water levels
- All effects diminish proportionally downstream of Kennady Lake, with no effects in Watershed N

179

KLOIs: Assessment Summary – Water Quality

- Operations
  - Minor effects from deposition of air emissions
    - lake acidification not predicted
- Post-Closure
  - Several parameters are projected to increase in Kennady Lake and the downstream watershed lakes after closure
    - Projected concentrations decrease downstream in the watershed relative to Kennady Lake
    - Impacts to water quality are expected to negligible at the Lake 410 outlet
  - Additional depletion of oxygen under ice in Kennady Lake after closure, but the surface zone (78% volume) is expected to maintain sufficient oxygen concentrations to support cold-water aquatic life
    - Increased oxygen demands are likely to affect 22% of the water volume, mainly below 6 m depth and near the lake bed sediment

180

KLOIs: Assessment Summary – Aquatic Health

- Potential for adverse effects from dust and metals deposition in during operations is minor
- Changes to concentrations of all substances considered in the assessment predicted to result in negligible effects to aquatic health in Kennady Lake, and in water bodies downstream of Kennady Lake

181

KLOIs: Assessment Summary – Fish and Fish Habitat (Construction and Operations)

- Dewatering – Kennady Lake
  - Fish salvage to remove fish before and during dewatering
  - Dewatering will result in a temporary loss of fish habitat in Kennady Lake during the life of the mine
- Dewatering - Downstream
  - Flows augmented in downstream (N, and L and M) watersheds in summer
  - Negligible effects on Arctic grayling spawning and rearing
  - May improve fish passage between lakes for some species
  - Small increases in lake water levels and areas may benefit fish through increased littoral area and summer rearing habitat

182

KLOIs: Assessment Summary – Fish and Fish Habitat (Construction and Operations)

- Watershed Diversions
  - Dykes will interrupt movement of fish between Kennady Lake and upstream waterbodies
  - Increased lake habitat area and depth will benefit fish residing in these lakes
  - Watersheds will be reconnected at closure, allowing for fish migration
- Changes to Fish Habitat from Project Footprint
  - Affected habitat areas include permanently lost areas; physically altered and re-submerged; dewatered and re-submerged areas
  - Habitat compensation plan will create new fish habitat to offset predicted habitat losses (no net loss of fish habitat)

183

KLOIs: Assessment Summary – Fish and Fish Habitat (Operations)

- Dust Deposition
  - Associated with open water deposition and spring melt from dust accumulating on snow over winter
  - Effects localized to a small number of lakes close to Project site for a short period after freshet
    - Low potential for adverse effects to aquatic health
- Kennady Lake - Isolation of Area 8
  - During operations, Area 8 will be isolated from Areas 2 to 7 of Kennady Lake, and upper watershed flow
  - A fish community will continue to be present in Area 8
  - Existing shallow depths in Area 8 may limit overwintering habitat in isolated basin for species such as lake trout and round whitefish

184

KLOIs: Assessment Summary – Fish and Fish Habitat (Operations)

- Downstream Flows
  - Flow reductions in L and M watershed during operations , but will return to near baseline during post-closure

185

KLOIs: Assessment Summary – Fish and Fish Habitat (Post-Closure)

- Refilled Kennady Lake
  - Increased nutrients will increase primary and secondary productivity in Kennady Lake
  - Due to increases in food base, likely will be increased growth and production in forage fish, as well as large-bodied fish species
  - Kennady Lake is expected to retain sufficient DO during winter to support fish; however, may be reduction in availability or suitability of overwintering habitat for cold-water fish species
  - Negligible changes to fish populations or communities in refilled Kennady Lake (aquatic health)

186

KLOIs: Assessment Summary – Fish and Fish Habitat (Post-Closure)

- Downstream Watersheds
  - Increased nutrients along gradient downstream in L and M watersheds, which will increase primary and secondary productivity
  - Increased potential for growth and production of forage fish, as well as large-bodied fish
  - Potential for small changes in habitat availability or suitability, but not expected to affect fish populations or distribution
  - No effects to fish populations or communities downstream of Kennady Lake from changes in aquatic health (negligible)

187

KLOIs: Assessment Summary – Lake Recovery (Post-Closure)

A viable and self sustaining aquatic ecosystem will re-develop in Kennady Lake

188

Assessment Findings – Water Quality

- Suitability of water quality to support viable and self-sustaining aquatic ecosystem
  - The Project should not have a significant adverse effect for Kennady Lake and Downstream Watershed KLOIs
    - Water quality changes will result in negligible effects to aquatic health in Kennady Lake and downstream
    - Projected increases in long-term P levels will not pose health risk to viable and self-sustaining aquatic ecosystem; lakes and streams may be more productive

189

Assessment Findings – Key Fish Species

- Abundance and persistence of desired populations of Arctic grayling, lake trout, and northern pike
  - The Project should not have a significant adverse effect for Kennady Lake and Downstream Watershed KLOIs
    - Fish affected by loss of habitat in Kennady Lake during life of mine; however, self-sustaining populations should establish in refilled lake
    - Reduced flows downstream during operations may affect habitat availability, suitability and movement of fish between Area 8 and Lake 410
      - However, flow mitigation plan under development, and flows return to near baseline post-closure
    - Nutrient enrichment may provide for improved productivity for fish, although may be some localized changes to habitat conditions

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Gahcho Kué Project
SON: Impacts to Great Slave Lake (11.2)

SON – Impacts on Great Slave Lake

- In section 5.2.1 of the ToR, the analysis of the EIS must address the question of how far downstream any effects from changes to flows and water quality are likely to reach
- This SON was asked to provide a summary of the analysis for Great Slave Lake

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SON – Impacts on Great Slave Lake

- Study area
  - The Lockhart and Hoarfrost river watersheds
- Baseline setting
  - Characterized from LSA data, and existing government data for the RSA beyond Kirk Lake
- Pathways:
  - Changes to flows
  - Changes to water quality from flows from Kennady Lake and from air emissions
    - All No Linkage Pathways

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SON – Impacts on Great Slave Lake

- The Project will not have a significant negative influence on Great Slave Lake
  - Project effects will not be measurable in the Lockhart River watershed, the Hoarfrost watershed or in Great Slave Lake
  - The Project will therefore not have a measurable contribution to cumulative effects
  - The deposition of air emissions is expected to have a negligible effect on water and sediment quality in regional waterbodies located more than 2 km away from the Project site
  - Water releases and potential changes in surface water flow and/or quality within and downstream of Kennady Lake will have no effect on surface water flows, water levels or water quality outside of the LSA

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Aquatics Assessment Summary

- To meet the Terms of Reference and provide confidence in the assessment, the EIS used multiple approaches for making predictions
- The EIS integrated uncertainty throughout the assessment so actual impacts would not be worse than predicted
- Incremental impacts from the Project will not have a significant negative influence on the resilience and persistence of aquatic VCs
  - based on weight of evidence from the analysis of primary pathways

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Environmental Impact Statement

- Impacts from the Project will not have a significant negative influence on:
  - Suitability of water quality to support a viable aquatic ecosystem, and key fish species
  - Abundance and persistence of desired populations of key fish species
- Based on weight of evidence from analysis of primary pathways to effects on VCs
- The EIS was based on multiple assessment approaches and endpoints for key aquatics components
  - To meet Terms of Reference
- The EIS considered a suite of conservatisms throughout the assessment
  - Impacts should not be worse than predicted

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