TECHNICAL MEMORANDUM

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WATER QUALITY OBJECTIVES (WQO) AND SEDIMENT QUALITY OBJECTIVES (SQO) FOR THE PROPOSED GAHCHO KUÉ PROJECT - INITIAL DEVELOPMENT PROCESS

1.0 INTRODUCTION

During the Technical Sessions as part of the Mackenzie Valley Environmental Impact Review Board process for the proposed Gahcho Kué Diamond Mine Project (the Project) held on May 22 to 25, 2012, De Beers Canada Inc. (De Beers) made a commitment to develop water quality objectives (WQOs) and sediment quality objectives (SQOs) for the proposed Project. The Mackenzie Valley Land and Water Board (Board), on behalf of all Boards in the NWT, notes (MVLWB 2011, footnote p 10) that the Northwest Territories Waters Act refers in subsection 4(c) to 'water quality standards', not water quality objectives; however, such standards are believed to be "*equivalent to the more widely accepted term "water quality objective" which has been defined by the Canadian Council of Ministers of the Environment (CCME) as: "a numerical concentration or narrative statement that has been established to support and protect the designated uses of water at a specified site." (CCME (1999), Canadian Environmental Quality Guidelines. Guidelines and Standards Division, Winnipeg, MB.)*."

De Beers' commitment to develop SQOs and WQOs is based on the above definition of such objectives, as provided by the MVLWB (2011). The purpose of this technical memorandum is to explain how this commitment will be undertaken by De Beers. As such, it serves to inform discussions on the development of details for the Aquatic Effects Monitoring Program that will be resolved during the regulatory process.

2.0 PROCESS FOR DEVELOPMENT OF WATER AND SEDIMENT QUALITY OBJECTIVES

CCME (2007) provides the basis for development of national water quality guidelines (WQGs) for the protection of aquatic life. Such guidelines are intended to provide a conservative level of protection for all aquatic fauna in Canada. However, CCME (2007) notes the need to account for both natural background concentrations of naturally occurring substances such as inorganic metals and for the influence of exposure and toxicity modifying factors (ETMFs).

Development of WQOs and SQOs for the proposed Project will follow the guidance of CCME (2007), focusing on providing conservative numerical values that protect aquatic fauna in the receiving environment without providing an unnecessarily high level of conservatism that restricts development without providing any additional

environmental protection. Accordingly, the following tiered, iterative process, using data obtained during preliminary baseline screening, will be followed for substances of potential concern (SOPCs) related to the project's development:

1. Apply generic national (CCME) WQGs and sediment quality guidelines (SQGs) or, where such do not exist for some substances, the nearest equivalent benchmarks (e.g., USEPA water or sediment quality criteria).
2. Compare these guidelines or benchmarks to natural, baseline/reference concentrations of SOPCs.
3. If baseline/reference concentrations are above the guidelines or benchmarks, replace the guidelines or benchmarks with those concentrations.
4. Consider the effect of ETMFs on the bioavailability and toxicity of potential WQOs and SQOs. In particular, consider work done at other diamond mines in the NWT to develop site-specific objectives. For example, the Snap Lake Mine is developing site-specific water quality objectives for total dissolved solids (TDS), strontium, and nitrate; the EKATI Mine has developed site-specific water quality objectives for nitrate and strontium and, in their recent Water License Renewal Application, discuss ETMFs for cadmium and copper.
5. Based on the above and, if necessary, additional site-specific studies, propose WQOs and SQOs that could be used for screening purposes. Specifically screening would provide two possible conclusions: if concentrations of SOPCs are below their respective WQOs and SQOs there would be no concern for potential toxicity to exposed aquatic fauna; or, if concentrations are above, then there would be potential for toxicity to exposed aquatic fauna and additional investigations to determine whether this could realistically occur would be required.

3.0 BASELINE AND MODEL-BASED PREDICTIONS OF WATER QUALITY IN KENNADY LAKE, LAKE N11 AND LAKE 410

A preliminary screening of baseline water quality, as well as a mass-balance model predicting water quality for all stages of mine life has been performed for Kennady Lake, including Area 8, Lake N11 and Lake 410 (EIS Supplement, Sections 8.2.5.1.1, 9.2.5.1.1, and 9.2.5.1.3 [De Beers 2012]). Copper and cadmium have been identified as being above CCME WQGs in Kennady Lake under baseline conditions (Table 1). Per CCME (2007), these naturally elevated baseline concentrations indicate that site-specific WQOs for copper and cadmium should be above the CCME WQGs.

Water quality parameters of potential concern have been further investigated in terms of their potential effect to the health of aquatic life in post-closure conditions in Kennady Lake, including Area 8, Lake N11 and Lake 410 (EIS Supplement, Sections 8.2.6 and 9.2.6 [De Beers 2012]). In the 2012 Supplement, for direct waterborne exposure, SOPCs were selected based on WQGs; 12 SOPCs were identified (Table 2). For these SOPCs, preliminary chronic effects benchmarks (CEBs) were derived. CEBs are the water concentrations predicted to cause aquatic health issues at the level of the individual organism. CEBs are conservative and, as noted above, will be considered as part of the process undertaken to derive appropriately protective WQOs.

A subset of the SOPCs listed in Table 2 for Kennady Lake (9: TDS, antimony, barium, beryllium, cadmium, cobalt, manganese, strontium and vanadium) were selected for Lake N11 (during operations) and Lake 410 (operations and closure) (EIS Supplement, Section 9.2.6 [De Beers 2012]) using the same selection basis.

Table 1 Predicted Water Quality in Kennady Lake during Post-closure

Regulated Parameter	Units	CCME Water Quality Guidelines (WQGs) [a]	Kennady Lake Baseline Water Quality	Projected Concentrations in Kennady Lake	
				Maximum Post-closure Concentration [b] 2012	Long-term Steady State Concentration [b] 2012
Conventional Parameter					
TDS	mg/L	-	13	145	37
Hardness [c]	mg/L	-	-	85	19
Major Ions					
Calcium	mg/L	-	1.2	27	5
Chloride	mg/L	120	0.55	64	3
Fluoride	mg/L	0.12	0.03	**0.13**	**0.13**
Magnesium	mg/L	-	0.52	4.6	1.6
Potassium	mg/L	-	0.48	2.8	1.9
Sodium	mg/L	-	0.71	15	2.4
Sulphate	mg/L	-	0.83	20	10
Nutrients					
Nitrate	mg N/L	13	-	2.0	0.024
Ammonia	mg N/L	5.55 [d]	0.032	1.9	0.03
Total Nitrogen	mg N/L	-	0.35	2.3	0.35
Dissolved P	mg/L	-	0.0057	0.011	0.009
Total Phosphorus	mg/L	-	0.0033	0.011	0.009
Total Metals					
Aluminum	mg/L	0.005 to 0.1 [e]	0.0098	0.092	0.057
Antimony	mg/L	-	0.0001	0.0008	0.0005
Arsenic	mg/L	0.005	0.00014	0.0024	0.0006
Barium	mg/L	-	0.0027	0.03	0.02
Beryllium	mg/L	-	0.000041	0.00014	0.00012
Boron	mg/L	1.5	0.0031	0.11	0.09
Cadmium	mg/L	0.000017 [f]	**0.00002**	**0.000045**	**0.000041**
Chromium	mg/L	0.001	0.0002	0.001	0.0005
Cobalt	mg/L	-	0.000135	0.00136	0.00105
Copper	mg/L	0.002-0.004 [f]	0.0012	**0.0023**	**0.002**
Iron	mg/L	0.3	0.065	0.19	0.1
Lead	mg/L	0.001-0.007 [f]	0.000049	0.00034	0.00026
Manganese	mg/L	-	0.0122	0.043	0.033
Mercury	mg/L	0.000026	0.0000102	0.00001	0.00001
Molybdenum	mg/L	0.073	0.000074	0.007	0.003
Nickel	mg/L	0.025-0.15 [f]	0.00032	0.0048	0.0029
Selenium	mg/L	0.001	0.00019	0.00017	0.00014
Silver	mg/L	0.0001	0.00008	0.000061	0.000056
Strontium	mg/L	0.049	0.0082	0.03	0.02
Thallium	mg/L	0.0008	0.000021	0.00005	0.000029
Uranium	mg/L	-	0.000026	0.0016	0.00121
Vanadium	mg/L	-	0.00024	0.0027	0.0024
Zinc	mg/L	0.03	0.0028	0.008	0.0067

Table 1 Predicted Water Quality in Kennady Lake during Post-closure (continued)

Regulated Parameter	Units	CCME Water Quality Guidelines (WQGs) [a]	Kennady Lake Baseline Water Quality	Projected Concentrations in Kennady Lake	
				Maximum Post-closure Concentration [b] 2012	Long-term Steady State Concentration [b] 2012
Dissolved Metals					
Aluminum	mg/L	0.005 to 0.1 [e]	0.0055	0.063	0.054
Antimony	mg/L	-	0.000082	0.0007	0.0005
Arsenic	mg/L	0.005	0.00012	0.0024	0.0006
Barium	mg/L	-	0.0027	0.03	0.02
Beryllium	mg/L	-	0.000038	0.00014	0.00012
Boron	mg/L	-	0.0023	0.11	0.09
Cadmium	mg/L	0.000017 [f]	0.000022	**0.000035**	**0.000032**
Chromium	mg/L	0.001	0.00016	0.0005	0.00044
Cobalt	mg/L	-	0.000135	0.00129	0.00105
Copper	mg/L	0.002-0.004 [f]	0.00069	**0.0017**	**0.0015**
Iron	mg/L	0.3	0.021	0.11	0.079
Lead	mg/L	0.001-0.007 [f]	0.00003	0.00031	0.00025
Manganese	mg/L	-	0.0122	0.042	0.033
Mercury	mg/L	0.000026	0.0000077	0.000009	0.0000081
Molybdenum	mg/L	0.073	0.000058	0.007	0.003
Nickel	mg/L	0.025-0.15 [f]	0.00032	0.0034	0.0028
Selenium	mg/L	0.001	0.00004	0.00017	0.00014
Silver	mg/L	0.0001	0.000051	0.000061	0.000056
Strontium	mg/L	-	0.0082	0.06	0.05
Thallium	mg/L	0.0008	0.000017	0.00005	0.000023
Uranium	mg/L	-	0.000019	0.0015	0.00121
Vanadium	mg/L	-	0.000134	0.0025	0.0022
Zinc	mg/L	0.03	0.0023	0.008	0.0067

Source: EIS Supplement, Table 8.2-12 (De Beers 2012).

[a] Chronic Aquatic Health Guidelines from Canadian Environmental Quality Guidelines (CCME 1999, updated 2012).

[b] Bold font indicates concentration is higher than the CCME WQG.

[c] Theoretical hardness calculated based on observed calcium and magnesium concentrations; measured as mg $CaCO_3$/L.

[d] Dependent on pH and temperature (assumed 15ºC, to give most conservative guideline).

[e] Dependent on pH.

[f] Dependent on hardness.

mg/L = milligrams per litre; mg/L as $CaCO_3$ = milligrams per litre as calcium carbonate; mg N/L = milligrams per litre as nitrogen; - = not available or not applicable.

Table 2 Summary of Substances of Potential Concern Identified in Kennady Lake and Area 8 during Modelled Closure

Parameter	Kennady Lake		Area 8	Lake N11	Lake 410
	Initial Closure Discharge Water Quality	Long-term Water Quality	Post-closure Water Quality	Operations	Operations and Post Closure Water Quality
Conventional Parameters					
Total Dissolved Solids	√	√	√	√	√
Total Suspended Solids	-	-	-	-	-
Major Ions					
Chloride	-	-	-	-	-
Fluoride	√	-	-	-	-
Nutrients					
Ammonia	-	-	-	-	-
Nitrate	-	-	-	-	-
Total Metals					
Aluminum	-	-	-	-	-
Antimony	√	√	√	√	√
Arsenic	-	-	-	-	-
Barium	√	√	√	√	√
Beryllium	√	√	√	√	√
Boron	-	-		-	-
Cadmium	√	√	√	√	√
Chromium	√	-	-	-	-
Cobalt	√	√	√	√	√
Copper	√	√	√	-	-
Iron	-	-	-	-	-
Lead	-	-	-	-	-
Manganese	√	√	√	√	√
Mercury	-	-	-	-	-
Molybdenum	-	-	-	-	-
Nickel	-	-	-	-	-
Selenium	-	-	-	-	-
Silver	-	-	-	-	-
Strontium	√	√	√	√	√
Thallium	-	-	-	-	-
Uranium	-	-	-	-	-
Vanadium	√	√	√	√	√
Zinc	-	-	-	-	-

Source: Modified from EIS Supplement, Table 8.2-14 (De Beers 2012).

Checkmark (√) indicates that the substance in question was identified as a substance of potential concern (SOPC);
"-" indicates that the substance was not identified as an SOPC.

4.0 SUMMARY

De Beers made the commitment during the May 22-25, 2012 Gahcho Kuè Technical Session to develop preliminary WQOs and SQOs by September 2012. The methods for developing these preliminary benchmarks will follow the process defined above and will utilize the information presented in De Beers (2012). The water quality modeling results indicate that baseline levels of only cadmium and copper exceed CCME WQGs and therefore these the only two parameters predicted to exceed CCME WQGs at closure. The SOPCs, as defined

above and in De Beers (2012), provide a list of potential substances for consideration when developing the preliminary WQOs and SQOs. These preliminary benchmarks, which will be developed during the Environmental Impact Review process, may need to be further refined during the regulatory phase and as the Aquatic Effects Monitoring Program is developed.

5.0 REFERENCES

CCME (Canadian Council of Ministers of the Environment). 1999 (updated 2012). *Canadian Environmental Quality Guidelines*. Winnipeg, MB, Canada. Available at: http://ceqg-rcqe.ccme.ca/ (Accessed June 14, 2012).

CCME. 2007. *A protocol for the derivation of water quality guidelines for the protection of aquatic life.* Winnipeg, MN, Canada.

De Beers (De Beers Canada Inc.). 2012. *Environmental Impact Statement Supplemental Information Submission for the Gahcho Kué Project.* Submitted to the Mackenzie Valley Environmental Impact Review Board, Yellowknife, NWT, Canada.

MVLWB (Mackenzie Valley Land and Water Board). 2011. *Water and effluent quality management policy.* Yellowknife, NWT, Canada.

6.0 CLOSURE

We trust this technical memorandum provides you with the information you require at this time. Should you have any questions, or require further information please contact the undersigned.

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