DE BEERS GROUP

November 1, 2019

Jacqueline Ho,
Regulatory Specialist
Mackenzie Valley Land and Water Board
P.O. Box 2130
Yellowknife, NT X1A 2P6

Via Email: jho@mvlwb.com

Dear Ms. Ho:

RE: 2018 Aquatic Effects Monitoring Program Response Plan – Water Quality, Plankton, and Benthic Invertebrates, Version 2

De Beers Canada is pleased to submit the 2018 Aquatic Effects Monitoring Program Response Plan Version 2 for water quality, plankton and benthic invertebrates. The plan is updated based on the board directive received on October 11, 2019.

If you have any questions regarding this submission, I can be contacted at william.liu@debeersgroup.com or (867) 445-1485.

Sincerely,

William Liu
Regulatory Specialist
De Beers Canada Inc.

DE BEERS GROUP

Gahcho Kué Mine

2018 Aquatic Effects Monitoring Program Response Plan for Water Quality, Plankton, and Benthic Invertebrates – Version 2

November 2019

ABBREVIATIONS AND ACRONYMS

Abbreviation / Acronym	Definition
AEMP	Aquatic Effects Monitoring Program
ANOSIM	analysis of similarity
BACI	*before-after control-impact*
CCME	Canadian Council of Ministers for the Environment
CWQG-PAL	Canadian water quality guidelines for the protection of aquatic life
De Beers	De Beers Canada Inc.
DO	dissolved oxygen
ECCC	Environment and Climate Change Canada
EIS	Environmental Impact Statement
e.g.	for example
Golder	Golder Associates Ltd.
GNWT-ENR	Government of Northwest Territories Environment and Natural Resources
i.e.	that is
Mine	Gahcho Kué Mine
MDS	multidimensional scaling
MVLWB (the Board)	Mackenzie Valley Land and Water Board
NT	Northwest Territories
P	probability
SNP	Surveillance Network Program
SSWQO	site-specific water quality objective
TBD	to be determined
TDS	total dissolved solids
TP	total phosphorus
WMP	water management pond

UNITS OF MEASURE AND SYMBOLS

Unit / Symbol	Definition
%	percent
↑	increase
n	sample size
mg/L	milligrams per litre
mg-Ca/L	milligrams of calcium per litre
mg-Mg/L	milligrams of magnesium per litre
mg-N/L	milligrams of nitrogen per litre
org/m^2	organisms per square metre
org/L	organisms per litre
mg/m^3	milligrams per cubic meter
µg/L	micrograms per litre

TABLE OF CONTENTS

LIST OF TABLES

1 INTRODUCTION

De Beers Canada Inc. (De Beers) monitors hydrology, water and sediment quality, plankton, benthic invertebrates, and fish and fish habitat in lakes and streams near the Gahcho Kué Mine (Mine) as components of the Aquatic Effects Monitoring Program (AEMP). The purpose of the AEMP is to identify potential effects of the Mine on the surrounding aquatic environment, and evaluate whether aquatic ecosystems and their uses are adequately protected in areas affected by the Mine. Monitoring under the AEMP is a requirement of Water Licence MV2005L2-0015, issued by the Mackenzie Valley Land and Water Board (MVLWB or the Board; MVLWB 2018a).

The 2018 AEMP was conducted by Golder Associates Ltd. (Golder) according to the approved AEMP Design Plan Version 5, which was submitted to MVLWB in January 2016 (De Beers 2016a). The AEMP endpoints are assessed for a Mine-related effect according to Action Levels in the AEMP Response Framework described in Section 8 of the AEMP Design Plan. Action Levels address the three impact hypotheses evaluated by the AEMP:

- Toxicological Impairment Hypothesis
- Nutrient Enrichment Hypothesis
- Physical Habitat Alteration Hypothesis

- No Low Action Levels were triggered for physical habitat alteration by the aquatic components in 2018 (Section 15.4 in De Beers 2019a) and are not discussed further herein.

Based on results of the 2018 AEMP, Action Level triggers were identified for:

- toxicological impairment:
  - nine water quality parameters in Lake N11 (ice-cover: calculated total dissolved solids [TDS], chloride, potassium, sulphate, nitrate, molybdenum, nickel, and strontium; open-water: chloride, potassium, strontium, and thallium) and four water quality parameters in Area 8 (open-water: chloride, potassium, manganese, and strontium);
  - one plankton variable (zooplankton abundance) in Lake N11; and
  - two benthic invertebrate community variables (Nematoda density and *Corynocera* density) in Lake N11 and two benthic invertebrate community variables (Simpson's diversity index [SDI] and *Corynocera* density) in Area 8.
- nutrient enrichment:
  - one water quality parameter in Lake N11 (ice-cover: nitrate);
  - one plankton variable (phytoplankton biomass) in each of Lake N11 and Area 8; and
  - two benthic invertebrate community variables (Nematoda density and Pisidiidae density) in Area 8.

De Beers notified the MVLWB of these Action Level exceedances on May 15, 2019, in accordance with Part 1 Condition 7 of the Water Licence MV2005L2-0015 (De Beers 2019b). Part 1 Condition 7 also states that De Beers is required to submit an AEMP Response Plan within ninety days of when the exceedances were detected.

In accordance with Schedule 6, Item 4 of Water Licence MV2005L2-0015, the Response Plan should contain the following information where appropriate:

a) *A description of the parameter, its relation to Significance Thresholds and the ecological implication of the Action Level exceedances;*

b) *A summary of how the Action Level exceedance was determined and confirmed;*

c) *Recommended values for subsequent Action Levels;*

d) *A description of likely causes of the Action Level exceedances and potential mitigation options if appropriate;*

e) *A description of actions to be taken by the Licensee in response to the Action Level exceedances including:*

    i) *A justification of the selected action, which may include a cost/benefit analysis;*

    ii) *A description of timelines to implement the proposed actions;*

    iii) *A projection of the environmental response to the planned actions, if appropriate;*

    iv) *A monitoring plan for tracking the response to the actions, if appropriate; and*

    v) *A schedule to report on the effectiveness of actions and to update the AEMP Response Plan as required; and*

f) *Any other information necessary to assess the response to an Action Level exceedance or that has been requested by the Board.*

Components of the aquatic environment that triggered Action Levels for toxicological impairment and nutrient enrichment are presented in the sections that follow, along with a discussion of the likely causes, ecological implications, and response actions. Full details relating to the annual monitoring results for these components are provided in the corresponding sections of the 2018 AEMP Annual Report (De Beers 2019a).

1.1 Board Directives from Review of Version 1

De Beers submitted Version 1 of the 2018 AEMP Response Plan to MVLWB on June 28, 2019. On October 10, 2019, MVLWB informed De Beers that the response plan was to be resubmitted in accordance with the Directives listed in Table 1.1-1.

Table 1.1-1 Concordance of the 2018 AEMP Response Plan for Water Quality, Plankton, and Benthic Invertebrates (Version 2) with MVLWB Directives for Resubmission

Directive from the 2018 Response Plan for Water Quality, Plankton, and Benthic Invertebrates (Version 1 dated June 2019)		Section Number
a	Correct the units and predicted concentration for manganese and strontium, update the status of lake-wide mean/medium manganese and strontium in comparison to the 2018 update EIS Predictions. (ECCC-4 and GNWT-ENR-2)	Secion 2.1.2, Table 2.1-2
b	Update the reference on page 3-11 to EC 2012 to Environment Canada. 2012. Metal Mining Technical Guidance for Environmental Effects Monitoring. National EEM Office, Ottawa, ON, Canada. (ECCC-7)	Not applicable – this reference is not used in Version 2
c	Include the discussion on the ecological implications of increasing nitrate concentrations, increasing nitrate concentration in Lake N11 (including the influence on plankton community) and observed increases in phytoplankton biomass. (GNWT-ENR-4, 16, and 19)	Section 2.1.4 Section 3.1.4 Section 3.2.4
d	Update Section 3.1.3 to include the evidence of discharge from the Water Management Pond contributing to the increase of nitrate concentration, and reflect that nitrate AEMP benchmark is not appropriate for assessing the nutrient. (GNWT-ENR-13)	Section 3.1.3
e	Clarify if nutrient enrichment is mine-related and be consistent. (GNWT-ENR-18)	Section 3.1.3 Section 3.2.3
f	Clarify if evidence of nutrient enrichment has been observed. (GNWT-ENR-23)	Section 3.1.3 Section 3.2.3 Section 3.3.3 Section 3.4
g	Clarify the mesh size used to conduct field sampling and the recommendation to remove Nematodes. (MVLWB-3)	Section 2.3.5

Source: MVLWB (2019).

AEMP = Aquatic Effects Monitoring Program; EIS = Environmental Impact Statement; ECCC = Environment and Climate Change Strategy; GNWT-ENR = Government of Northwest Territories Environment and Natural Resources; MVLWB = Mackenzie Valley Land and Water Board.

2 TOXICOLOGICAL IMPAIRMENT

2.1 Water Quality

2.1.1 Parameter Description

The 2018 water quality data were evaluated in relation to Action Levels for toxicological impairment responses under the Response Framework in the AEMP Design Plan (De Beers 2016a). Based on the Toxicological Impairment Hypothesis, concentrations of nine water quality parameters in Lake N11 (ice-cover: TDS, chloride, potassium, sulphate, nitrate, molybdenum, nickel, and strontium; and, open-water: chloride, potassium, strontium, and thallium) and four in Area 8 (open-water: chloride, potassium, manganese, and strontium) triggered the Low Action Level.

The Significance Thresholds for Lake N11, Area 8, and all waters downstream of Kennady Lake are defined in Section 8.3 of the AEMP Design Plan (De Beers 2016a). Significance Thresholds are the levels of change that, if exceeded, would result in significant adverse effects to valued components of the environment. The selection of Significance Thresholds was based on the commitment by De Beers that traditional water uses should not be affected by mining activities throughout construction, operations, and closure and reclamation. Traditional water uses include drinking the water and harvesting and consuming fish. The Significance Thresholds for the water quality component are defined as:

- *Water is not drinkable (i.e., risk to human health and/or wildlife).*
- *Ecological function is not maintained (i.e., inadequate food for fish; fish unable to survive, grow and reproduce; and/or sustained absence of a fish species).*

An effect equivalent to the Significance Threshold for a water quality parameter would occur if:

- a risk assessment determined that water is not safe for humans and or wildlife, or
- if water quality conditions result in an adverse effect on ecological function to the extent that it is no longer maintained.

The Low Action Levels triggered in 2018 pertain to ecological function. No Action Levels were triggered for drinking water; therefore, Action Levels and the Significance Threshold related to drinking water are not discussed further in this document.

2.1.2 Action Level Determination

Action Levels for toxicological impairment for the water quality component, as it relates ecological function, are defined in the AEMP Design Plan (Section 8.4 in De Beers 2016a) and are reproduced in Table 2.1-1. The Action Level classifications incorporate the results of the *before-after control-impact* (BACI) analysis and comparisons of AEMP data to the normal range, as described in Sections 5.2.3.2.3 and 5.2.3.2.2, respectively of the 2018 AEMP Annual Report (De Beers 2019a).

To assess whether, on average, water quality parameter concentrations or values measured in the core lakes in 2018 fell outside the range of natural variability, lake-wide mean/median concentrations were compared to their representative normal ranges. The normal ranges were developed in consideration of baseline data (i.e., 1996 to 2013, or a subset of those years). The method to calculate the normal ranges for whole-lake mean concentrations is described in the 2015 AEMP Annual Report (De Beers 2016b).

Table 2.1-1 Action Levels for Toxicological Impairment for the Water Quality Component

Action Level	Toxicological Impairment
Low[a]	Lake-wide average value/concentration greater than normal range or EIS prediction, supported by a visual temporal trend **AND** Lake-wide average concentration exceeds 75% of AEMP benchmark[b] **OR** Relative difference between core lake and reference lakes statistically significant compared to baseline (i.e., significant BACI effect detected)
Moderate	*TBD*[c]
High	*TBD*[c]

a) Changes below the Low Action Level are within the estimated magnitude of background variation and are considered to represent negligible levels of environment change.

b) Benchmarks currently used in the AEMP to which substance concentrations are compared (i.e., EIS benchmarks and CCME guidelines for the protection of aquatic life). This criterion does not apply if no benchmark exists.

c) TBD if Low Action Level is reached.

TBD = to be determined; BACI = *before-after control-impact*; AEMP = Aquatic Effects Monitoring Program; EIS = Environmental Impact Statement.

To evaluate potential Low Action Level triggers, concentrations in core lakes were compared to AEMP benchmarks, which were developed based on Canadian Council of Ministers for the Environment (CCME) Canadian water quality guidelines for the protection of aquatic life (CWQG-PAL; CCME 1999); some of the AEMP benchmarks are lake specific, as defined in Table 9.2-5 of the AEMP Design Plan (De Beers 2016a).

For the purpose of the Action Level evaluation, it was assumed that the criterion related to the BACI analysis was met if:

- significant BACI effects are detected relative to both reference lakes, with the changes representing increases relative to the reference lakes;
- the measurement endpoint (i.e., concentration or value) in the *impact* (i.e., core) lake showed a clear increase between the *before* and the *after* period, with the exception of pH and dissolved oxygen (DO), which could cause toxicological impairment if they decrease, and the direction of this change differed from the trends observed in the *control* (i.e., reference) lakes; and
- the effects can be linked to the Mine through corresponding changes of sufficient magnitude in other ecosystem components (e.g., hydrology, Surveillance Network Program [SNP] results, and potentially other supporting environmental data).

Lake N11 mean/median concentrations of chloride, potassium, nitrate, barium, strontium, and thallium were higher than their normal range upper bound concentrations during ice-cover and open-water. Mean/median concentrations of fluoride, sulphate, nitrite, TDS, arsenic, molybdenum, and nickel were higher than their normal range upper bound concentrations during ice-cover only. During open-water, mean/median concentrations of total phosphorus (TP) and manganese were higher than their normal range upper bound concentrations. For both seasons, none of these parameters had lake-wide average concentrations that were above 75% of AEMP benchmarks.

After consideration of detection limits and normal ranges, significant BACI effects relative to both reference lakes that could potentially be attributable to the Mine were detected during ice-cover in Lake N11 for TDS, chloride, potassium, sulphate, nitrate, molybdenum, nickel, strontium, and uranium (Table 2.1-2). For open-water, significant BACI effects relative to both reference lakes that could potentially be attributable to the Mine were detected in Lake N11 for field specific conductivity, chloride, potassium, strontium, and thallium. As a result, the Low Action Level was triggered for nine water quality parameters in Lake N11 under on the Toxicological Impairment Hypothesis (ice-cover: TDS, chloride, potassium, sulphate, nitrate, molybdenum, nickel, and strontium; and, open-water: chloride, potassium, thallium, and strontium), on the basis that their lake-wide average concentrations in Lake N11 were greater than the normal range and the relative difference from the reference lakes was statistically significant.

For Area 8, during ice-cover, lake-wide mean/median concentrations for TDS, potassium, total ammonia, arsenic, barium, nickel, and thallium exceeded the upper bound of the normal range. For the open-water period, mean/median TDS, potassium, chloride, sulphate, barium, cobalt, iron, manganese, strontium, and uranium concentrations exceeded the upper bound of the normal range. For both seasons, none of these parameters had lake-wide average concentrations that were above 75% of AEMP benchmarks.

After consideration of detection limits and normal ranges, significant BACI effects relative to both reference lakes that could be potentially attributable to the Mine were detected in Area 8 during open-water conditions for field specific conductivity, chloride, potassium, manganese, strontium, and thallium. No significant BACI effects relative to both reference lakes were detected during ice-cover conditions that could potentially be attributable to the Mine. As a result, the Low Action Level was triggered for four water quality parameters in Area 8 under the Toxicological Impairment Hypothesis (open-water: chloride, potassium, manganese, and strontium), based on lake-wide average concentrations being greater than their normal range and the relative difference from the reference lakes being statistically significant.

Table 2.1-2 Summary of Comparisons for Water Quality Action Levels for Toxicological Impairment

Lake	Parameter	Unit	Normal Range		2018 AEMP Lake-wide Mean/ Median	Normal Range Exceeded?	AEMP Benchmark	Exceeds 75% of AEMP Benchmark?	2018 Update EIS Predictions (Maximum Operations Conditions)[a]	Exceeds 2018 EIS Predictions?	BACI Analysis	
			Lower Bound	Upper Bound							Type of Effect[b]	Direction Relative to Reference Lakes
Ice-cover												
Lake N11	TDS, calculated	mg/L	5	8.2	56	yes	500	no (11%)	253	no	Press and Pulse[c]	↑
	Chloride	mg/L	0.5	1.04	17	yes	120	no (14%)	98	no	Press and Pulse	↑
	Potassium	mg/L	0.492	0.741	1.83	yes	41	no (4%)	3.6	no	Press and Pulse	↑
	Sulphate	mg/L	0.5	0.7	5.1	yes	41	no (12%)	15	no	Press[c] and Pulse	↑
	Nitrate	mg-N/L	0.00496	0.0403	2.20	yes	3.76[d]	no (69%)	7.4[e]	no	Press and Pulse	↑
	Molybdenum	µg/L	0	0.05	0.074	yes	73	no (0.1%)	2.4	no	Press	↑
	Nickel	µg/L	0.216	0.344	0.538	yes	25	no (2%)	2.7	no	Press and Press	↑
	Strontium	µg/L	9.23	13.0	85.8	yes	10,700[f]	no (0.8%)	450	no	Press and Pulse	↑
Open-water												
Lake N11	Chloride	mg/L	0	1.02	7.56	yes	120	no (6%)	98	no	Press and Pulse	↑
	Potassium	mg/L	0.347	0.39	0.85	yes	41	no (2%)	3.6	no	Press and Pulse	↑
	Strontium	µg/L	6.01	6.54	35.6	yes	10,700[f]	no (0.3%)	450	no	Press[c] and Pulse	↑
	Thallium	µg/L	0	0.0026	0.0033	yes	0.8	no (0.4%)	0.1	no	Press	↑
Area 8	Chloride	mg/L	0	0.8	2.5	yes	120	no (2%)	4.6	no	Press	↑
	Potassium	mg/L	0	0.5[g]	0.59	yes	41	no (1.4%)	1.9	no	Press and Pulse	↑
	Manganese	µg/L	2.88	4.5	7.3	yes	-	-	40	no	Press and Pulse	↑
	Strontium	µg/L	6.46	8.31	13.3	yes	10,700[f]	no (0.1%)	32	no	Pulse	↑

a) Source: De Beers (2018a).

b) Press (long-term) and pulse (short-term) effects.

c) Both press and pulse effects detected, but each significant relative to only one reference lake.

d) Hardness-dependent site-specific water quality objective (SSWQO) for nitrate was accepted by the MVWLB as part of the 2018 Water Licence Amendment (MVLWB 2018b); this new SSWQO was used as the AEMP benchmark. Lake-wide median hardness during ice-cover conditions in Lake N11 was 34 mg/L; therefore, the nitrate benchmark at this hardness is 3.76 mg-N/L.

e) Predicted maximum calcium and magnesium concentrations were 38 mg/L and 7.7 mg/L, respectively (De Beers 2018a), which yield a maximum predicted calculated hardness of 127 mg/L. Therefore, the associated nitrate AEMP benchmark at the maximum predicted nitrate concentration of 7.4 mg-N/L would be 12.9 mg-N/L.

f) Revised SSWQO for strontium (MVLWB 2018b) was used as the AEMP benchmark.

g) The upper bound of the normal range was below the lowest detection limit; therefore, the upper bound of the normal range was set to the lowest detection limit (Table 5.2-5 in De Beers 2019a).

BACI = *before-after control-impact*; AEMP = aquatic effects monitoring program; EIS = Environmental Impact Statement; TDS = total dissolved solids; ↑ = increase; - = not applicable or data not available; mg/L = milligrams per litre; mg-N/L = milligrams of nitrogen per litre; µg/L = micrograms per litre; SSWQO = site-specific water quality objective; MVLWB = Mackenzie Valley Land and Water Board; mg-Ca/L = milligrams of calcium per litre; mg-Mg/L = milligrams of magnesium per litre.

2.1.3 Likely Causes and Lines of Evidence

Although water quality in Lake N11 and Area 8 satisfied the Low Action Level criteria for toxicological impairment, analysis of other lines of evidence provided no consistent indication of a toxicological impairment effect in Lake N11 and Area 8. This interpretation is based on the following lines of evidence:

- Significant BACI effects indicating increasing concentrations relative to both reference lakes and concentrations above the normal ranges in Lake N11 were identified for TDS, chloride, potassium, sulphate, nitrate, molybdenum, nickel, and strontium during ice-cover conditions, and chloride, potassium, strontium, and thallium during open-water conditions (Table 5.6-2 in De Beers 2019a). These changes are attributed to the operational discharges from the water management pond (WMP) to Lake N11. However, lake-wide mean/median concentrations for all water quality parameters in Lake N11 during ice-cover and open-water conditions were within expectations and remained below 75% of the AEMP benchmarks. A change in water quality was expected during operations; the Environmental Impact Statement (EIS) and subsequent water quality modelling updates projected that concentrations of nutrients, TDS, major ions, and some metals in Lake N11 would increase as a result of operational discharge from the WMP to Lake N11, but would remain within AEMP benchmarks (De Beers 2011, 2012, 2018a).
- Significant BACI effects indicating increasing concentrations relative to both reference lakes and concentrations above the normal ranges were identified for chloride, potassium, manganese, and strontium in Area 8 during open-water conditions (Table 5.6-2 in the 2018 AEMP Annual Report; De Beers 2019a). These increasing concentrations may be related to hydrological changes to Area 8 through its isolation from Kennady Lake and its upper watershed, resulting in a modified watershed area and reduced flows (i.e., longer residence time and greater potential for evaporation). Further compounding the hydrological changes was the consecutive dry climate conditions in 2016, 2017, and 2018 and the short duration of downstream flow mitigation pumping from Lake N11. A combination of these factors has likely influenced water quality in Area 8, and therefore contributed to the increasing concentrations of these parameters, especially during open-water conditions. A change in water quality was expected during operations; the EIS and subsequent water quality modelling updates projected that concentrations of nutrients, TDS, major ions, and some metals in Area 8 would increase as a result of isolation of Area 8 from Kennady Lake, but would remain within AEMP benchmarks (De Beers 2011, 2012, 2018a).
- Concentrations of the parameters listed above exceeded the upper bound of their respective normal ranges. However, there is uncertainty associated with the accuracy of the normal ranges, as a result of limited data used to calculate them. The core lake normal ranges may be updated at the Aquatic Effects re-evaluation stage, based on an evaluation of data collected from each core lake during the construction and early operations phases of the Mine.
- The Low Action Level triggers in 2018 are attributed in part to the application of conservative Action Level criteria. Under the current AEMP Response Framework, the Low Action Level is triggered for water quality if the lake-wide average of a parameter exceeds the normal range and <u>either</u> there is a significant BACI effect <u>or</u> lake-wide average concentration exceeds 75% of the AEMP benchmark. The Action Level criteria used for the Low Action Level for toxicological impairment should be revised so that the sensitivity of the AEMP Response Framework is appropriate for responding to Mine-related effects or appropriate magnitude. This recommended revision involves changing the Low Action Level definitions to replace the “or” logical operator with “and”, thereby requiring all three criteria be met before the Low Action Level is triggered.

2.1.4 Ecological Implications

The Low Action Level triggers identified for water quality during the 2018 monitoring period are considered to represent a low-level effect on water quality in Lake N11 and Area 8, below levels that would be of concern to aquatic life. Concentrations of each parameter that triggered Low Action Levels based on the Toxicological Impairment Hypothesis remain below AEMP benchmarks for the protection of aquatic life. A short-term increase in nitrate concentrations in Lake N11 was predicted in the EIS due to discharge from the WMP during operations. Although the 2018 lake-wide mean concentration of nitrate has reached 69% of the AEMP benchmark at the time of the under-ice sampling event (April 2018), mean concentration was lower during the open-water season (i.e., 2.20 mg-N/L under-ice compared to 0.375 mg-N/L open-water). In addition, nitrate concentrations in the discharge met the effluent quality criteria (EQC), which were developed to be protective of the receiving environment.

The weight of evidence analysis found no evidence of effects due to toxicological impairment related to changes in water quality on plankton, benthic invertebrates, or fish (Section 14.3.2.2.1 in De Beers 2019a). There were some changes in exposure endpoints, but observed biological responses were inconsistent with a toxicological effect. The ecological implications of the observed change in water quality on the aquatic ecosystems of Lake N11 and Area 8 are therefore considered to be negligible to minor.

2.1.5 Response Actions

Annual and seasonal water quality monitoring will continue in the core and reference lakes, according to the schedule defined in the AEMP Design Plan (De Beers 2016a). The 2019 AEMP monitoring data will be examined to confirm whether the observed changes in water quality in Lake N11 and Area 8 have persisted or reverted back to conditions similar to baseline. Water quality changes are anticipated to continue in 2019 as a result of mine-related activities. Water will continue to be discharged in to Lake N11 as part of the water management plan and in accordance with effluent quality criteria. In addition, dry conditions are forecasted again in the area for 2019; therefore, water quality conditions in Area 8 will be similar to 2018.

The results of the 2019 monitoring program will be reported in the 2019 AEMP Annual Report, to be submitted in May 2020. The weight of evidence assessment will continue as part of the 2019 AEMP to determine the strength of linkage between exposure, toxicity, and field biological responses. The upcoming Aquatic Effects Re-evaluation Report will evaluate overall patterns in Mine-related effects on water quality from 2015 and 2018.

The water quality parameters that triggered Low Action Levels in 2018 did so based on the results of the BACI analysis and/or normal range comparisons. Lake-wide average concentrations of most parameters were well below 75% of AEMP benchmark criterion. Therefore, concentrations of water quality parameters with Low Action Level exceedances are not expected to adversely affect aquatic life.

The results of the water quality data analysis provide some indication that the Low Action Levels triggered represent Mine-related effects in Lake N11 and Area 8. However, the magnitudes of the observed effects for most of the parameters are low and not reflective of the changes typically associated with an Action Level trigger. Changes in water quality are expected in the core lakes as a result of the Mine, and measured concentrations are within updated EIS predictions. Therefore, the main response action is intended to address oversensitivity of the currently approved Action Levels in response to Mine-related effects. Data handling and analysis methods used for the AEMP that may have contributed to the unrealistically high sensitivity of the Low Action Level criteria will also be examined as part of the Aquatic Effects re-evaluation, and changes to the Action Levels will be proposed as appropriate. Consideration will be given to specific recommendations for changes to Action Levels and data analysis methods provided in Section 4 of this technical memorandum.

In addition to the above, as per the recently finalized *Guidelines for Aquatic Effects Monitoring Programs* (MVLWB and GNWT 2019), Moderate and High Action Levels will be developed as part of the updated AEMP Design Plan.

2.2 Plankton

2.2.1 Parameter Description

The 2018 plankton community data were evaluated in relation to Action Levels for toxicological impairment responses under the Response Framework in the AEMP Design Plan (De Beers 2016a). Results of the Action Level evaluation indicate that one of the plankton endpoints (zooplankton abundance) triggered the Low Action Level for toxicological impairment in Lake N11. None of the variables evaluated in Area 8 triggered Action Levels based for the Toxicological Impairment Hypothesis.

The Significance Threshold for plankton is defined in terms of a corresponding effect on fish communities, as:

- *Ecological function is not maintained (i.e., inadequate food for fish; fish unable to survive, grow and reproduce; and/or sustained absence of a fish species).*

Therefore, an effect equivalent to the Significance Threshold for plankton would occur if changes in phytoplankton or zooplankton biomass or community structure resulted in a change in food availability that adversely affects fish communities.

2.2.2 Action Level Determination

Action Levels for toxicological impairment for the plankton component are defined in the AEMP Design Plan (Section 8.4 in De Beers 2016a) and are reproduced in Table 2.2-1. The Action Level classifications incorporate comparisons of AEMP data to the normal range and the results of the BACI analysis, as described in Sections 7.2.3.8 and 7.2.3.7, respectively, of the 2018 AEMP Annual Report (De Beers 2019a). The Low Action Level for the Toxicological Impairment Hypothesis for plankton is based on two trigger statements; if one or both of these trigger statements are true, the Low Action Level is triggered. When seasonality was present in the baseline dataset, separate normal ranges were calculated for each of the three sampling events (i.e., June/July, August, and September); this was done when calculating normal ranges for the zooplankton abundance and biomass endpoints. For the Action Level assessment, 2018 data from at least two sampling events must be outside the normal range for the trigger statement to be considered true.

Table 2.2-1 Action Levels for Toxicological Impairment for the Plankton Component

Action Level	Toxicological Impairment
Low[b]	Lake-wide average value for total phytoplankton biomass, zooplankton abundance, or zooplankton biomass less than normal range **OR** A statistically significant relative difference in total phytoplankton biomass, zooplankton abundance, or zooplankton biomass, between core lake and reference lakes compared to baseline (i.e., significant BACI effect detected)
Moderate	*TBD*[a]
High	*TBD*[a]

a) TBD if Low Action Level is reached.

b) Changes below the Low Action Level are within the estimated magnitude of background variation and are considered to represent negligible levels of environmental change.

TBD = to be determined; BACI = *before-after control-impact*.

The Low Action Level for Toxicological Impairment for total zooplankton abundance in Lake N11 was triggered in 2018 based on two consecutive sampling events (August and September) falling below the lower bound of the normal range (Table 2.2-2).

Significant negative press or pulse effects in core lakes relative to both reference lakes were not observed in a minimum of two out of three sampling periods for any of the variables assessed; therefore, the Low Action Level for total zooplankton abundance was not triggered based on BACI analysis results.

Table 2.2-2 Summary of Comparisons for Plankton Action Levels for Toxicological Impairment

Lake	Variable	Normal Range Lower Bound[a,b]			2018 AEMP Lake-wide Mean[c]			Lower Bound Exceeded	BACI Analysis	
		Jun/Jul	Aug	Sep	Jun/Jul	Aug	Sep		Type of Effect	Direction Relative to Reference Lakes
Lake N11	Zooplankton Abundance (org/L)	32	31	27	43	**24**	**23**	Yes (Aug, Sep)	-	-

a) Normal range for the mean of a sample of size of 5 (n = 5) (De Beers 2019a).

b) Because seasonality was present in the zooplankton datasets, separate lower bounds were calculated for each of the three sampling events (i.e., July, August, and September) based on the regression equation and the sampling dates from the 2018 AEMP (De Beers 2019a).

c) Values below the normal range are **bolded**.

Jun/Jul = June/July; Aug = August; Sep = September; org/L = organisms per litre; n = sample size; AEMP = Aquatic Effects Monitoring Program. BACI = *before-after control-impact*; - = no effect.

2.2.3 Likely Causes and Lines of Evidence

Although zooplankton abundance satisfied the Low Action Level criteria for toxicological impairment in Lake N11, analysis of the zooplankton community and biomass data in Lake N11 did not provide a consistent indication of a toxicological effect. Similarly, analysis of the phytoplankton community and biomass data in Lake N11 did not indicate toxicological impairment, but rather suggested mild nutrient enrichment. The Low Action Level trigger for zooplankton abundance is more likely to be related to year-to-year variability in zooplankton abundance and the limited data used to estimate the normal range for zooplankton abundance, than toxicological impairment of the community. This conclusion is based on the following lines of evidence:

- The water quality component identified increases in the concentrations of several variables that have the potential to cause toxicity to aquatic organisms (TDS, chloride, potassium, sulphate, nitrate, molybdenum, nickel, thallium, and strontium); however, none of the concentrations of these parameters exceeded guidelines in the core lakes, indicating that they are not found at concentrations that would result in a toxicological effect on the zooplankton community in Lake N11.
- Mean annual total zooplankton abundance in the core lakes in 2018 was near or below baseline but was higher than values in the reference lakes, and there were no consistent BACI effects found for zooplankton abundance for Lake N11 relative to both reference lakes.
- Mean annual zooplankton biomass in Lake N11 was higher than the biomass in the reference lakes in 2018, and statistical comparisons of zooplankton community composition by abundance and biomass at the species level indicated no significant differences from baseline.
- The 2018 results are consistent with EIS predictions of a negligible to low effect on the plankton community in Lake N11. The results did not reveal a consistent indication of toxicological impairment, but rather suggested that mild nutrient enrichment is affecting the plankton communities in the core lakes.

2.2.4 Ecological Implications

Overall, there was no consistent evidence to suggest that the Low Action Level exceedance identified for zooplankton abundance in Lake N11 was caused by mining activities, or that the changes observed in 2018 were related to toxicological impairment of the zooplankton community. The observed changes likely reflect among-year variability in the zooplankton community. Oversensitivity of the Low Action Level criterion, related to meeting a single condition for a trigger, also contributed to the Low Action Level trigger reported in 2018. As such, the response observed in zooplankton abundance does not reflect adverse effects on the aquatic ecosystems of Lake N11.

2.2.5 Response Actions

Zooplankton abundance in the core and reference lakes will continue to be monitored on an annual basis according to the schedule defined in the AEMP Design Plan (De Beers 2016a). The 2019 AEMP monitoring data will be examined to confirm whether the observed decrease in zooplankton abundance has persisted and the results will be reported in the 2019 AEMP Annual Report, to be submitted in May 2020. Weight of evidence assessment will continue as part of the 2019 AEMP to determine the strength of linkage between exposure, toxicity, and field biological responses. The upcoming Aquatic Effects Re-evaluation Report will evaluate overall patterns in Mine-related effects on water quality and plankton from 2015 and 2018.

The results of the plankton data analysis do not provide a strong indication that the Low Action Level trigger identified for zooplankton abundance in 2018 represents a Mine-related effect in Lake N11. Therefore, the main response action is to address the unrealistically high sensitivity of the currently approved Action Levels. As described in Section 2.1.5, data analysis methods used for the AEMP that may contribute to sensitivity of the Action Levels will be examined as part of the Aquatic Effects Re-evaluation Report. This will include evaluating potential changes to the Action Levels as part of updates to the AEMP Response Framework. Specific recommendations for changes to Action Levels and data analysis methods are discussed in Section 4.

2.3 Benthic Invertebrate Community

2.3.1 Parameter Description

The 2018 benthic invertebrate community data were evaluated in relation to Action Levels for toxicological impairment and nutrient enrichment under the Response Framework in the AEMP Design Plan (De Beers 2016a). Results of the Action Level determination indicate that *Corynocera* and Nematoda density in Lake N11 and benthic invertebrate diversity (as SDI) and *Corynocera* density in Area 8 triggered the Low Action Level for toxicological impairment.

The Significance Threshold for benthic invertebrates is defined in terms of a corresponding effect on fish communities, as:

- *Ecological function is not maintained (i.e., inadequate food for fish; fish unable to survive, grow and reproduce; and/or sustained absence of a fish species).*

Therefore, an effect equivalent to the Significance Threshold for benthic invertebrates would occur if changes in benthic invertebrate density or community structure resulted in a change in food availability that adversely affects fish communities.

2.3.2 Action Level Determination

Action Levels for toxicological impairment for the benthic invertebrate component are defined in the AEMP Design Plan (Section 8.4 in De Beers 2016a) and are reproduced in Table 2.3-1. The Action Level classifications incorporate the results of the BACI analysis and comparisons of AEMP data to the normal range, as described in Sections 8.2.3.5 and 8.2.3.4, respectively, of the 2018 AEMP Annual Report (De Beers 2019a).

Table 2.3-1 Action Levels for Toxicological Impairment for the Benthic Invertebrate Component

Action Level	Toxicological Impairment
Low[(a)]	Lake-wide average value for total density, richness, Simpson’s diversity index, or densities of dominant taxa less than normal range **OR** Relative difference in total density, richness, Simpson’s diversity index, or densities of dominant taxa, between core lake and reference lakes statistically significant compared to baseline (i.e., significant BACI effect detected)
Moderate	*TBD*[(b)]
High	*TBD*[(b)]

a) Changes below the Low Action Level are within the estimated magnitude of background variation and are considered to represent negligible levels of environmental change.

b) TBD if Low Action Level is reached.

BACI = *before-after control-impact*; TBD = to be determined.

For the purpose of the Action Level evaluation, it was assumed that the criterion related to the BACI analysis was met only if:

1) the BACI interaction term was significant relative to both reference lakes, with the changes occurring in the same direction relative to both reference lakes; and

2) the direction of the effect was consistent with the impact hypothesis (i.e., an increase in a variable in the exposure area would indicate a nutrient enrichment effect, whereas a decrease would indicate a toxicological effect).

Nematoda and *Corynocera* density in Lake N11 had lake-wide means below the lower bound of the normal range and diversity, and *Corynocera* density in Area 8 had lake-wide means below the lower bound of the normal range, which both triggered the Low Action Level based on the Toxicological Impairment Hypothesis (Table 2.3-2). There were no significant BACI effects relative to both reference lakes for Lake N11 or Area 8.

Table 2.3-2 Summary of Comparisons for Benthic Invertebrate Action Levels for Toxicological Impairment

Area	Variable	Normal Range		2018 AEMP Lake-wide Mean	Outside Normal Range?	BACI Analysis	
		Lower Bound	Upper Bound			Type of Effect	Direction Relative to Reference Lakes
Lake N11	Nematoda Density (org/m^2)	3,660	11,164	**2,104**	Yes	-	-
	Corynocera Density (org/m^2)	316	67,307	**208**	Yes	-	-
Area 8	Benthic Invertebrate Diversity	0.757	0.869	**0.753**	Yes	-	-
	Corynocera Density (org/m^2)	11	4,906	**0**	Yes	-	-

Note: Values above or below the normal range are **bolded**.
BACI = *before-after control-impact*; org/m^2 = organisms per square metre; - = not applicable.

2.3.3 Likely Causes and Lines of Evidence

Although Nematoda and *Corynocera* density satisfied the Low Action Level criteria for toxicological impairment in Lake N11, analysis of the benthic invertebrate community data in Lake N11 provided no consistent indication of a toxicological effect. Similarly, benthic invertebrate diversity and *Corynocera* density satisfied the Low Action Level conditions for toxicological impairment in Area 8; however, analysis of the benthic invertebrate community data in Area 8 provided no consistent indication of a toxicological effect. Rather, these observed responses appear to be related to habitat characteristics and year-to-year variability in the benthic invertebrate community. This conclusion is based on the following lines of evidence:

- The water quality component identified increases in the concentrations of several variables that have the potential to cause toxicity to aquatic organisms (TDS, chloride, potassium, sulphate, nitrate, manganese, molybdenum, strontium, nickel, and thallium in water); however, none of the concentrations of these parameters exceeded guidelines in the core lakes, indicating that they are not found at concentrations that would result in a toxicological effect on the benthic invertebrate community in Lake N11 or Area 8.
- No Mine-related changes in sediment chemistry was observed in the 2018 AEMP.
- No consistent effects were detected in the benthic invertebrate communities at core lakes relative to reference lakes in 2018.

- The 2018 results are consistent with EIS predictions of a negligible to low effect on the benthic invertebrate community in Lake N11 and Area 8.

In addition to the above factors that relate to the 2018 results, there is uncertainty associated with the accuracy of the normal ranges used for the benthic invertebrate component, as they are based on a single year of baseline monitoring data and, therefore, may not accurately represent baseline conditions in the core lakes. This may have interfered with the ability of the Action Level evaluation to differentiate between Mine-related effects and year-to-year variability in the benthic invertebrate community.

2.3.4 Ecological Implications

Overall, there was no consistent evidence to suggest that the Low Action Level exceedances identified for Nematoda and *Corynocera* density in Lake N11, or benthic invertebrate diversity and *Corynocera* density in Area 8, were caused by mining activities, or that the changes observed in 2018 were related to toxicological impairment of the benthic invertebrate community. The observed changes likely reflect habitat differences and/or among-year variability in the benthic invertebrate community. Oversensitivity of the Low Action Level criterion, related to meeting a single condition for a trigger, also contributed to the Low Action Level trigger reported in 2018. As such, the responses observed in Nematoda and *Corynocera* density or benthic invertebrate diversity do not reflect adverse effects on the aquatic ecosystems of Lake N11 or Area 8.

2.3.5 Response Actions

Benthic invertebrate communities in the core and reference lakes will continue to be monitored on an annual basis according to the schedule defined in the AEMP Design Plan (De Beers 2016a). The 2019 AEMP monitoring data will be examined to confirm whether the observed changes in Nematoda[1] and *Corynocera* density in Lake N11 or benthic invertebrate diversity and *Corynocera* density have persisted and the results will be reported in the 2019 AEMP Annual Report to be submitted in May 2020. Weight of evidence assessment will continue as part of the 2019 AEMP to determine the strength of linkage between exposure, toxicity, and field biological responses. The upcoming Aquatic Effects Re-evaluation Report will evaluate overall patterns in Mine-related effects on water and sediment quality and the benthic invertebrate community from 2015 and 2018.

The results of the benthic invertebrate community data analysis do not provide an indication that the Low Action Level triggers identified in 2018 represent a Mine-related effect in Lake N11 or Area 8, nor do they conclusively show that the change that triggered the Action Level was outside of natural variability. Therefore, the main response action is to address the unrealistically high sensitivity of the currently approved Action Levels. As described in Section 2.1.5, data analysis methods used for the AEMP that may contribute to sensitivity of the Action Levels will be examined as part of the Aquatic Effects Re-evaluation Report. This will include evaluating potential changes to the Action Levels as part of updates to the AEMP Response Framework. Specific recommendations for changes to Action Levels and data analysis methods are discussed in Section 4.

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[1] In Version 1 of the 2018 Response Plan, it was stated that 500 µm mesh was used when collecting the field samples and therefore there was uncertainty in the estimate of Nematoda density. This was an error; 250 µm was used as per the currently approved AEMP Design Plan (De Beers 2016a) and therefore the recommendation to remove Nematoda density from the data analysis is not valid.

2.4 Summary – Toxicological Impairment

Based on the Toxicological Impairment Hypothesis, water quality Low Action Levels were triggered in Lake N11 for TDS, chloride, potassium, sulphate, nitrate, molybdenum, nickel, and strontium during ice-cover conditions, and for chloride, potassium, strontium, and thallium during open-water conditions. The Low Action Level based on the Toxicological Impairment Hypothesis was also triggered for open-water concentrations of chloride, potassium, manganese, and strontium in Area 8. Changes in Lake N11 can be attributed to the operational discharges from the WMP to Lake N11. However, lake-wide mean/median concentrations for all water quality parameters in Lake N11 were within expectations (i.e., 2018 updated EIS predictions), and remained below 75% of the AEMP benchmarks. Increasing parameter concentrations in Area 8 may be related to hydrological changes to Area 8 through its isolation from Kennady Lake, but exacerbated by consecutive dry climate conditions since 2016, and the short duration of downstream flow mitigation pumping from Lake N11. However, increases in water quality parameter concentrations in Area 8 were predicted in the EIS, and remained below 75% of the AEMP benchmarks.

The results of the Action Level evaluation for the plankton and benthic invertebrate components indicated that the Low Action Level based on the Toxicological Impairment Hypothesis was triggered for zooplankton abundance, and Nematoda and *Corynocera* density in Lake N11. In Area 8, benthic invertebrate diversity and *Corynocera* density triggered the Low Action Level for the benthic invertebrate component based on the Toxicological Impairment Hypothesis. Even though the Low Action Level criteria were met for these variables, the overall conclusions of the analysis provided no indication of toxicity-related effects on the plankton or benthic invertebrate communities in Lake N11 or Area 8. In addition, the weight of evidence assessment did not support toxicological impairment in Lake N11 or Area 8 in 2018 (De Beers 2019a).

The response actions identified to address the Low Action Level exceedances for toxicological impairment for the water quality, plankton, and benthic invertebrate components will be:

1) to continue monitoring these components on an annual (and seasonal, where applicable) basis according to the schedule defined in the AEMP Design Plan (De Beers 2016a); and

2) to re-evaluate the AEMP Response Framework and data analysis methods that may contribute to higher than reasonable sensitivity of the Action Levels, as part of the Aquatic Effects Re-evaluation Report.

Criteria for subsequent Action Levels (i.e., Moderate and High Action Levels) are being developed as part of the new AEMP Design Plan. The current Low Action Levels will also be re-evaluated and potentially adjusted because they are believed to be inappropriately scaled and appear to result in false positive triggers.

3 NUTRIENT ENRICHMENT

3.1 Water Quality

3.1.1 Parameter Description

The 2018 water quality data were evaluated in relation to Action Levels for nutrient enrichment responses, and the Low Action Level for nutrient enrichment was triggered in Lake N11 for ice-cover season nitrate concentrations under the Response Framework of the approved AEMP Design Plan (De Beers 2016a). The Significance Thresholds for water quality are defined in Section 2.1.1 and the threshold pertinent to nutrient enrichment is:

- *Ecological function is not maintained (i.e., inadequate food for fish; fish unable to survive, grow and reproduce; and/or sustained absence of a fish species).*

3.1.2 Action Level Determination

Action Levels for nutrient enrichment for the water quality component are defined in the AEMP Design Plan (Section 8.4 in De Beers 2016a) and are reproduced in Table 3.1-1. Data analysis methods used to assess Action Levels based on nutrient enrichment responses are the same as those described for toxicological impairment in Section 2.1.2, and apply to nitrogen and phosphorus parameters.

During the ice-cover season, significant BACI effects were detected in Lake N11 for concentrations of nitrate (Table 3.1-2). The lake-wide mean ice-cover concentration of nitrate also exceeded the upper bound of the normal range but did not exceed 75% of the AEMP Benchmark in Lake N11 (Table 3.1-2). As a result, ice-cover concentrations of nitrate in Lake N11 triggered the Low Action Level based on the Nutrient Enrichment Hypothesis. However, the lake-wide mean ice-cover season nitrate concentration remained below the 2018 updated EIS predictions.

Table 3.1-1 Action Levels for Nutrient Enrichment for the Water Quality Component

Action Level	Nutrient Enrichment
Low[a]	Lake-wide average nitrogen and phosphorus nutrient concentrations greater than normal range or EIS prediction, supported by a visual temporal trend **AND** Lake-wide average nitrogen and phosphorus nutrient concentrations exceed 75% of AEMP benchmark[b] **OR** Relative difference of nitrogen and phosphorus nutrient concentrations between core lake and reference lakes statistically significant compared to baseline (i.e., significant BACI effect detected)
Moderate	*TBD*[c]
High	*TBD*[c]

a) Changes below the Low Action Level are within the estimated magnitude of background variation and are considered to represent negligible levels of environment change.

b) Benchmarks currently used in the AEMP to which substance concentrations are compared (i.e., EIS benchmarks and CCME guidelines). This criterion does not apply if no benchmark exists.

c) TBD if Low Action Level is reached.

TBD = to be determined; BACI = *before-after control-impact*; AEMP = Aquatic Effects Monitoring Program; EIS = Environmental Impact Statement.

Table 3.1-2 Summary of Comparisons for Water Quality Action Levels for Nutrient Enrichment in Lake N11

Lake	Parameter	Unit	Normal Range		2018 AEMP Lake-wide Mean	Upper Bound Exceeded?	AEMP Benchmark	Exceeds 75% of AEMP Benchmark?	2018 Updated EIS Predictions (Maximum Operations Conditions)[a]	Exceeds 2018 Updated EIS Predictions?	BACI Analysis	
			Lower Bound	Upper Bound							Type of Effect[b]	Direction Relative to Reference Lakes
Under-ice												
Lake N11	Nitrate	mg-N/L	0.00496	0.0403	2.20	yes	3.76[c]	No (69%)	7.4[d]	no	Press and Pulse	↑

a) Source: De Beers (2018a).

b) Press (long-term) and pulse (short-term) effects.

c) Hardness-dependent site-specific water quality objective (SSWQO) for nitrate was accepted by the MVWLB as part of the 2018 Water Licence Amendment (MVLWB 2018b); this new SSWQO was used as the AEMP benchmark. Lake-wide median hardness during ice-cover conditions in Lake N11 was 34 mg/L; therefore, the nitrate benchmark at this hardness is 3.76 mg-N/L.

d) Predicted maximum calcium and magnesium concentrations were 38 mg-Ca/L and 7.7 mg-Mg/L (De Beers 2018a), which yield a maximum predicted calculated hardness of 127 mg/L. Therefore, the associated nitrate AEMP benchmark at the maximum predicted nitrate concentration of 7.4 mg-N/L would be 12.9 mg-N/L.

BACI = *before-after control-impact*; AEMP = aquatic effects monitoring program; EIS = environmental impact statement; ↑ = increase; mg-N/L = milligrams of nitrogen per litre; SSWQO = site-specific water quality objective; MVLWB = Mackenzie Valley Land and Water Board; mg-Ca/L = milligrams of calcium per litre; mg-Mg/L = milligrams of magnesium per litre.

3.1.3 Likely Causes and Lines of Evidence

Discharge from the WMP during operations is a source of nitrate to Lake N11. Nutrient enrichment exhibited as an increase in nitrate concentration was observed in Lake N11 in 2018. An increase in nitrate concentrations in Lake N11 was predicted in the EIS.

The discharge to Lake N11 is regulated by EQC to protect the receiving environment. Nitrate concentrations in 2017 at Station SNP-02 (end-of-pipe to Lake N11) were below the EQC. The 2017 discharge occurred from September 4 to November 13, 2017; this was the last discharge prior to the 2018 AEMP under-ice sampling event. As discussed in Section 5.4.2.2.1 of the 2018 AEMP Annual Report, nitrate concentrations were higher during under-ice conditions than during open-water conditions, because the September to November discharge had not completely dispersed from the southern basin by the time of the April AEMP sampling event; this lack of dispersion is likely due to ice cover (limiting wind-driven mixing and tributary inputs) and low flow through the lake. The results suggest that a portion of the effluent, as indicated by nitrate concentrations, remained in the southern basin during under-ice conditions, but dispersed by the June sampling event with the onset of thaw and open-water conditions.

Total phosphorus (TP) is the limiting nutrient in Lake N11 and Area 8. Phosphorus limitation in lakes is denoted by a nitrogen to phosphorus (N:P) ratio that exceeds approximately 7:1 by mass, which corresponds to a molar Redfield ratio of 16:1 (Hecky et al. 1993; Wetzel 2001). Baseline N:P mass ratios in Lake N11 were 50:1 in open-water conditions and 150:1 in under-ice conditions, using median nitrogen and phosphorus data collected up to 2014. These ratios are consistent with, although a little higher than, the general N:P range for Canadian Shield lakes reported by Hecky et al. (1993), Pienitz et al. (1997) and Rühland et al. (2003). In 2018, the N:P ratios in Lake N11 ranged from 126:1 to 867:1 in open-water to under-ice conditions, using lake-wide average nitrogen and phosphorus data. Therefore, as a result of the operational discharge, the increase in nitrogen loading has increased the N:P ratio; however, the associated increase in phosphorus has been non-measurable to very small (i.e., 2018 median TP concentrations were 0.004 mg-P/L during open-water and 0.003 mg-P/L under-ice, compared to baseline median TP concentrations of 0.004 mg-P/L during open-water and 0.002 mg-P/L under-ice). Phosphorus-limited lakes have limited available phosphorus concentrations to sustain primary productivity (Wetzel 2001), and this is generally irrespective of the amount of available nitrogen. Work by Schindler (1974, 2012) and others examining trophic conditions in lakes have illustrated the significance of phosphorus as the principal growth-limiting factor compared to nitrogen (and carbon), especially in oligotrophic lakes. Section 7.4.4 of the 2018 AEMP Annual Report further discusses the trophic status classification of the core lakes; phosphorus-limitation in Lake N11 is illustrated in a multivariate comparison of TP, Secchi depth, and chlorophyll *a* using Carlson's Trophic State Index (TSI) equations (Carlson and Simpson 1996).

There has been an enrichment of nitrogen in Lake N11, as was predicted in the EIS (De Beers 2012), but no measurable enrichment of phosphorus. No significant before-after control-impact (BACI) effects relative to both reference lakes were detected for TP in either core lake in 2018 (Section 5.4.2.5 in the 2018 AEMP Annual Report) and lake-wide mean concentrations were within normal ranges in Area 8 for ice-cover and open-water, and in Lake N11 for ice-cover (Section 5.4.2.5 in the 2018 AEMP Annual Report). The lake-wide mean concentration in Lake N11 for open-water was 0.0052 mg-P/L, which was slightly above the upper bound of the normal range (i.e., 0.00491 mg-P/L). However, no consistent significant BACI effect for TP during open-water was observed related to both reference lakes. Therefore, there is little potential for a shift in productivity in Lake N11 from an oligotrophic to mesotrophic status. The EIS predicted that the overall biological productivity in Lake N11 and farther downstream would increase compared to baseline conditions as a result of short-term operational pumping from the WMP to Lake N11. The increased nutrients were projected to potentially cause increased growth and production in large-bodied fish species as a result of an increased food base, but as the lakes and streams are predicted to remain oligotrophic, changes to habitat suitability or availability (i.e., spawning habitat or winter dissolved oxygen levels) will be minor. This conclusion was based on higher phosphorus concentrations occurring in Lake N11 (0.0085 mg-P/L) than is currently being measured.

Despite the lack of significant change in TP in Lake N11, open-water phytoplankton biomass and chlorophyll *a* results in Lake N11 were consistent with nutrient enrichment. It is possible that under the condition of slight increase in TP concentration, rapid uptake and settling of dead algae may have resulted in no significant TP increase, but a measurable phytoplankton biomass increase.

Although water quality in Lake N11 satisfied the Low Action Level conditions for nutrient enrichment for ice-cover season concentrations of nitrate, based on the BACI analysis and normal range comparison, the use of the current AEMP benchmark for nitrate is not appropriate for further assessing nutrient enrichment. The current AEMP benchmark is based on toxicological data and is therefore only appropriate for evaluating effects related to toxicity. To evaluate the effects of increased nitrogen in the aquatic receiving environment, either development of an additional benchmark specific to nutrient enrichment is recommended, or the parameters to be evaluated need to be specified in consideration of the limiting nutrient in the core lakes (i.e., potentially limiting the Action Level evaluation to phosphorus). The Aquatic Effects Re-evaluation Report will evaluate the need for both a TP and TN benchmark to assess nutrient enrichment in the core lakes based on nutrient limitation and the peer-reviewed literature, and will recommend an appropriate nitrogen benchmark for nutrient enrichment, as an alternative to the nitrate benchmark.

3.1.4 Ecological Implications

The Low Action Level exceedance identified for water quality during the 2018 monitoring period is considered to represent a low-level effect on water quality in Lake N11, below levels that would be of concern to aquatic life. Even though nitrate concentrations triggered the Low Action Level based on the Nutrient Enrichment Hypothesis, no corresponding effects were detected for phosphorus, which is the limiting nutrient in Lake N11.

The observed nutrient concentrations are likely to result in a lower level of productivity than predicted in the 2012 EIS Supplement (De Beers 2012). Nitrogen and phosphorus were projected to peak at 3.4 mg N/L and 0.0085 mg P/L, respectively, in Lake N11 in the last year of operational discharge from the WMP, and then return to pre-development conditions several years after the cessation of discharge. Depth-integrated mean nutrient concentrations in Lake N11 were 1.3, 0.8, and 0.5 mg/L for TN and 0.005, 0.005 and 0.006 mg/L for TP in June/July, August and September 2018, respectively (based on results presented in Appendix 7E of the 2018 AEMP Annual Report). The 2018 AEMP results for phytoplankton biomass in Lake N11 showed significant increasing press and/or pulse BACI effects compared to both reference lakes in June/July, August and September. The significant BACI results for Lake N11 suggest that the operational discharge was influencing phytoplankton biomass during the 2018 open-water season. Chlorophyll *a* results were similar and indicate that the level of productivity in Lake N11 remained within the oligotrophic range in June/July and August, and was within the mesotrophic range in September, although mean open-water concentrations remained within the oligotrophic range. Other indicators of productivity also suggested oligotrophic conditions, on average (see details in Section 7.4.4 in the 2018 AEMP Annual Report). In 2018, lake-wide mean annual phytoplankton community composition by abundance and biomass in Lake N11 showed differences from baseline and from the reference lakes, but did not indicate major community-level changes since baseline that would suggest a Mine-related effect on community composition other than low level nutrient enrichment. Changes in the growth of phytoplankton and algae in Lake N11 were predicted in the EIS and are also expected to be limited to the period of discharge. A lower than projected level of nitrogen and phosphorus in Lake N11 at this time in the Mine operation suggests that the increase in overall productivity associated with the observed changes in plankton biomass is lower than projected in the EIS.

While nitrogen concentration has increased in Lake N11, phosphorus concentration has remained similar to baseline conditions. There has been an enrichment of nitrogen in Lake N11, as was predicted in the EIS (De Beers 2012), but no measurable enrichment of phosphorus; therefore, there is little potential for a shift in productivity in Lake N11 from an oligotrophic to mesotrophic status. The EIS predicted that the overall biological productivity in Lake N11 and downstream would increase compared to baseline conditions as a result of short-term operational pumping from the WMP to Lake N11. The increased nutrients were projected to potentially cause increased growth and production in large-bodied fish species as a results of the increased food base, but as the lakes and streams are predicted to remain oligotrophic, changes to habitat suitability or availability (i.e., spawning habitat or winter dissolved oxygen levels) will be minor. This conclusion was based on higher phosphorus concentrations occurring in Lake N11 (0.0085 mg-P/L) than is currently being measured.

The ecological implications of the increase in phytoplankton biomass in Lake N11 are considered to be minor (Section 3.2), because productivity indicators remain representative of oligotrophic conditions in both lakes, and no major phytoplankton community shifts were observed. If the enrichment persists, the observed slight increases in primary productivity may provide more food for zooplankton, benthic invertebrates and ultimately for fish.

3.1.5 Response Actions

Annual and seasonal water quality monitoring will continue in the core and reference lakes, according to the schedule defined in the AEMP Design Plan (De Beers 2016a). The 2019 AEMP monitoring data will be examined to confirm whether the observed changes in nitrate concentrations in Lake N11 have persisted or returned to baseline conditions, and the results will be reported in the 2019 AEMP Annual Report to be submitted in May 2020. Weight of evidence assessment will continue as part of the 2019 AEMP to determine the strength of linkage between exposure, toxicity, and field biological responses. The upcoming Aquatic Effects Re-evaluation Report will evaluate overall patterns in Mine-related effects on water quality from 2015 and 2018.

In addition, data handling and analysis methods used for the AEMP that may contribute to oversensitivity of the Action Levels will be examined as part of the Aquatic Effects Re-evaluation Report. This will include investigating potential changes to statistical analysis methods and Action Level criteria. Specific recommendations for changes to Action Levels and data analysis methods that will be evaluated as part of the Aquatic Effects re-evaluation are discussed in Section 4. The Aquatic Effects re-evaluation report will recommend an appropriate nitrogen benchmark for nutrient enrichment, as an alternative to the toxicity-based nitrate benchmark.

3.2 Plankton

3.2.1 Parameter Description

The 2018 plankton community data were evaluated in relation to Action Levels for nutrient enrichment responses under the Response Framework in the AEMP Design Plan (De Beers 2016a). Results of the

Action Level evaluation indicate that one of the plankton endpoints (phytoplankton biomass) triggered the Low Action Level for nutrient enrichment in Lake N11 and Area 8.

The Significance Threshold for plankton is defined in terms of a corresponding effect on fish communities, as:

- *Ecological function is not maintained (i.e., inadequate food for fish; fish unable to survive, grow and reproduce; and/or sustained absence of a fish species).*

Therefore, an effect equivalent to the Significance Threshold for plankton would occur if changes in phytoplankton or zooplankton biomass or community structure resulted in a change in food availability that adversely affects fish communities.

3.2.2 Action Level Determination

Action Levels for nutrient enrichment for the plankton component are defined in the AEMP Design Plan (Section 8.4 in De Beers 2016a) and are reproduced in Table 3.2-1. The Action Level classifications incorporate comparisons of AEMP data to the normal range, changes in plankton community composition, and the results of the BACI analysis, as described in Sections 7.2.3.8 (normal range and community composition) and 7.2.3.7 (BACI analysis) of the 2018 AEMP Annual Report (De Beers 2019a).

The Low Action Level for the Nutrient Enrichment Hypothesis for plankton is based on three trigger statements (Table 3.2-1). If one or more of these trigger statements are true, the Low Action Level is triggered.

Only the Action Level criterion related to a statistically significant difference in total phytoplankton biomass between the core and reference lake or compared to baseline (i.e., significant BACI effect detected) is described in detail below, as the other two are not relevant to the Low Action Level exceedance in 2018.

Table 3.2-1 Action Levels for Nutrient Enrichment for the Plankton Component

Action Level	Nutrient Enrichment
Low[(b)]	Lake-wide average value for total phytoplankton biomass, zooplankton abundance, or zooplankton biomass persistently (three consecutive years) above normal range[(c)] **OR** An ecologically relevant change in phytoplankton or zooplankton community composition[(d)] **OR** A statistically significant relative difference in total phytoplankton biomass, zooplankton abundance, or zooplankton biomass, between core lake and reference lakes compared to baseline (i.e., significant BACI effect detected) [(e)]
Moderate	*TBD*[(a)]
High	*TBD*[(a)]

a) TBD if Low Action Level is reached.

b) Changes below the Low Action Level are within the estimated magnitude of background variation and are considered to represent negligible levels of environmental change.

c) Some level of nutrient enrichment is expected and, at a low level, the nutrient enrichment may be beneficial to the plankton community. Thus, a more persistent effect on the plankton community (i.e., three consecutive years) is required to reach the Low Action Level for nutrient enrichment.

d) An ecologically relevant change in plankton community composition was assessed by examining ANOSIM results from monthly MDS ordination plots and monthly stacked bar time series plots of lake-wide means for community composition by major taxonomic group.

e) Two out of three significant BACI results are required for the Action Level to be triggered.

TBD = to be determined; BACI = *before-after control-impact*; ANOSIM = analysis of similarities; MDS = multidimensional scaling.

A significant press and/or pulse effect showing an overall increase compared to both reference lakes was observed for phytoplankton biomass in Area 8 in June/July and August, triggering the Low Action Level for nutrient enrichment (Table 3.2-2). Significant press and/or pulse effects showing an overall increase compared to both reference lakes were also observed for phytoplankton biomass in Lake N11 in June/July, August and September, triggering the Low Action Level for nutrient enrichment.

Table 3.2-2 Summary of Comparisons for Phytoplankton to Action Levels for Nutrient Enrichment

Lake	Variable	Normal Range[(a)] (mg/m^3)	2018 AEMP Lake-wide Mean/Median[(b)] (mg/m^3)			Upper Bound Exceeded	BACI Analysis	
		Upper Bound	Jun/Jul	Aug	Sep		Type of Effect	Direction Relative to Reference Lakes
Area 8	Phytoplankton biomass (mg/m^3)	882	653	**1,644**	**1,318**	Yes (Aug, Sep)	Press and Pulse (Jun/Jul, Aug)	↑
Lake N11	Phytoplankton biomass (mg/m^3)	718	619	**1,132**	**1,879**	Yes (Aug, Sep)	Pulse (Jun/Jul), Press and Pulse (Aug, Sep)	↑

a) Normal range for the mean of a sample of size of 5 (n = 5) (De Beers 2019a).

b) When calculating lake-wide means/medians for core lakes in 2018, the arithmetic mean was used when the 2018 data were determined to be normally distributed based significance of the Shapiro-Wilk test ($P<0.05$). The geometric mean was used to estimate the lake-wide mean in 2018 when normality could be achieved by applying a log-transformation to the data. The median was used to provide an estimate of central tendency in cases where normality could not be achieved by applying a transformation to the 2018 data. Values above the normal range are **bolded**.

Jun/Jul = June/July; Aug = August; Sep = September; mg/m^3 = milligrams per cubic metre; n = sample size. BACI = *before-after control-impact*; ↑ = increase.

3.2.3 Likely Causes and Lines of Evidence

Phytoplankton biomass in Lake N11 and Area 8 satisfied Low Action Level criteria for nutrient enrichment. Similarly, chlorophyll *a* concentrations were consistent with a nutrient enrichment response by the plankton community in both Area 8 and Lake N11. These changes suggest that Mine-related changes may be occurring in both core lakes, but do not signal impairment of biological communities because the plankton communities in the core lakes appear to be healthy. This interpretation is based on the following lines of evidence:

- Significant BACI effects in both core lakes triggered the Low Action Level for nutrient enrichment. These changes in phytoplankton biomass, along with chlorophyll *a* results, suggest Mine-related enrichment effects in the core lakes.
- Water quality results indicate that concentrations of some parameters are increasing in both lakes, but only small increases have been observed to date in the concentration of phosphorus (i.e., the limiting nutrient). As expected, nitrate concentrations are increasing in Lake N11 due to operational discharge. However, nitrate concentrations are not changing in Area 8. Further monitoring is required to evaluate the cause of the observed increases in primary productivity in both core lakes.

The EIS predicted that nutrient concentrations, particularly nitrate, would increase in Lake N11 during operational discharge. Also, the EIS predicted slight increases in nutrients due to the isolation of Area 8 from the Kennady Lake watershed. These changes in nutrients would be expected to increase plankton productivity. The 2018 results were generally consistent with EIS predictions of a negligible to low effect on the plankton community in Area 8 and Lake N11. The results reveal that mild nutrient enrichment may be affecting the plankton communities in the core lakes.

3.2.4 Ecological Implications

The Low Action Level exceedance identified for plankton during the 2018 monitoring period is considered to represent a potential low-level effect on plankton in Lake N11 and Area 8. Although an increase in phytoplankton biomass in Lake N11 and Area 8 was observed in 2018, concentrations of the limiting nutrient (i.e., phosphorus) did not indicate effects consistent with nutrient enrichment. Nitrate concentrations in Lake N11 are increasing due to operational discharge, but are not changing in Area 8. The ecological implications of the increase in phytoplankton biomass in Lake N11 and Area 8 are considered to be minor, because productivity indicators remain representative of oligotrophic conditions in both lakes, and no major phytoplankton community shifts were observed. If the enrichment persists, the observed slight increases in primary productivity may provide more food for zooplankton, benthic invertebrates and ultimately for fish.

3.2.5 Response Actions

The proposed response actions for the Action Level trigger identified for increased phytoplankton biomass based on nutrient enrichment are the same as those identified in Section 3.1.5 for the water quality component, and consist of continued monitoring and evaluation of the statistical method and Action Level criteria as part of the Aquatic Effects re-evaluation.

3.3 Benthic Invertebrate Community

3.3.1 Parameter Description

The 2018 benthic invertebrate community data were evaluated in relation to Action Levels for nutrient enrichment responses under the Response Framework in the AEMP Design Plan (De Beers 2016a). Results of the Action Level determination indicate that the density of two common taxa (Nematoda and Pisidiidae) triggered the Low Action Level in Area 8 based on the Nutrient Enrichment Hypothesis. The Significance Threshold for benthic invertebrates is defined in Section 2.3.1.

3.3.2 Action Level Determination

Action Levels for nutrient enrichment for the benthic invertebrate component are defined in the AEMP Design Plan (Section 8.4 in De Beers 2016a) and are reproduced in Table 3.3-1. Data analysis methods used to assess Action Levels for the Nutrient Enrichment Hypothesis are the same as those described for toxicological impairment in Section 2.3.2.

Table 3.3-1 Action Levels for Nutrient Enrichment for the Benthic Invertebrate Component

Action Level	Nutrient Enrichment
Low[(a)]	Lake-wide average value for total density, richness, Simpson's diversity index, or densities of dominant taxa greater than normal range **OR** Relative difference in total density, richness, Simpson's diversity index, or densities of dominant taxa, between core lake and reference lakes statistically significant compared to baseline (i.e., significant BACI effect detected)
Moderate	*TBD*[(b)]
High	*TBD*[(b)]

a) Changes below the Low Action Level are within the estimated magnitude of background variation and are considered to represent negligible levels of environmental change.

b) TBD if Low Action Level is reached.

TBD = to be determined; BACI = *before-after control-impact*.

Lake-wide means for the density of two common taxa (Nematoda and Pisidiidae) exceeded the upper bound of the normal range in Area 8, each triggering the Low Action Level based on the Nutrient Enrichment Hypothesis (Table 3.3-2). No significant BACI effect in Area 8 consistent with a nutrient enrichment-related effect was detected in any of the variables in 2018.

Table 3.3-2 Summary of Comparisons for Benthic Invertebrate Action Levels for Nutrient Enrichment in Area 8

Variable	Normal Range		2018 AEMP Lake-wide Mean	Upper Bound Exceeded	BACI Analysis	
	Lower Bound	Upper Bound			Type of Effect	Direction Relative to Reference Lakes
Nematoda Density (org/m^2)	128	883	**1,143**	Yes	-	-
Pisidiidae Density (org/m^2)	0	10	**336**	Yes	-	-

BACI = *before-after control-impact*; org/m^2 = organisms per square metre; - = not applicable.

3.3.3 Likely Causes and Lines of Evidence

The 2018 AEMP benthic invertebrate data did not provide consistent evidence to suggest a nutrient enrichment effect in Area 8. Although the plankton component identified an increase in the concentration of chlorophyll *a* and phytoplankton biomass, suggesting that the increase in Pisidiidae density in Area 8 may have been influenced by an increase in primary production, other factors including habitat variation, year-to-year variability in the benthic invertebrate community, and oversensitivity of the Action Level criteria may also have accounted for the Action Level exceedances noted for the benthic invertebrate community in 2018. This interpretation is based on the following lines of evidence:

- No significant increasing BACI effect was observed for benthic invertebrate community endpoints in Area 8 relative to both reference lakes.
- Increases noted in the density of common taxa may have been due to year-to-year variability in the benthic invertebrate community.
- Action Levels for benthic invertebrate variables were dependent on the results of comparisons of AEMP data to the normal range; however, normal ranges were based on a single year of baseline data and are likely too narrow to fully encompass natural variability. This interfered with the ability of the Action Level evaluation to differentiate between Mine-related effects and year-to-year variability in the benthic invertebrate community. Hence, even though Action Level criteria have been triggered, the changes do not appear to be Mine-related.
- No consistent effects were detected in the benthic invertebrate communities in core lakes relative to reference lakes in 2018.
- The weight of evidence assessment suggested that the 2018 results provided evidence of nutrient enrichment of the plankton community, but did not provide evidence of nutrient enrichment of the benthic invertebrate community (De Beers 2019a).
- The 2018 results are consistent with EIS predictions of a negligible to low effect on the benthic invertebrate community in Area 8.

3.3.4 Ecological Implications

Although Nematoda and Pisidiidae densities satisfied the criteria for the Low Action Level trigger for the benthic invertebrate component in 2018, the results of the 2018 AEMP data analysis do not clearly suggest that these triggers were caused by nutrient enrichment of Area 8 because the other benthic invertebrate variables are not responding. Rather, the changes may reflect habitat differences, among-year variation in the benthic invertebrate community and, potentially, oversensitivity of the Action Levels.

Responses for other AEMP endpoints (i.e., phytoplankton biomass and nitrate concentrations) indicate that Mine-related nutrient enrichment is occurring in Area 8; however, the benthic invertebrate community is not demonstrating a clear nutrient enrichment response. It may be that the benthic invertebrate community has not responded to the nutrient enrichment yet. Additional monitoring is needed to confirm whether the changes observed in the benthic invertebrate community in Area 8 are Mine-related. Overall, the 2018 results do not clearly suggest that an adverse effect on the benthic invertebrate community and aquatic ecosystem of Area 8 has occurred.

3.3.5 Response Actions

The proposed response actions for Action Level triggers identified for benthic invertebrate community variables based on nutrient enrichment are the same as those identified in Section 3.1.5 for the water quality component, and consist of continued monitoring and evaluation of statistical methods and Action Level criteria as part of the Aquatic Effects re-evaluation.

3.4 Summary – Nutrient Enrichment

Based on the Nutrient Enrichment Hypothesis for water quality, concentrations of nitrate in Lake N11 triggered the Low Action Level during the ice-cover season. These changes can be attributed to the operational discharges from the WMP to Lake N11. Even though nitrate concentrations triggered the Low Action Level based on the Nutrient Enrichment Hypothesis, no significant effects were detected on the concentration of the limiting nutrient (i.e., phosphorus) in Lake N11. The increase in nitrate concentration represents a low-level, likely transient effect on water quality, with negligible ecological implications.

A significant press and/or pulse effect showing an overall increase compared to both reference lakes was observed for phytoplankton biomass in Area 8 and Lake N11 in June/July and August, and triggered the Low Action Level for nutrient enrichment in both lakes. The observed increases in the core lakes occurred in the absence of significant changes in the concentration of phosphorus (i.e., the key limiting nutrient), and other plankton variables (i.e., zooplankton abundance and biomass) sensitive to nutrient enrichment. However, chlorophyll *a* concentration increased in both lakes. Therefore, the response of the phytoplankton community is consistent with a nutrient enrichment response. Overall, the 2018 results were consistent with EIS predictions of a negligible to low effect on the plankton community in Area 8 and Lake N11.

The density of Pisidiidae increased from the *before* to the *after* period relative to trends in each of the reference lakes. The plankton component identified an increase in the concentration of chlorophyll *a* and phytoplankton biomass in both of the core lakes relative to the reference lakes, indicating that the increase in Pisidiidae density in Area 8 may have been influenced by an increase in primary production. However, other variables, in particular phosphorus, used to evaluate nutrient enrichment did not demonstrate trends that were consistent with nutrient enrichment. Also, no significant increasing BACI effect was observed for benthic invertebrate community endpoints in Area 8 relative to both reference lakes. Overall, the benthic invertebrate community did not demonstrate a clear nutrient enrichment response in Area 8 in 2018.

The weight of evidence assessment suggested that the 2018 results provided evidence of nutrient enrichment of the plankton community but did not support evidence of nutrient enrichment of the benthic invertebrate community (De Beers 2019a).

The response actions identified to address the Low Action Level exceedances for nutrient enrichment for the water quality, plankton, and benthic invertebrate components will be:

1) to continue monitoring these components on an annual (and seasonal, where applicable) basis according to the schedule defined in the AEMP Design Plan (De Beers 2016a);

2) to re-evaluate the data analysis methods; and

3) to re-evaluate Low Action Level criteria, as part of the Aquatic Effects Re-evaluation Report.

Criteria for subsequent Action Levels (i.e., Moderate and High Action Levels) are being developed as part of the new AEMP Design Plan. The current Low Action Levels will also be re-evaluated and potentially adjusted, because they are believed to be inappropriately scaled and appear to result in false positive triggers.

4 RECOMMENDATIONS

The following recommendations are made to address oversensitivity of the AEMP Response Framework. Additional rationale for these recommendations is provided in Section 15.7 of the 2018 AEMP Annual Report (De Beers 2019a):

- The Action Level criteria the Low Action Level for toxicological impairment and nutrient enrichment hypotheses should be re-evaluated so that the sensitivity of the AEMP Response Framework is appropriate for managing Mine-related effects. Under the current AEMP Response Framework, the Low Action Level is triggered for:

  - water quality: if the lake-wide average of a parameter is greater than the normal range or 2018 updated EIS prediction **AND** it exceeds 75% of the AEMP benchmark **OR** there is a significant BACI effect;

  - plankton: if the lake-wide average of a variable is persistently (three consecutive years) outside the normal range, **OR** there is an ecologically relevant change in community composition, **OR** there is a signficant BACI effect; and

  - benthic invertebrates: if the lake-wide average of a variable is outside the normal range, **OR** there is a significant BACI effect.

  A recommended revision consists of changing the Low Action Level definitions to replace the "**OR**" logical operators between the Action Level criteria with "**AND**". This would require all the criteria to be met before the Low Action Level is triggered. A single criterion by itself (e.g., normal range exceedance, or significant BACI effect) should not be sufficient to trigger the Low Action Level, because the evaluation needs to consider both a change in direction relative to the reference lakes and the magnitude of the resulting value. In the case of water chemistry-related components, the magnitude of the measured concentration needs to be considered to avoid triggers that result from normal range exceedances combined with significant BACI results, but at concentrations far below those of toxicological concern.

- Comparisons of AEMP data to normal ranges is a key factor in the evaluation of Action Level exceedances for the water quality, sediment quality, plankton, and benthic invertebrate components. A recommended revision may be to include 2015 (and potentially 2016) data in the normal ranges for the core lakes, or to otherwise adjust normal ranges to appropriately account for year-to-year variability. Inclusion of these data in datasets used to calculate normal ranges would provide a more robust estimate of natural variability in the core lakes and would address issues with the sensitivity of the normal range used to evaluate Mine-related changes.

- The 2015 AEMP plankton data should be included in the before-impact treatment group in the BACI model run on Area 8 during future AEMP cycles. For Lake N11, the 2015 and 2016 AEMP data should be included in the before-impact treatment group in the BACI model. The 2016 AEMP data for Area 8 should be excluded from the normal range or before-impact treatment group, because 2016 results suggest possible Mine-related effects resulting from the disconnection of Area 8 from the rest of Kennady Lake and the resulting reduced watershed area or flows.

- The Aquatic Effects re-evaluation report will recommend an appropriate nitrogen benchmark for nutrient enrichment, as an alternative to the toxicity-based nitrate benchmark.

Revisions to Action Levels and to data analyses that factor into the Action Levels will be evaluated and reported as part of the Aquatic Effects Re-evaluation Report and AEMP Design Plan update.

5 SUMMARY AND CONCLUSIONS

Given the 2018 AEMP data and the methods established in the AEMP Design Plan, Low Action Levels were triggered for:

- Toxicological impairment: ice-cover season concentrations of eight water quality parameters (i.e., calculated TDS, chloride, potassium, nitrate, sulphate, molybdenum, nickel, and strontium), open-water season concentrations of four water quality parameters (i.e., chloride, potassium, strontium and thallium), one plankton variable (i.e., total zooplankton abundance), and two benthic invertebrate variables (i.e., Nematoda and *Corynocera* densities) in Lake N11; and open-water concentrations of four water quality parameters (i.e., chloride, potassium, manganese, and strontium) and two benthic invertebrate variables (i.e., benthic invertebrate diversity and *Corynocera* density) in Area 8.
- Nutrient enrichment: ice-cover season concentrations of nitrate, phytoplankton biomass in Lake N11 and Area 8; and two benthic invertebrate variables (i.e., density of Nematoda and Pisidiidae) in Area 8.

The Low Action Level triggers identified for water quality during the 2018 monitoring period are considered to represent a low-level effect on water quality in Lake N11 and Area 8, below levels that would be of concern to aquatic life. The Low Action Level triggers for Toxicological Impairment for plankton and benthic invertebrate communities may have resulted from narrow normal ranges, combined with Action Level criteria that are too sensitive, because a single criterion by itself (i.e., normal range exceedance or significant BACI effects) can trigger an Action Level. Although the 2018 AEMP results have provided an indication of slight nutrient enrichment in Lake N11 and Area 8, the Low Action Level triggers for Nutrient Enrichment are also influenced by these factors. The factors that may account for Action Level exceedances representing false positive triggers are discussed in more detail in the 2017 and 2018 AEMP annual reports, and recommendations are provided for refining Action Levels to achieve an appropriate level of sensitivity to environmental change (De Beers 2018b, 2019a).

Response actions consist of continued monitoring in 2019 according to the existing AEMP schedule, which will further inform the interpretation of Action Level triggers observed in 2017 and 2018, and re-evaluation of Action Level criteria, normal ranges, and data analysis methods.

Recommendations include updating normal ranges using the 2015 (and potentially 2016) water and sediment quality, plankton, and benthic invertebrate data, re-evaluating the data analysis methods, developing an appropriate nitrogen benchmark for nutrient enrichment, and adjusting the Action Level criteria to reduce false positive triggers by requiring multiple criteria to be true before the Low Action Level is triggered. The 2015 to 2018 Aquatic Effects Re-evaluation Report and AEMP Design Plan update will provide an opportunity to re-evaluate the Action Levels for the AEMP.

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