Table 9.2-18 Projected Water Quality in Lake 410 during All Phases

Parameter	Units	CCME Water Quality Guidelines (a)	Baseline Water Quality (b)	Projected Concentrations			
				Maximum Concentration (b)		Long-term Steady State Concentration (b)	
				2012	2011	2012	2011
Conventional							
Total Dissolved Solids	mg/L	-	16	31	29	21	24
Hardness (c)	mg/L as $CaCO_3$	-	4.5	14	13	8	10
Major Ions							
Calcium	mg/L	-	1.1	4.1	3.5	2.1	2.6
Chloride	mg/L	-	0.49	7.9	6.0	2.2	2.7
Fluoride	mg/L	0.12	0.03	0.04	-	0.044	-
Magnesium	mg/L	-	0.43	0.94	0.92	0.65	0.77
Potassium	mg/L	-	0.39	0.63	1.1	0.6	0.9
Sodium	mg/L	-	0.78	2.4	2.2	1.3	1.7
Sulphate	mg/L	-	0.88	2.7	3.7	2.2	3.2
Nitrogen - Nutrients							
Ammonia	mg N/L	23 (d)	0.019	0.54	0.62	0.03	0.05
Nitrate	mg N/L	2.9	0.019	0.60	0.61	0.04	0.05
Total Nitrogen	mg N/L	-	0.12	1.31	1.4	0.23	0.24
Dissolved Phosphorus	mg/L	-	0.005	0.005	0.005	0.003	0.005
Total Phosphorus	mg/L	-	0.005	0.006	0.007	0.005	0.007
Total Metals							
Aluminum	mg/L	0.1(e)	0.017	0.025	0.026	0.023	0.027
Antimony	mg/L	-	0.000053	0.00016	0.00031	0.00013	0.00027
Arsenic	mg/L	0.005	0.0001	0.00034	0.00043	0.00021	0.00049
Barium	mg/L	-	0.002	0.0056	0.027	0.005	0.018
Beryllium	mg/L	-	0.000064	0.000073	0.00079	0.000073	0.00008
Boron	mg/L	1.5	0.0017	0.013	0.077	0.013	0.05
Cadmium	mg/L	0.000002 (f)	0.000019	0.000022	0.000024	0.000022	0.000024
Chromium	mg/L	0.001	0.00016	0.00026	0.0007	0.00021	0.00032
Cobalt	mg/L	-	0.00019	0.0003	0.00023	0.0003	0.00022
Copper	mg/L	0.002 (f)	0.00099	0.0014	0.0016	0.0014	0.0016
Iron	mg/L	0.3	0.045	0.07	0.09	0.07	0.08
Lead	mg/L	0.001(f)	0.000027	0.00009	0.00009	0.00009	0.00009
Manganese	mg/L	-	0.004	0.0098	0.011	0.0095	0.008
Mercury	mg/L	0.000026	0.0000051	0.0000061	0.0000067	0.000006	0.000006
Molybdenum	mg/L	0.073	0.000014	0.00062	0.0016	0.00047	0.0012
Nickel	mg/L	0.025 (f)	0.00039	0.00086	0.00084	0.00078	0.00079
Selenium	mg/L	0.001	0.000032	0.00006	0.000099	0.00005	0.00007
Silver	mg/L	0.0001	0.0000025	0.000019	0.000017	0.000017	0.000017
Strontium	mg/L	-	0.0069	0.0119	0.03	0.0118	0.024
Thallium	mg/L	0.0008	0.0000012	0.000028	0.000036	0.000017	0.00002
Uranium	mg/L	-	0.000011	0.00017	0.00019	0.00017	0.00023
Vanadium	mg/L	-	0.000039	0.00039	0.00047	0.00039	0.00038
Zinc	mg/L	0.03	0.0024	0.003	0.0034	0.003	0.0029
Dissolved Metals							
Aluminum	mg/L	0.1(e)	0.019	0.022	0.021	0.022	0.022
Antimony	mg/L	-	0.000062	0.00015	0.0003	0.00011	0.00025
Arsenic	mg/L	0.005	0.00012	0.00032	0.00041	0.00019	0.00047
Barium	mg/L	-	0.0027	0.0048	0.026	0.0044	0.017
Beryllium	mg/L	-	0.000064	0.000073	0.000079	0.000073	0.00008
Boron	mg/L	1.5	0.0017	0.013	0.077	0.012	0.05
Cadmium	mg/L	0.000002 (f)	0.000019	0.000022	0. 000023	0.000022	0.000022
Chromium	mg/L	0.001	0.00016	0.00021	0.00065	0.0002	0.00026

Table 9.2-18 Projected Water Quality in Lake 410 during All Phases (continued)

Parameter	Units	CCME Water Quality Guidelines [a]	Baseline Water Quality [b]	Projected Concentrations			
				Maximum Concentration [b]		Long-term Steady State Concentration [b]	
				2012	2011	2012	2011
Cobalt	mg/L	-	0.00019	0.0003	0.0023	0.0003	0.00021
Copper	mg/L	0.002 [f]	0.0013	0.00109	0.0012	0.00109	0.0012
Iron	mg/L	0.3	0.059	0.052	0.069	0.051	0.053
Lead	mg/L	0.001[f]	0.000061	0.00006	0.000056	0.00006	0.00006
Manganese	mg/L	-	0.0057	0.0082	0.009	0.00803	0.0063
Mercury	mg/L	0.000026	0.0000051	0.0000058	0.0000065	0.0000058	0.000006
Molybdenum	mg/L	0.073	0.00003	0.00061	0.0016	0.00046	0.0012
Nickel	mg/L	0.025 [f]	0.00047	0.0007	0.00058	0.00069	0.00053
Selenium	mg/L	0.001	0.000032	0.00005	0.000099	0.00005	0.00007
Silver	mg/L	0.0001	0.0000081	0.000011	0.000012	0.000011	0.000012
Strontium	mg/L	-	0.0069	0.013	0.031	0.013	0.025
Thallium	mg/L	0.0008	0.000014	0.0000151	0.000023	0.0000047	0.0000067
Uranium	mg/L	-	0.000016	0.00017	0.00019	0.00016	0.00022
Vanadium	mg/L	-	0.000094	0.00032	0.00038	0.00032	0.00029
Zinc	mg/L	0.03	0.0024	0.003	0.0034	0.003	0.0029

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

[b] Bold font indicates concentration is higher than the CCME water quality guideline.

[c] Theoretical hardness calculated based on observed calcium and magnesium concentrations.

[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/L as N = milligrams per litre as nitrogen; - = not applicable or not available.

Total Dissolved Solids and Major Ions

Concentrations of TDS and major ions in Lake 410 are projected to increase during the operations phase due to water pumped from the WMP to Lake N11 in the first three years of operations. Temporal patterns of concentrations of these parameters in Lake 410 are similar to those in Lake N11 during operations and Area 8 during post-closure, with the following exceptions:

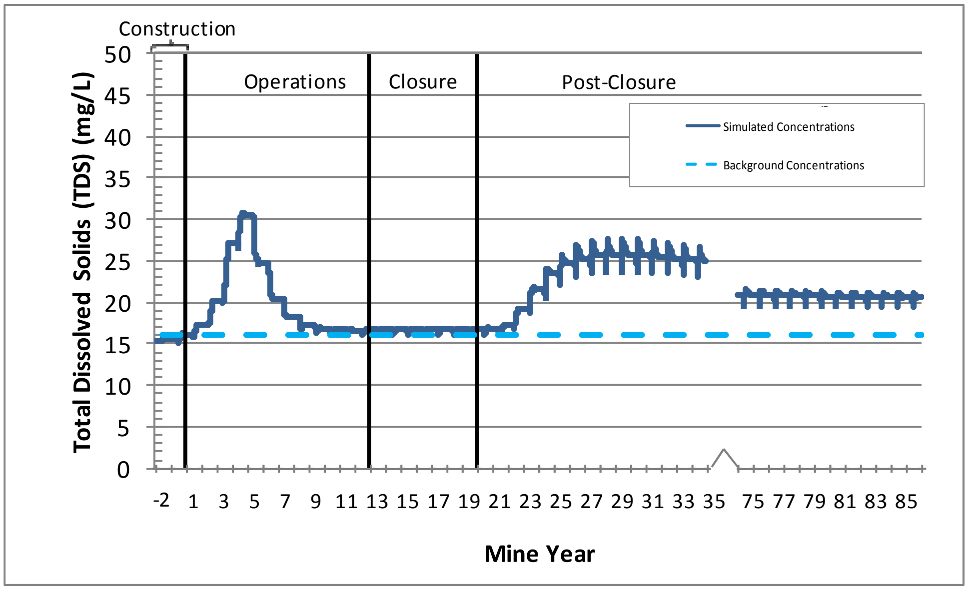
- concentrations are lower in Lake 410 due to dilution from the majority of the Lake 410 watershed, which is anticipated to be unaffected by mining activities; and
- the peaks in concentrations show up one to two years later in Lake 410 than in Lake N11 during operations and Area 8 during post-closure, reflecting travel time.

During the closure phase, concentrations in Lake 410 are projected to return to near background conditions during the refilling period, at which time no water is released from Kennady Lake. During post-closure, when Kennady Lake is reconnected to Area 8, TDS and major ion concentrations in Lake 410 increase again and reach steady state concentrations in the long-term. However, maximum concentrations in Lake 410 are lower than Area 8 due to dilution and the concentration peak is offset by travel time.

In Lake 410, TDS and most major ions follow a similar bimodal time series trend (Figure 9.2-8 for TDS, and Figure 9.2-9 for potassium). The timing and magnitude of maximum projected concentrations are associated with various loading sources, such as groundwater inflows, or geochemical loading through the mine rock and PK storage facilities, or a combination of both. Parameters that have their maximum concentration during operations are more strongly associated with groundwater inflows to the WMP (e.g., TDS), whereas those that have their maximum concentrations following closure, and elevated condition into the future, are more strongly associated with geochemical loadings (e.g., fluoride). Maximum projected and long-term steady state concentrations of TDS and major ions are similar to those presented in the 2011 EIS Update (De Beers 2011).

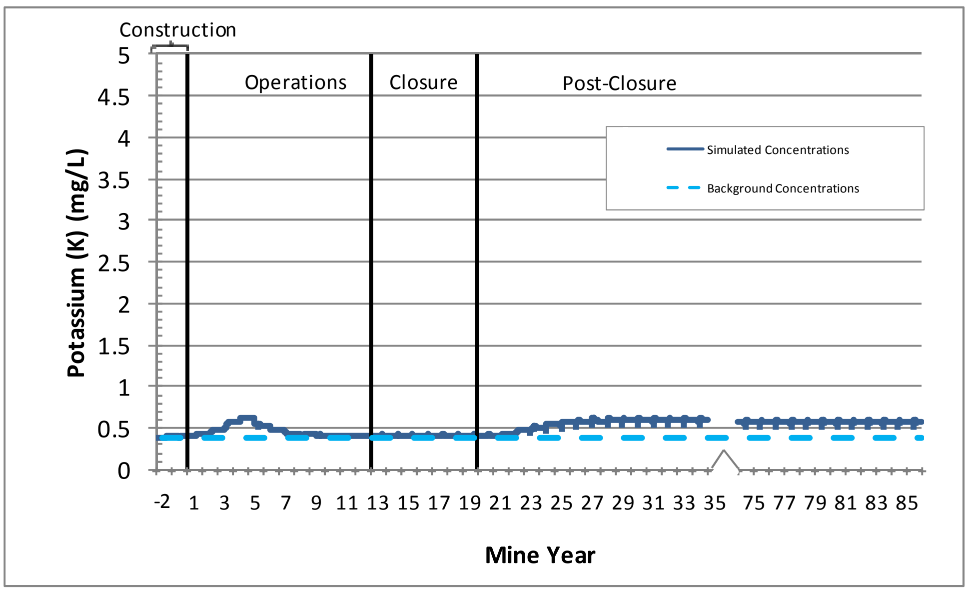
Fluoride in Lake 410 was not modelled in the 2011 EIS Update (De Beers 2011). Fluoride concentrations are projected to slightly increase in early operations due to operational discharge of water from the WMP to Lake N11, decrease to near-background levels following the cessation of operational discharge, and then increase following the reconnection of Kennady Lake (Figure 9.2-10). A steady state is expected to become established within ten years of the reconnection of Kennady Lake with downstream waters. The predominant source of fluoride concentrations is geochemical loading from the PK facilities under the assumption of permafrost-free conditions. However, the maximum and long-term steady state concentrations of fluoride (0.04 mg/L) are below CCME guidelines (Table 9.2.-2, Figure 9.2-10).

Figure 9.2-8 Projected Trends of Total Dissolved Solids Concentrations in Lake 410



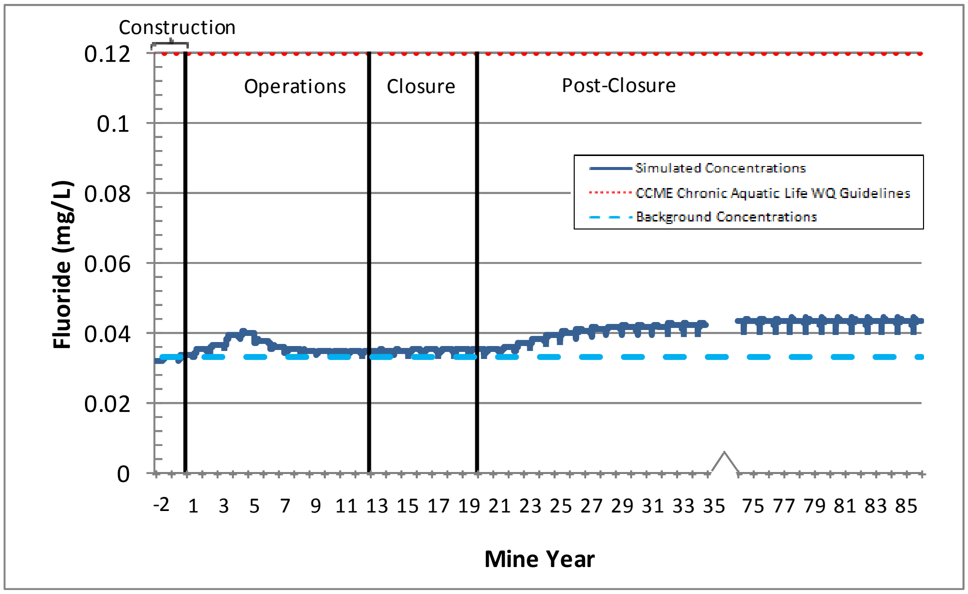
mg/L = milligrams per litre.

Figure 9.2-9 Projected Trends of Potassium Concentrations in Lake 410



mg/L = milligrams per litre.

Figure 9.2-10 Projected Trends of Fluoride Concentrations in Lake 410



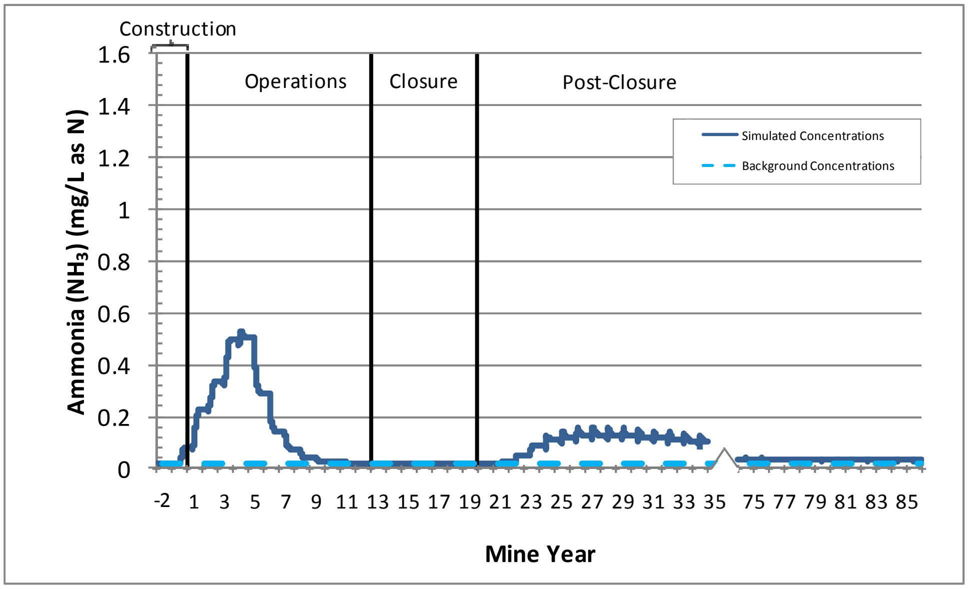
mg/L = milligrams per litre.

Nutrients

Nitrogen

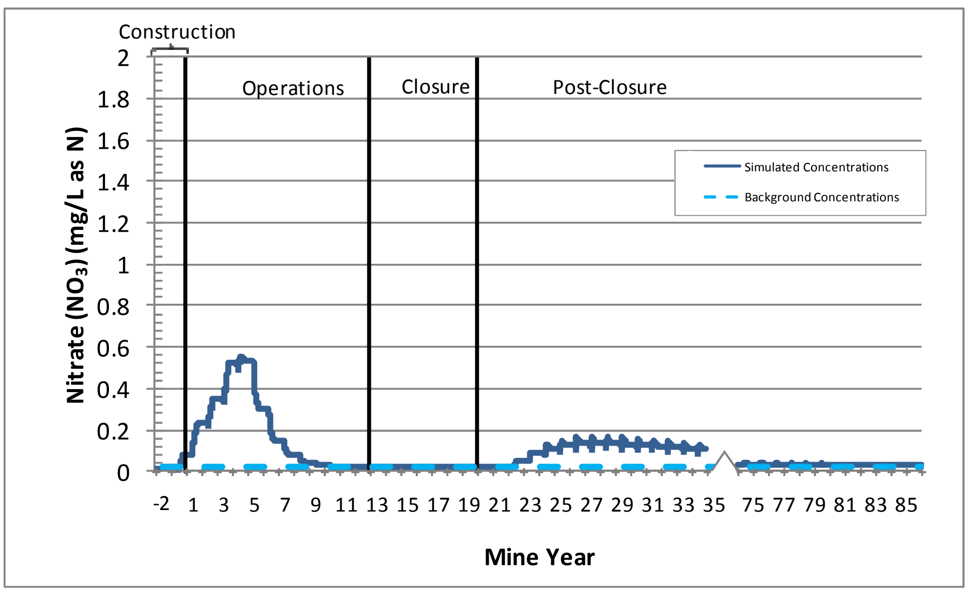
Concentrations of nitrogen-based nutrients, such as nitrate, ammonia, and total nitrogen show a similar bi-modal pattern in the time series plots for TDS and major ions (Figure 9.2-11 for ammonia, and Figure 9.2-12 for nitrate). As discussed for Lake N11, the primary source of ammonia and nitrate in Lake 410 is from the nitrogen residuals associated with blasting activity that enter the WMP during operations, and from flow from Kennady Lake following closure through geochemical loading from the stored mine rock and PK material. After closure, concentrations of ammonia and nitrate are projected to decrease to near-background concentrations (Figure 9.2-11 for ammonia, and Figure 9.2-12 for nitrate) as the blasting residual is depleted. Maximum and long-term concentrations are projected to be similar to those presented in the 2011 EIS Update (De Beers 2011) (Table 9.2-18). Concentrations are projected to remain below CCME guidelines for both nitrate and ammonia during all phases (Table 9.2-18).

Figure 9.2-11 Projected Trends of Ammonia Concentrations in Lake 410



mg/L as N = milligrams per litre as nitrogen

Figure 9.2-12 Projected Trends of Nitrate Concentrations in Lake 410



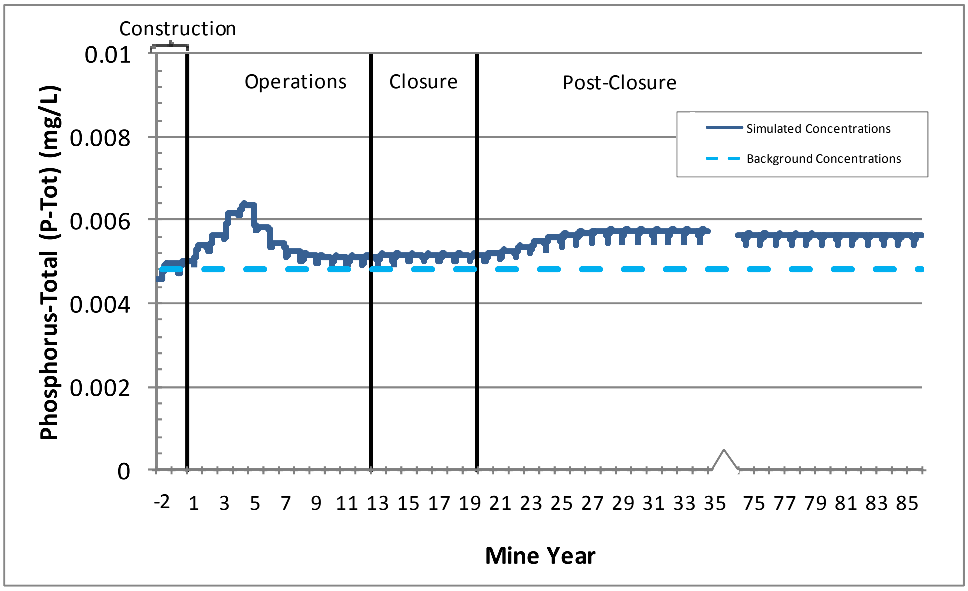
mg/L as N = milligrams per litre as nitrogen

Phosphorus

Total phosphorus concentrations are projected to increase in Lake 410 from a background concentration of 0.005 mg/L to a maximum concentration of 0.006 mg/L, and then return to a long-term steady state concentration of

0.005 mg/L (Table 9.2-18, Figure 9.2-13). Maximum and long-term concentrations are projected to be similar to those presented in the 2011 EIS Update (De Beers 2011) (Table 9.2-18). Lake 410 is anticipated to remain oligotrophic (CCME 2004; Environment Canada 2004).

Figure 9.2-13 Projected Trends of Total Phosphorus Concentrations in Lake 410



mg/L = milligrams per litre

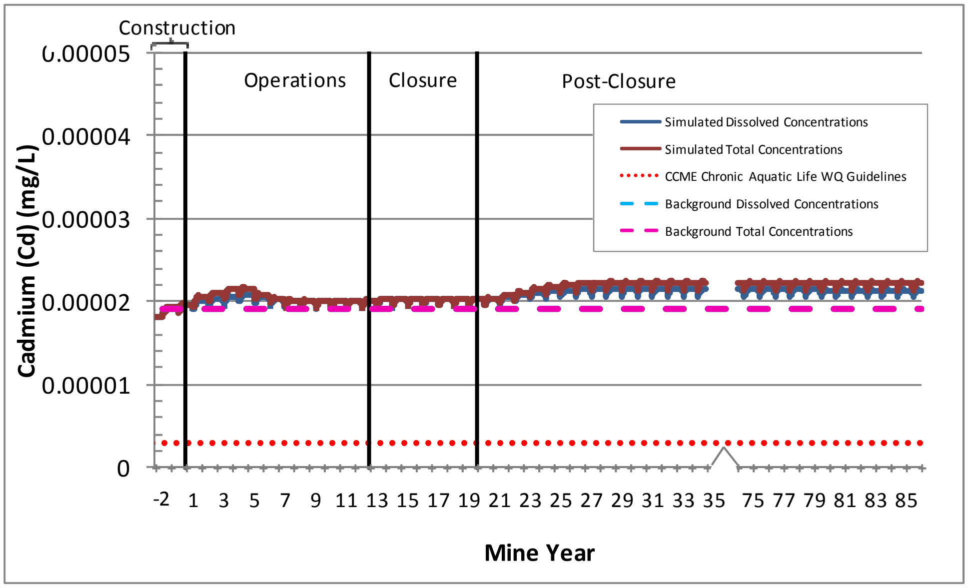
Trace Metals

The maximum and long-term steady state metals concentrations in Lake 410 are presented in Table 9.2-2. A bi-modal time series pattern similar to other modelled parameters in Lake 410 is projected to occur for each trace metal; the first peak is associated with operational discharge from the WMP to Lake N11 during operations, and the second peak is associated with downstream flows from the Kennady Lake watershed following closure, after Kennady Lake is reconnected to Area 8. Maximum and long-term concentrations are projected to be slightly lower than those presented in the 2011 EIS Update (De Beers 2011), with the exceptions of the maximum projected concentrations of barium, cobalt, nickel and silver, which are only slightly higher (Table 9.2-18). Consistent with the trends presented in the 2011 EIS Update, trace metals concentrations follow three characteristic patterns:

A. Trace Metals that are Projected to have a Small Increase in Concentrations

Of the 23 modelled metals, cadmium, cobalt, copper, chromium, and mercury are projected to increase slightly above baseline concentrations during the operational and post-closure phases, and remain to near-background conditions in the long-term. A representative time series plot showing this pattern is shown for cadmium (Figure 9.2-14). Cadmium is the only metal projected to be higher than CCME guidelines in Lake 410; cadmium was also measured above CCME guidelines in baseline conditions (Table 9.2-18).

Figure 9.2-14 Projected Trends of Cadmium Concentrations in Lake 410



mg/L = milligrams per litre.

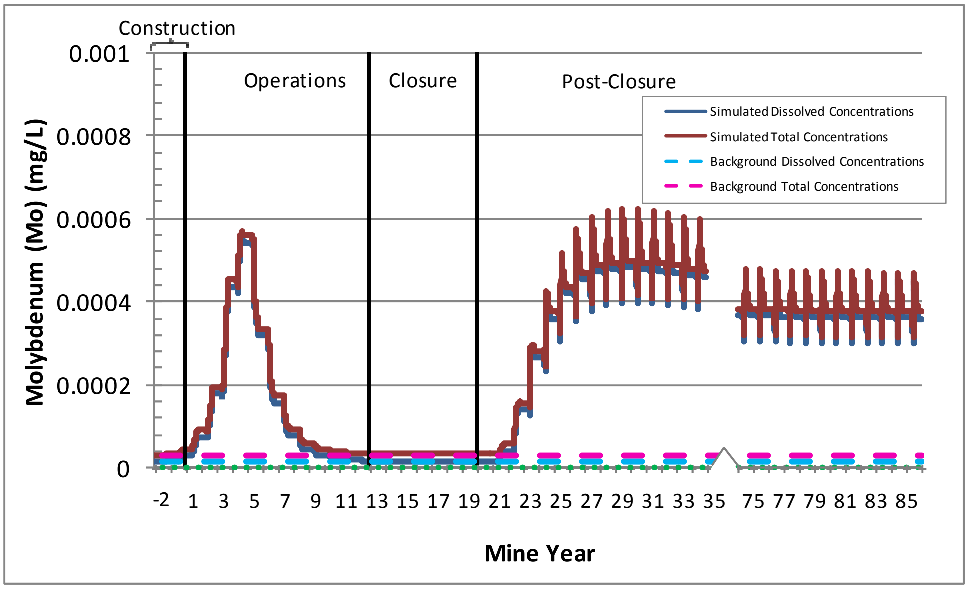
B. Trace Metals that are Projected to Follow Similar Trends to TDS

A range of metals including aluminum, arsenic, barium, iron, molybdenum, nickel, selenium, silver, and thallium are projected to increase above baseline conditions during the operational and post-closure phases, but decline to a steady state concentration near-background conditions in the long-term (Table 9.2-18). Time series trends for these metals are similar to TDS and major ions, indicating a strong association with groundwater influences on operational discharges and following the reconnection of Kennady Lake after refilling. None of these metals are projected to be higher than CCME guidelines. A representative time series plot is shown in Figure 9.2-15 for molybdenum.

C. Trace Metals that are Projected to Reach Steady State Soon after Closure

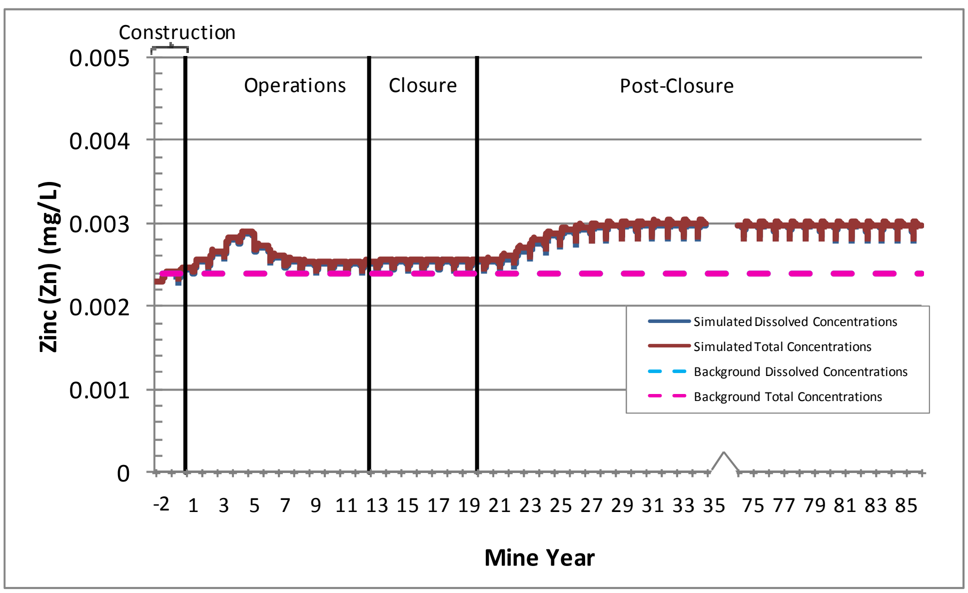
The remaining nine metals, antimony, beryllium, boron, cobalt, lead, manganese, strontium, uranium, vanadium, and zinc, are projected to increase and reach long-term steady state concentrations during the post-closure phase. Time series trends for these metals are similar to fluoride, indicating a strong association with geochemical loadings to Kennady Lake. None of these metals are projected to be higher than CCME guidelines (Table 9.2-18). A representative time series plot is shown in Figure 9.2-16 for zinc.

Figure 9.2-15 Projected Trends of Molybdenum Concentrations in Lake 410



mg/L = milligrams per litre.

Figure 9.2-16 Projected Trends of Zinc Concentrations in Lake 410



mg/L = milligrams per litre.

9.2.6 Effects to Aquatic Health

9.2.6.1 Introduction

Section 9.9 of the 2011 EIS Update (De Beers 2011) assessed the potential for effects to the health of aquatic life (referred to herein as aquatic health) in waterbodies downstream of Kennady Lake resulting from modelled changes in water quality as presented in Section 9.8 of the 2011 EIS Update. The aquatic health assessment evaluated two exposure pathways by which the predicted changes to water quality could affect aquatic health:

- direct exposure to substances in the water column; and
- indirect effects related to possible accumulation of substances within fish tissue via uptake from both water and diet.

The water quality model was revised based on the supplemental mitigation associated with the Fine PKC Facility. The results of the revised water quality modelling were used to update the aquatic health assessment. The same pathways and scenarios assessed in the 2011 EIS Update (De Beers 2011) were assessed in this revised aquatic health assessment, namely:

- water quality in Lake N11. This scenario summarizes the maximum concentrations of substances in Lake N11 after Kennady Lake is dewatered during construction, during mine operations when mine-affected water from the WMP is discharged to Lake N11, and during closure when water is withdrawn from Lake N11 to refill Kennady Lake.
- water quality in Lake 410. This scenario summarizes the overall effect to Lake 410 as a result of Project activities during construction, operations, and closure (expressed as maximum concentrations of substances).

The methods for the revised aquatic health assessment are the same as those outlined in the 2011 EIS Update in Section 9.9.2 (De Beers 2011).

9.2.6.2 Direct Waterborne Exposure

For the direct waterborne exposure pathway, substances of potential concern (SOPCs) were selected based on the three-step screening process described in Section 9.9.2.1.1 in the 2011 EIS Update (De Beers 2011). This screening process identified SOPCs as parameters that had the potential to detrimentally affect aquatic health, and whose predicted concentrations were more than 10% greater than baseline concentrations and greater than water quality guidelines

(WQG) for the protection of aquatic life (i.e., CCME 1999). Parameters without guidelines were identified as SOPCs if the other two SOPC selection criteria were met. Based on this screening process, nine SOPCs were identified in Lake N11 and Lake 410 during construction, operations, and closure (Appendix 9.III, Tables 9.III-1 to 9.III-3):

- total dissolved solids (TDS)
- antimony
- barium
- beryllium
- cadmium
- cobalt
- manganese
- strontium
- vanadium

Chronic effects benchmarks (CEBs) were derived for the SOPCs identified in the direct waterborne exposure assessment. The CEBs represent water concentrations above which changes to aquatic health could occur on the scale of individual organisms. The CEBs are less conservative (i.e., more realistic) than water quality guidelines, but retain a level of conservatism for the evaluation of population-level effects, which would require concentrations to be higher than the CEBs described herein. Consequently, the CEBs are considered to be conservative thresholds by which potential effects to aquatic health can be assessed.

For TDS, the CEB took the form of a range of concentrations, which were derived based on a review of the applicable literature. For the remaining SOPCs, single point benchmarks were identified, following the approach outlined in Appendix 8.IV of the 2011 EIS Update (De Beers 2011). New scenario-specific CEBs for copper were derived using the Biotic Ligand Model; Appendix 8.VI describes how these copper CEBs were derived. The predicted water concentrations were compared to the CEBs to conservatively evaluate the potential for adverse effects to aquatic health. The results of these comparisons are discussed below, beginning with TDS.

Total Dissolved Solids

Using the revised water quality model, predicted maximum concentrations of TDS and constituent ions increased by 24% on average compared to the 2011 EIS Update (De Beers 2011) predictions in Lake N11 and was similar to the 2011 EIS Update predictions in Lake 410 (Table 9.2-19). However, the new predicted maximum TDS concentrations are still below concentrations associated with adverse effects to freshwater aquatic life. Thus, the prediction that increases in TDS and major ion concentrations will have negligible residual effects on aquatic health has not changed.

Table 9.2-19 Maximum Concentrations of Total Dissolved Solids and Constituent Ions in Lake N11 and Lake 410 during Construction, Operations, and Closure

Parameter	Background Concentrations (Long-term Average) [mg/L]	Lake N11 Predicted Maximum Concentrations (mg/L)			Lake 410 Predicted Maximum Concentrations (mg/L)		
		2011 EIS Update [(a)]	2012 EIS Supplement	Change (%)	2011 EIS Update [(a)]	2012 EIS Supplement	Change (%)
Total Dissolved Solids	16	46	57	24	29	31	7
Calcium	1.1	7.5	9.6	28	3.5	4.1	17
Chloride	0.49	16	22	38	6.0	7.9	32
Fluoride	0.03	-	0.05	-	-	0.04	-
Magnesium	0.43	1.5	1.8	20	0.92	0.94	2
Potassium	0.39	0.95	1.03	8	1.1	0.63	-43
Sodium	0.78	4.1	5.4	32	2.2	2.4	9
Sulphate	0.88	3.9	5.7	46	3.7	2.7	-27
Nitrate as N	0.019	1.6	1.5	-6	0.61	0.57	-7

(a) From De Beers (2011).

mg/L = milligrams per litre; "-" no predicted concentrations for that parameter; N = nitrogen.

Remaining Parameters

The predicted maximum concentrations of the remaining eight SOPCs are predicted to decrease on average by 7% in Lake N11 and 25% in Lake 410 (Table 9.2-20). Maximum concentrations are predicted to remain below the CEB identified for each substance (Table 9.2-20). As a result, the predicted changes in the concentrations of these eight SOPCs are expected to have a negligible effect on aquatic health in Lake N11 and Lake 410 under the assessed conditions.

Table 9.2-20 Maximum Concentrations for Selected Substances of Potential Concern in Lake N11 and Lake 410 during Construction, Operations, and Closure

Substance of Potential Concern	Chronic Effect Benchmark (mg/L) [(a)]	Lake N11 Predicted Maximum Concentration during Construction, Operations, and Closure (mg/L)			Lake 410 Predicted Maximum Concentrations during Construction, Operations, and Closure (mg/L)		
		2011 EIS Update [(b)]	2012 EIS Supplement	Change (%)	2011 EIS Update [(b)]	2012 EIS Supplement	Change (%)
Antimony	0.157	0.00053	0.00035	-34	0.00031	0.00016	-48
Barium	5.8	0.017	0.01	-41	0.027	0.0056	-79
Beryllium	0.0053	0.000072	0.000072	0	0.000079	0.000073	-8
Cadmium	0.000105 [(c)]	0.000022	0.000024	9	0.000024	0.000022	-8
Cobalt	0.0093	0.00023	0.00036	57	0.00023	0.0003	30
Manganese	1.455	0.019	0.0136	-28	0.011	0.0098	-11
Strontium	0.049	0.015	0.0172	15	0.030	0.0119	-60
Vanadium	0.0338	0.00078	0.00051	-35	0.00047	0.00039	-17

Source: Adapted from Table 9.9-8 in De Beers (2011).

(a) Developed as outlined in Appendix 8.IV of the 2011 EIS Update (De Beers 2011).

(b) From De Beers (2011).

(c) The CEB for cadmium varies with hardness; the reported value is based on a hardness of 14 mg/L, which is the lowest predicted hardness in the 2012 water quality predictions.

mg/L = milligrams per litre.

9.2.6.3 Indirect Exposure - Changes to Fish Tissue Quality

To assess potential effects due to changes in fish tissue quality, potential changes to fish tissue concentrations in Lake N11 and Lake 410 were estimated by multiplying predicted maximum concentrations in water by parameter-specific bioaccumulation factors (Appendix 9.III, Tables 9.III-4 and 9.III-5). Only those parameters for which toxicological benchmarks could be defined were considered. These parameters, hereafter called substances of interest (SOI), were:

- aluminum
- antimony
- arsenic
- cadmium
- chromium
- copper
- lead
- mercury
- nickel
- selenium
- silver
- vanadium
- zinc

Predicted fish tissue concentrations were then compared to toxicological benchmarks that have been shown in laboratory studies to be associated with sublethal effects in fish.

The predicted fish tissue concentrations decreased on average by 10% in Lake N11 and 17% in Lake 410 (Table 9.2-21). Predicted fish tissue concentrations remain below the toxicological benchmarks for all parameters considered in the assessment. As a result, the predicted changes in the concentrations of these 13 SOIs are expected to have a negligible effect on fish tissue quality in Lake N11 and Lake 410 under the assessed conditions.

Table 9.2-21 Predicted Metal Concentrations in Fish Tissues in Lake N11 and Lake 410 during Construction, Operations, and Closure

Substance of Interest	Toxicological Benchmark (mg/kg ww) [(a)]	Lake N11 Predicted Fish Tissue Concentrations during Construction, Operations, and Closure (mg/kg ww)			Lake 410 Predicted Fish Tissue Concentrations during Construction, Operations, and Closure (mg/kg ww)		
		2011 EIS Update [(b)]	2012 EIS Supplement	Change (%)	2011 EIS Update [(b)]	2012 EIS Supplement	Change (%)
Aluminum	20	7.2	8.2	14	7.4	6.9	-7
Antimony	9	1.4	0.94	-33	0.85	0.45	-47
Arsenic	3.1	0.17	0.31	82	0.18	0.142	-21
Cadmium	0.6	0.0052	0.0056	8	0.0056	0.0053	-5
Chromium	0.58	0.13	0.029	-78	0.054	0.02	-63
Copper	3.4	1.3	1.3	0	1.3	1.2	-8
Lead	4.0	0.010	0.009	-10	0.0072	0.007	-3
Mercury	0.8	0.074 [(c)]	0.061 [(c)]	-18	0.063 [(c)]	0.058 [(c)]	-8
Nickel	0.82	0.22	0.28	27	0.19	0.2	5
Selenium	2.58	0.63	0.168	-73	0.3	0.17	-43
Silver	0.06	0.045	0.04	-11	0.034	0.04	18
Vanadium	0.41	0.075	0.049	-35	0.045	0.037	-18
Zinc	60	1.4	1.3	-7	1.3	1.1	-15

Source: Adapted from Tables 9.9-9 and 9.9-10 in De Beers (2011).

[(a)] Developed as outlined in Section 9.9.2.1.2 of the 2011 EIS Update (De Beers 2011). Benchmarks originate from Jarvinen and Ankley (1999), with the exception of selenium; the selenium benchmark is based on data contained in US EPA (2004) expressed as wet weight assuming a moisture content of 76%.

[(b)] From De Beers (2011).

[(c)] Mercury concentration in tissue increases with fish size. The largest lake trout captured during the baseline (789 mm) had a measured mercury concentration in muscle tissue that was about three times higher than the median concentration. A predicted tissue concentration that is three times higher than that reported here would not exceed the toxicological benchmark, indicating that there is negligible risk of the predicted mercury water concentrations even to the largest fish.

mg/kg ww = milligrams per kilogram wet weight.

9.2.7 Effects to Fish and Fish Habitat

The Effects Analysis Methods sections of the 2011 EIS Update (De Beers 2011) for Fish and Fish Habitat have not changed (i.e., Section 9.10.1 for Construction and Operations, and Section 9.10.2 for Closure and Post-Closure).

The effects analysis results sections for downstream effects are updated for all pathways:

Construction and Operations

- Effects of Changes to the Flow Regime in Streams Downstream of Kennady Lake on Fish and Fish Habitat (Section 9.10.3.1 of the 2011 EIS Update)
- Effects of Changes in Water Levels in Lakes Downstream of Kennady Lake to Fish and Fish Habitat (Section 9.10.3.2 of the 2011 EIS Update)

- Effects of Increased Nutrients on Fish and Fish Habitat in N Watershed (Section 9.10.3.3 of the 2011 EIS Update)

Closure and Post-Closure

- Effects of Changes to the Flow Regime in Streams Downstream of Kennady Lake on Fish and Fish Habitat (Section 9.10.4.1 of the 2011 EIS Update)
- Effects of Changes in Water Levels in Lakes Downstream of Kennady Lake to Fish and Fish Habitat (Section 9.10.4.2 of the 2011 EIS Update)
- Effects of Increased Nutrients on Fish and Fish Habitat in streams and lakes downstream of Kennady Lake (Section 9.10.4.3 of the 2011 EIS Update).

A discussion on how the supplemental mitigation associated with the Fine PKC facility has changed the results for each of these pathways is provided below.

9.2.7.1 Effects Analysis Results – Construction and Operations

9.2.7.1.1 Effects of Changes to the Flow Regime in Streams Downstream of Kennady Lake on Fish and Fish Habitat

Changes to Fish Habitat Availability – Construction

Similar to the 2011 EIS Update (De Beers 2011), dewatering of Kennady Lake during the construction phase will result in augmented flows in the N, L, and M watersheds during the summer months. Potential habitat impacts associated with flow augmentation would be stream erosion and the potential for flushing of fish and stranding of fish during start-up and shut-down periods. The volumes pumped during dewatering, natural lake attenuation, and the mitigation measures implemented to manage for stream erosion will remain the same as in the 2011 EIS Update; however, the distribution of pumping has changed slightly due to the revised diversion plan. Although the range of flows anticipated in the N, L, and M watersheds remains unchanged, the statistical representation of flow events (e.g., 1:100 dry flow) that the 2011 EIS Update assessment was based on may shift slightly due to small changes to the distribution and timing of flows during dewatering.

N Watershed

Similar to the 2011 EIS Update (De Beers 2011), augmented flows will be managed so that discharge at the outlet of Lake N1 during dewatering will approximate the 2-year flood discharge. The timing of pumping and ramp-up and ramp-down strategies will remain the same as that described in the 2011 EIS

Update to avoid sudden changes in stream discharge to minimize the risk of flushing or stranding of fish. The flows in the N watershed during construction are virtually identical as presented in the 2011 EIS Update (see Section 9.2.4 of this 2012 EIS Supplement), and as a result, the habitat availability remains unchanged. Therefore, the effects of changes in stream flow on fish and fish habitat availability in the N watershed streams are as described in the 2011 EIS Update.

L and M Watersheds

The revision in the diversion plan to direct the runoff from the A watershed to Area 8 would begin during the construction phase of the project; however, the pumping plan would maintain the same downstream flow targets during dewatering as presented in the 2011 EIS Update (De Beers 2011). The environmental design features and natural lake attenuation during the start-up and shut-down of pumping activities as described in the 2011 EIS Update would also remain unchanged. As a result, the difference in the magnitude and timing of flows to the downstream watershed would be similar under most flow conditions as presented in the 2011 EIS Update (see Section 9.2.4 of this 2012 EIS Supplement), and consequently, the habitat availability remains unchanged. Therefore, the effects of changes in stream flow on fish and fish habitat availability in the L and M watershed streams are as described in the 2011 EIS Update.

Changes to Fish Habitat Suitability – Construction

Augmented flows during dewatering may alter the suitability of habitat that is available to fish during the open-water season, primarily through changes to the depth and velocity characteristics within the streams. The statistical representation of flow events (e.g., 1:100 dry flow) that the 2011 EIS Update (De Beers 2011) assessment was based on may shift slightly due to small changes to the distribution and timing of flows during dewatering.

N Watershed

Changes to average water velocities in the N watershed channels between baseline conditions and dewatering were presented in the 2011 EIS Update (De Beers 2011) and were assessed as negligible for Arctic grayling spawning and rearing (Tables 9.10-4 and 9.10-5 in the 2011 EIS Update). With the revised diversion plan, average water velocities in the N watershed are expected to be largely unchanged, with a maximum change of 0.01 metres per second (m/s) at Stream N1 and a maximum increase of 0.03 m/s at Stream N11 relative to the 2011 EIS Update diversion results. These minimal changes would not result in an expected change in habitat suitability for fish. Therefore, the effects of changes in stream flow on fish and fish habitat suitability in the N watershed streams are as described in the 2011 EIS Update.

L and M Watersheds

Changes to average water velocities in the L and M watershed channels between baseline conditions and dewatering were presented in the 2011 EIS Update (De Beers 2011) and were assessed as negligible for Arctic grayling spawning and rearing (Tables 9.10-6, 9.10-7, and 9.10-8 in the 2011 EIS Update). With the revised diversion plan, average water velocities in the L and M watersheds are not expected to change from the 2011 EIS Update diversion results under most flow conditions (i.e., wet versus dry years). Under a few flow conditions, a maximum change in velocities of 0.02 m/s is predicted relative to the 2011 EIS Update due to the small shift in flow distribution. These minimal changes would not result in an expected change in habitat suitability for fish. Therefore, the effects of changes in stream flow on fish and fish habitat suitability in the L and M watershed streams are as described in the 2011 EIS Update.

Changes to Fish Migrations – Construction

Based on the similarity in flow magnitude and timing during dewatering under the revised diversion plan relative to the 2011 EIS Update (De Beers 2011), the conclusions for fish migrations in the N, L, and M watersheds are as described in the 2011 EIS Update.

Changes to Lower Trophic Levels – Construction

Based on the similarity in flow magnitude and timing during dewatering under the revised diversion plan relative to the 2011 EIS Update (De Beers 2011), the conclusions for lower trophic levels in the N, L, and M watersheds are as described in the 2011 EIS Update.

Changes to Fish Habitat Availability – Operations

Downstream flows during operations remain similar to the 2011 EIS Update (De Beers 2011), with changes to the diversion plan resulting in small changes to the distribution and timing of flows during operations. As a result, the statistical representation of flow events (e.g., 1:100 dry flow) that the 2011 EIS Update assessment was based on may shift slightly due to small changes to the distribution and timing of flows during operations.

N Watershed

During operations, flows continue to be diverted to the N watershed, but to a lesser extent than during dewatering. The revised pumping plan, with the A watershed no longer being diverted to Lake N6, will result in flow conditions downstream of N6 to be more similar to baseline conditions relative to the 2011 EIS Update (De Beers 2011). With an overall small reduction of flow augmentation in the N watershed during operations in combination with natural lake attenuation and the mitigation measures implemented to manage for stream erosion, which will remain the same as in the 2011 EIS Update, the effects of changes in stream flow on fish and fish habitat availability in the N watershed stream are as described in the 2011 EIS Update.

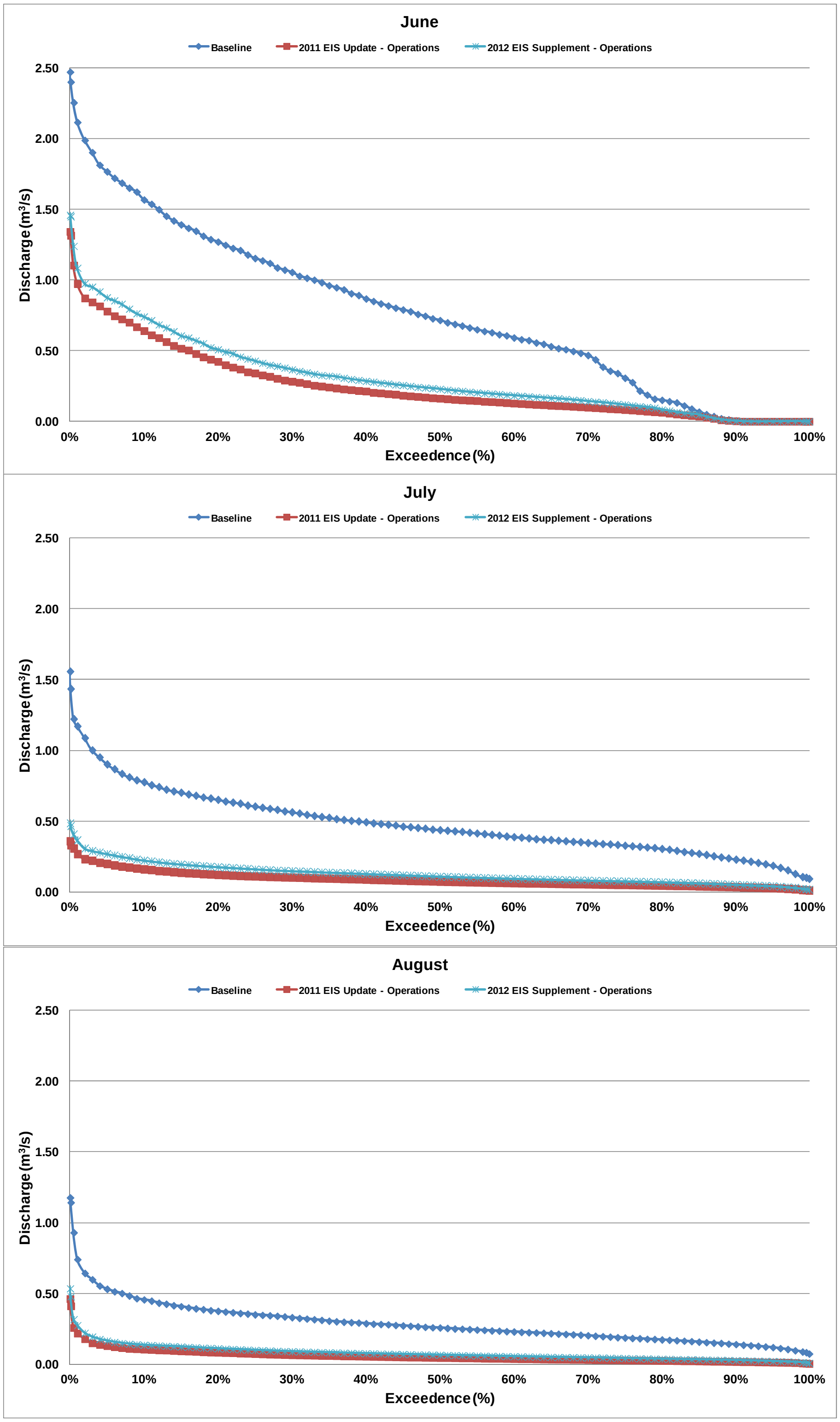
L and M Watersheds

Flows in the L and M watersheds will become substantially reduced during operations as described in the 2011 EIS Update (De Beers 2011). The revised diversion plan will direct runoff from the A watershed to Area 8, which will increase downstream flows relative to the results presented in the 2011 EIS Update. Although the increase in flow will result in conditions closer to baseline conditions relative to the 2011 EIS Update, which would be a positive effect, the resulting flows are still well below baseline flow conditions (Figure 9.2.17).

The magnitude of change in downstream flow at the outlet of Area 8 is representative of the change that would be expected throughout the L and M watersheds. Wetted widths under operations have increased relative to the 2011 EIS Update (Table 9.10-9 in the 2011 EIS Update); however, they remain well below baseline conditions (Table 9.2.23). There is a maximum reduction in wetted width of 83% relative to baseline conditions observed in Stream L3 (as compared to an 86% reduction in the 2011 EIS Update).

Although there is generally a positive change in habitat availability during operations relative to the 2011 EIS Update (De Beers 2011), the change relative to baseline conditions persists. Therefore, the effects of changes in stream flow on fish and fish habitat availability in the L and M watershed streams are similar to those described in the 2011 EIS Update. A flow mitigation plan is under development in consultation with regulators to offset downstream flow reductions, such that impacts to habitat availability will be mitigated.

Figure 9.2.17 Monthly Flow Duration Curves at the Outlet of Kennady Lake under Baseline, 2011 EIS Update Operations, and 2012 Supplement Operations



m^3/s = cubic metres per second; % = percent.

Table 9.2.23 Comparison of Average July Wetted Widths in Streams in the L and M Watersheds between Baseline and Operations (revised)

Stream	Phase	Wetted Width (m) by Return Period for July						
		1:100 Wet	1:50 Wet	1:10 Wet	1:2 Median	1:10 Dry	1:50 Dry	1:100 Dry
K5	Baseline	40.4	40.0	36.5	18.4	11.9	10.7	9.0
	Operations	15.0	13.4	11.5	7.9	5.8	5.6	5.4
L3	Baseline	50.9	50.0	47.3	37.9	29.3	8.7	7.7
	Operations	34.7	32.9	15.3	6.7	4.9	4.6	4.5
L2	Baseline	37.2	36.6	26.6	18.9	13.7	11.9	11.8
	Operations	21.5	18.7	14.9	11.8	10.4	9.5	9.1
L1	Baseline	56.3	54.8	49.1	43.9	36.5	21.3	20.6
	Operations	46.9	45.3	41.8	22.6	15.7	10.6	9.9
M4	Baseline	67.4	65.1	57.1	50.3	35.8	28.4	26.8
	Operations	55.9	53.6	47.2	31.1	21.9	15.8	14.3
M3	Baseline	51.8	51.1	50.0	47.0	43.9	39.8	38.0
	Operations	49.6	48.2	46.6	43.3	36.1	25.7	22.0
M2	Baseline	42.7	42.5	40.5	27.4	17.0	12.8	11.9
	Operations	36.2	30.5	24.9	16.5	10.8	8.0	7.4
M1	Baseline	59.8	59.1	56.8	46.8	27.4	20.1	19.9
	Operations	53.9	51.2	43.8	22.6	18.9	16.2	15.3

Source: Adapted from Table 9.10-9 of De Beers (2011).
m = metre

Changes to Fish Habitat Suitability – Operations

Downstream flows during operations remain similar to the 2011 EIS Update (De Beers 2011), with changes to the diversion plan resulting in small changes to the distribution and timing of flows during operations. As a result, the statistical representation of flow events (e.g., 1:100 dry flow) that the 2011 EIS Update assessment was based on may shift slightly due to small changes to the distribution and timing of flows during operations.

N Watershed

Flows in the N watershed during operations are similar to what was presented in the 2011 EIS Update (De Beers 2011), and as a result, changes to habitat suitability are also very small. Average June water velocities in the N watershed under baseline and operations presented in the 2011 EIS Update (Table 9.10-10) were similar and no impacts to fish habitat suitability were predicted. Average velocities under the revised diversion plan remain largely unchanged from the 2011 EIS Update, with a predicted maximum difference of 0.03 m/s under a few flow conditions. Therefore, the effects of changes in stream flow on fish and fish habitat suitability in the N watershed streams are as described in the 2011 EIS Update.

L and M Watersheds

Flows in the L and M watersheds are slightly higher, and closer to baseline, under operations compared to what was presented in the 2011 EIS Update (De Beers 2011). Maximum water depths from the 2011 EIS Update (Tables 9.10-11 and 9.10-12) either remain unchanged or increase in the range of 0.01 m to 0.05 m, which results in conditions closer to baseline. Average velocities from the 2011 EIS Update (Tables 9.10-13 and 9.10-14 of the 2011 EIS Update) remain largely unchanged, with a predicted maximum difference of 0.03 m/s under a few flow conditions. Therefore, the effects of changes in stream flow on fish and fish habitat suitability in the L and M watershed streams are as described in the 2011 EIS Update.

Changes to Fish Migrations – Operations

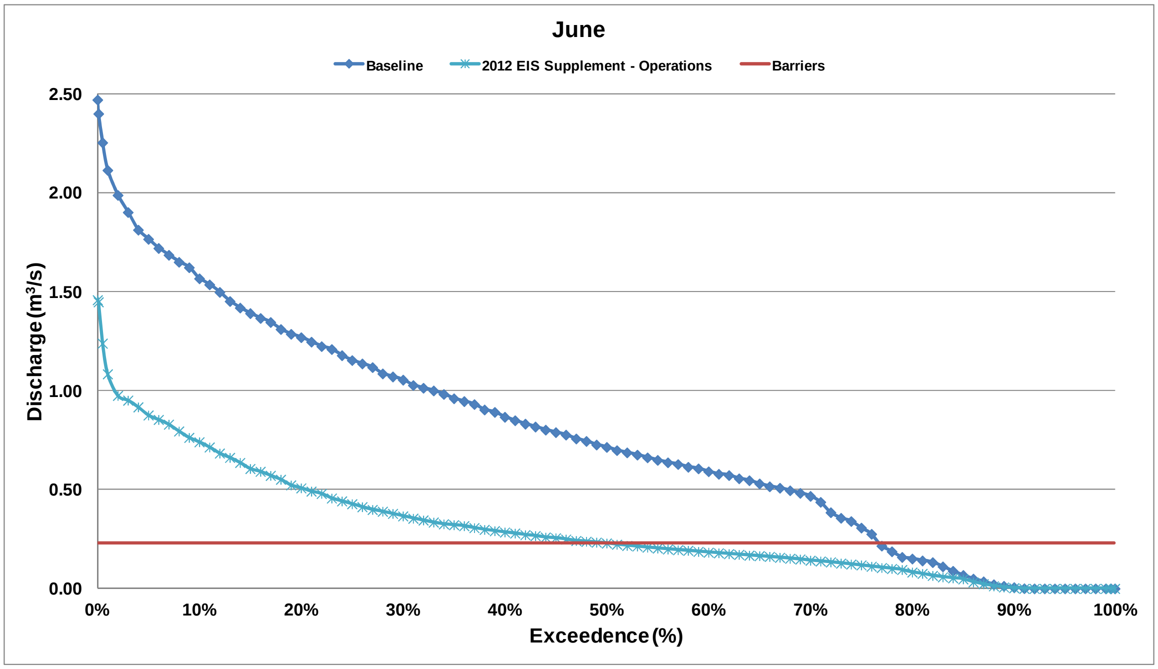
N Watershed

Based on the similarity in flow magnitude and timing during operations under the revised diversion plan relative to the 2011 EIS Update (De Beers 2011), the conclusions for fish migrations in the N watershed are as described in the 2011 EIS Update.

L and M Watersheds

Although a slight increase in downstream flows are predicted in the L and M watersheds relative to the 2011 EIS Update (De Beers 2011), the magnitude of the increase is not sufficient to alter the persistence of barriers to fish migration under operations. Barriers to spring migration would persist about 50% of the time (Figure 9.2.18). Based on the similarity in flow magnitude and timing during operations under the revised diversion plan relative to the 2011 EIS Update, the conclusions for fish migrations in the L and M watersheds are as described in the 2011 EIS Update.

Figure 9.2.18 Frequency of Barrier Formation in Streams between Kennady Lake and Lake 410 during Operations (revised)



Source: Adapted from Figure 9.10-13 of De Beers (2011).

Changes to Lower Trophic Levels – Operations

Based on the similarity in flow magnitude and timing during operations under the revised diversion plan relative to the 2011 EIS Update (De Beers 2011), with changes moving in a positive direction closer to baseline conditions, the conclusions for lower trophic levels in the N, L, and M watersheds are similar to those described in the 2011 EIS Update.

9.2.7.1.2 Effects of Changes in Water Levels in Lakes Downstream of Kennady Lake to Fish and Fish Habitat

Changes to Fish Habitat Availability – Construction

N Watershed

Similar to the 2011 EIS Update (De Beers 2011), small increases in lake water levels and lake areas are predicted compared to baseline conditions in the N watershed (i.e., Lake N11 and Lake N1) due to Kennady Lake dewatering. The changes in depths and areas are similar to those presented in the 2011 EIS Update (Table 9.10-15 in Section 9.10.3.2); changes from the 2011 EIS Update are very small and include 0 to 3 centimetre (cm) increase in lake levels and 0 to 0.4% increase in lake areas from the 2011 EIS Update. Therefore, the effects of changes in lake water levels on fish and fish habitat in the N watershed lakes are as described in the 2011 EIS Update. As the increases in lake level from baseline are small (i.e., less than 20 cm in Lake N11 and less than 10 cm in Lake N1), the increases in water levels during dewatering are unlikely to have a substantive effect on fish habitat or benthic invertebrate communities in these lakes.

L and M Watersheds

Similar to the 2011 EIS Update (De Beers 2011), water levels and lake areas in lakes between Kennady Lake and Lake 410 will change as a result of Kennady Lake dewatering. However, for the supplemental mitigation associated with the Fine PKC Facility, the A watershed is no longer being diverted to the N watershed, but instead to Lake J1b which drains into Area 8.

The changes in depths and areas in the L and M watershed lakes (i.e., the Interlakes) are similar to those presented in the 2011 EIS Update (De Beers 2011) (Table 9.10-16 in Section 9.10.3.2); there are some changes in lake levels and lake areas on a monthly basis with the revised pumping plan, as the largest changes compared to baseline are now predicted in August compared to September. However, similar to the results presented in the 2011 EIS Update, water levels and lake areas are predicted to be augmented during summer and fall compared to baseline conditions; water levels remain at near spring freshet levels longer into the summer and early fall during the dewatering phase compared to baseline. Once pumping begins in June, the water levels increase in the L watershed, but the response is delayed further downstream in M watershed.

In the 2011 EIS Update (De Beers 2011), the largest changes were predicted in Lakes L3 and L2 in September, with increases in lake depth of 33 cm and 32 cm, respectively (Table 9.10-16 of the 2011 EIS Update). The changes in maximum from the 2011 EIS Update are small, with predicted increases from baseline of 34 and 32 cm for these lakes in August. As these lakes are small, shallow lakes, this corresponds to changes in lake area of 20% and 12%, respectively.

Therefore, the effects of changes in lake water levels on fish and fish habitat in these lakes are as described in the 2011 EIS Update (De Beers 2011). The higher water levels over the summer and fall in the L and M lakes and Lake 410 during dewatering flows are small in comparison to baseline conditions (i.e., less than 35 cm); the higher water levels may also benefit fish in these lakes during summer through increased littoral area and summer rearing habitat.

9.2.7.1.3 *Changes to Fish Habitat Availability – Operations*

N Watershed – Operations

During operations, the B, D, and E watersheds will be diverted to the N watershed and pumping from the WMP will be directed to Lake N11. Due to the supplemental mitigation associated with the Fine PKC Facility, the A watershed is no longer being diverted to the N watershed.

The projected changes to water levels and lake areas during operations are similar to those presented in the 2011 EIS Update (De Beers 2011) (Table 9.10-18 in Section 9.10.3.2.2); there are some changes in lake levels and lake areas on a monthly basis, as the largest changes compared to baseline are now predicted in August compared to September. However, similar to the 2011 EIS Update, water levels and lake areas are expected to increase compared to baseline, as spring water levels take longer to attenuate than under baseline conditions.

In the 2011 EIS Update (De Beers 2011), the largest change compared to baseline was in July, with Lake N11 increasing by 7 cm and Lake N1 increasing by 4 cm. Currently, the largest change compared to baseline is in August (i.e., Lake N11 increases by 7 cm and Lake N1 increases by 3 cm); this corresponds to a less than 1% change in lake area. As a result, the effects on fish and fish habitat in the N watershed lakes are as described in the 2011 EIS Update. As the changes in water level and lake area are small and within natural variability, no effects on fish and fish habitat are expected.

L and M Watersheds – Operations

As a result of water management during operations, water levels and lake areas in lakes between Kennady Lake and Lake 410 are expected to decrease compared to baseline. However, due to the operational diversion of the A watershed to Area 8, water levels in the L and M watersheds (i.e., the Interlakes) are slightly higher, and closer to baseline, under operations compared to what was presented in the 2011 EIS Update (De Beers 2011).

The projected changes to water levels and lake areas during operations are similar to those presented in the 2011 EIS Update (De Beers 2011) (Table 9.10-19 in Section 9.10.3.2.2); there are some changes in lake levels and lake areas on a monthly basis. However, similar to the 2011 EIS Update, water levels and lake areas are expected to decrease compared to baseline. The largest change compared to baseline is for the month of July; the reductions in depth are attenuated throughout the summer, with smaller changes predicted for August through October.

In the 2011 EIS Update (De Beers 2011), the largest changes in the L and M lakes were predicted to occur in Lake L3 in July (decrease in lake depth of 22 cm) and Lake M3 in June (decrease in lake depth of 19 cm) (Table 9.10-19). Currently, for the L lakes, the largest change is still predicted to occur in Lake L3 in July, with a decrease in lake depth of 19 cm (10% change in lake area); for the M lakes, the largest change is predicted to occur in Lake M4, with a decrease in lake depth of 17 cm in July (2% change in lake area). The reduction in water levels under the ice is predicted to be less than a 12 cm change from baseline conditions, which is a less than 2 cm increase from the 2011 EIS Update.

Lake levels will increase relative to the 2011 EIS Update (De Beers 2011) and result in conditions closer to baseline conditions, which will be a positive effect. However, as the change is small, the effects on fish and fish habitat in the L and M watershed lakes are as described in the 2011 EIS Update; as the decreases in water levels in the L and M lakes downstream of Kennady Lake during operations are small (i.e., less than 20 cm), the effects on fish habitat or benthic invertebrate communities in these lakes would be expected to be minor. For Lake 410, the predicted changes are small and within natural variability.

9.2.7.1.4 Effects of Increased Nutrients on Fish and Fish Habitat in N Watershed

Concentrations of total phosphorus are predicted to increase from a background concentration of 0.005 mg/L in Lake N11, to a peak of 0.009 mg/L during operations as a result of loading from active WMP discharge during the first four years of operations. Once the dewatering and operational discharge period ends, phosphorus concentrations are expected to decrease back to the baseline concentration of 0.005 mg/L (see Appendix 9.II), as water stored in Lake N11 is replaced by natural runoff. The trophic status of Lake N11 would remain oligotrophic, as it is under baseline conditions.

The effects of nutrient loading from the WMP to Lake N11 on aquatic life are evaluated in the 2011 EIS update, in Sections 9.10.4.3.1 and 9.10.4.3.2. The supplemental mitigation described in this EIS Supplement does not result in changes to the assessment of effects in Lake N11.

9.2.7.2 Effects Analysis Results – Closure and Post-Closure

9.2.7.2.1 Effects of Changes to the Flow Regime in Streams Downstream of Kennady Lake on Fish and Fish Habitat

Changes to Fish Habitat

Under closure and post-closure, downstream flows in the N, L, and M watersheds are the same as presented in the 2011 EIS Update (De Beers 2011).

Flows from the A watershed, which were directed downstream to Area 8 under operations, are directed back to Kennady Lake for refilling, which is no change from what was assessed in the 2011 EIS Update. At post-closure, downstream flows return to near baseline conditions. Therefore, the effects of changes in stream flow on fish and fish habitat availability, suitability, and fish migrations during closure and post-closure in the N, L, and M watershed streams are as described in the 2011 EIS Update.

Changes to Lower Trophic Levels

Under closure and post-closure, downstream flows in the N, L, and M watersheds are the same as presented in the 2011 EIS Update (De Beers 2011). Therefore, the effects of changes in stream flow on lower trophic levels during closure and post-closure in the N, L and M watershed streams are as described in the 2011 EIS Update.

9.2.7.2.2 Effects of Changes in Water Levels in Lakes Downstream of Kennady Lake to Fish and Fish Habitat

N Watershed

Similar to the 2011 EIS Update (De Beers 2011), small decreases in lake water levels and lake areas are predicted during closure in Lake N11 and Lake N1 compared to baseline due to the abstraction of flow for Kennady Lake refilling.

The changes in depths and areas are similar to those presented in the 2011 EIS Update (De Beers 2011) (Table 9.10-20 in Section 9.10.4.2); changes from the 2011 EIS Update are very small and include a maximum 2 cm decrease in lake levels and 0.2% change in lake area for Lake N11 from the 2011 EIS Update. For Lake N1, the changes include a maximum decrease in lake levels of 8 cm and 1.4% in lake area from the 2011 EIS Update, as the A watershed is no longer diverted to the N watershed.

The effects of changes in lake water levels on fish and fish habitat in the N watershed lakes are as described in the 2011 EIS Update (De Beers 2011). As the decreases in water levels in Lake N11 and N1 during closure are small compared to baseline (i.e., less than 9 cm), they are unlikely to have a substantive effect on fish habitat or benthic invertebrate communities in these lakes.

The post-closure hydrological regime of Lake N11 and Lake N1 will be identical to baseline. The A watershed diversion will be re-diverted to Kennady Lake at closure, and is not permanently diverted to Lake N1 as was indicated in the 2011 EIS Update (De Beers 2011).

L and M Watersheds

During closure, when Kennady Lake is being refilled and the downstream watershed remains isolated, the lake levels, and associated effects on fish and fish habitat, in the L and M lakes (i.e., the Interlakes) downstream of Kennady Lake are as described for operations above.

During post-closure, when Dyke A is removed and the refilled Kennady Lake is discharging through Stream K5, water levels and lake areas in lakes between Kennady Lake and Lake 410 will be similar to baseline. The changes in depths and areas are similar to those presented in the 2011 EIS Update (De Beers 2011) (Table 9.10-21 in Section 9.10.4.2). Along with the B, D, and E watersheds, the A watershed will now be re-diverted to Kennady Lake at closure; as a result, the water levels in these downstream lakes will not decrease to the same extent as predicted in the 2011 EIS Update. The 2011 EIS Update prediction is unchanged in that negligible effects on fish and fish habitat would be expected to occur in these lakes as a result of the small changes to lake levels.

9.2.7.2.3 *Effects of Increased Nutrients on Fish and Fish Habitat*

Effects of changes to nutrients in Lake N11 for closure and post-closure are as described in the 2011 EIS Update (De Beers 2011). As a result, the following sections update information for the watersheds downstream of Kennady Lake (i.e., L and M watersheds, and Lake 410).

Based on the supplemental mitigation associated with the Fine PKC Facility, the predicted mean long-term concentrations of phosphorus in the L and M watershed lakes are 0.009 mg/L and 0.008 mg/L, respectively. This indicates that the long-term trophic status will remain oligotrophic, and not mesotrophic as presented in the 2011 EIS Update (De Beers 2011). By Lake 410, the long-term phosphorus concentration is predicted to be 0.006 mg/L. Surface waters in all of these watersheds are expected to remain phosphorus-limited.

A summary is provided below of the predicted changes to the downstream watersheds based on these long-term steady state total phosphorus concentrations. Literature review and other supporting information are in Section 9.10.4.3 of the 2011 EIS Update (De Beers 2011).

Changes to Lower Trophic Levels

As the trophic status in lakes downstream of Kennady Lake will remain oligotrophic, effects in L and M watershed lakes and Lake 410 will be similar to those described for Kennady Lake in Section 8.2.7.2. Nutrient concentrations will increase within the oligotrophic range, with corresponding small changes in productivity and composition of lower trophic communities. Increased productivity is expected at all lower trophic levels, likely reflected in increases in biomass of phytoplankton, zooplankton, and benthic invertebrates. Large shifts in the composition of plankton and benthic invertebrate communities are not expected, but some shifts in relative abundances of different plankton and invertebrate groups may occur, as communities adjust to the greater nutrient and food supply.

Similarly, streams receiving drainage from Kennady Lake will be more productive compared to existing conditions, likely reflected in increases in biomass of benthic algae and benthic invertebrates. Large shifts in the composition of lower trophic invertebrate communities are not expected. As the streams will remain relatively unproductive, with productivity frequently limited by physical factors (e.g., flow variation, ice scour), large increases in benthic algal growth on stream substrates are not expected.

Changes to Fish and Fish Habitat

In the downstream lakes, the phosphorus concentration during post-closure is predicted to be increased compared to baseline; however, the trophic status is not expected to change and the lakes will remain oligotrophic. As a result of the increased productivity, it is likely that there will be increases in the food base for fish (zooplankton and benthic invertebrates), as well as in the small-bodied fish community. Because of the increased food base, there may also be increased survival, growth, and production in the large-bodied fish species.

As described in the 2011 EIS Update (De Beers 2011), the four lakes in the L watershed (Lakes L3, L2, L1b, and L1a) likely freeze to, or close to, the bottom during winter. As a result, the slight increase in nutrient levels would not be expected to change the overwintering capability or suitability of these small lakes. In the M lakes, there may be a small reduction in under-ice dissolved oxygen levels compared to baseline conditions. However, it is expected that suitable overwintering habitat would continue be available for species remaining in these lakes through the winter; any changes to overwintering habitat would not be expected to affect fish populations or fish community structure in these lakes. Although nutrient concentrations are expected to increase slightly in Lake 410, effects are expected to be lower in magnitude, with corresponding smaller changes in productivity, lower trophic communities, and fish production; it is not expected that there will be changes in fish habitat in Lake 410 (i.e., changes to spawning shoals or winter dissolved oxygen levels).

Streams in the L and M watersheds will also likely be more productive compared to existing conditions. Due to the potentially increased food base, there may be increases in the growth and production of fish species within the streams. Due to the reduction in nutrient levels compared to the 2011 EIS Update (De Beers 2011), changes to Arctic grayling spawning habitat would be less than presented in the 2011 EIS Update. Although the streams would likely be more productive compared to existing conditions, any changes to Arctic grayling spawning habitat would be expected to be not measurable.

9.2.7.2.4 Effects from Changes to Aquatic Health on Fish and Fish Habitat Downstream of Kennady Lake

The results of the revised water quality modelling associated with the supplemental mitigation for the Fine PKC Facility were used to update the aquatic health assessment (Section 9.2.6).

For the direct waterborne exposure assessment, the prediction has not changed that adverse effects to fish and aquatic invertebrates are not expected at the predicted total dissolved solids (TDS) concentrations in Lake N11 and Lake 410. For all remaining SOPCs in Lake N11 and Lake 410 predicted maximum concentrations are expected to remain below the chronic effects benchmark (CEB) identified for each substance during closure; the predicted increases in the concentrations of these substances are expected to have a negligible residual effect on aquatic health in Lake N11 and Lake 410.

For the indirect exposure pathway, predicted fish tissue concentrations in Lake N11 and Lake 410 are projected to be below toxicological benchmarks for all parameters considered in the assessment.

Based on the aquatic health assessment, predicted changes to concentrations of all substances considered were projected to result in negligible residual effects to fish tissue quality and, by association, aquatic health in waterbodies downstream of Kennady Lake (i.e., Lake N11 and Lake 410). As a result, the conclusion from the 2011 EIS Update (De Beers 2011) has not changed, in that effects to fish populations or communities are not expected to occur from changes in aquatic health.

9.2.8 Conclusions

To mitigate phosphorus loadings to Kennady Lake, De Beers updated the mine plan to reduce the footprint of the Fine PKC Facility (mitigated) by approximately one half and use the 5034 and Hearne pits for the deposit of additional fine PK. As a result of the change in footprint and redesign of the A watershed diversion, the water balance and water quality model for the Project were updated.

An evaluation of the water quality for this supplemental mitigation, incorporating the most recent results from ongoing and supplemental geochemical testing, indicates total phosphorus concentrations in the downstream watershed will be less than presented in the 2011 EIS Update (De Beers 2011) (long-term steady state concentrations in the L and M watershed lakes of 0.009 mg/L and 0.008 mg/L, respectively, with the long-term trophic status remaining oligotrophic). By Lake 410, the long-term phosphorus concentration is predicted to be 0.006 mg/L. Similar to the 2011 aquatic health assessment, changes to water quality are predicted to have negligible effects on aquatic health in downstream waterbodies (i.e., Lake N11 and Lake 410) under the assessed conditions.

For both time periods, the supplemental mitigation associated with the Fine PKC Facility will not change the impact classification for the suitability of water downstream of Kennady Lake to support a viable and self-sustaining aquatic ecosystem. The impact classification for the three highly valued fish species (i.e., Arctic grayling, lake trout, and northern pike) will not change for the first time period (i.e., initiation of the Project to 100 years later). The classification of residual impacts within this period was conservatively based on the most negative impact over the 100-year period, which would take into account changes to the flow regime. However, as per the 2011 EIS Update (De Beers 2011), a flow mitigation plan is under development to reduce the risk of population level changes to these fish species. However, as the second time period (after 100 years from Project initiation) is focused on future, steady state conditions, the impact classification for this time period has changed for the abundance and persistence of Arctic grayling and lake trout from the 2011 EIS Update. The classification for both time periods is provided in Table 9.2.24.

As a result of the increased phosphorus in the long-term, it is expected that overall biological productivity in the downstream watershed will increase in comparison to the nutrient-limited pre-development conditions. The increased nutrients may cause increased growth and production in large-bodied fish species from the increased food base. However, 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 less than in the 2011 EIS Update (De Beers 2011). Therefore, projected impacts on the abundance and persistence of Arctic grayling, lake trout, and northern pike for the second time period are rated as neutral to positive in direction and negligible (Table 9.2.24).

Table 9.2.24 Residual Impact Classification of Projected Impacts to Water Quality and Fish Downstream of Kennady Lake

Assessment Endpoint	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Suitability of water downstream of Kennady Lake to support a viable and self-sustaining aquatic ecosystem							
Construction to 100 years from Project start	negative	negligible	-	-	-	-	-
Beyond 100 years from Project start	negative	negligible	-	-	-	-	-
Abundance and persistence of Arctic grayling within the Kennady Lake watershed							
Construction to 100 years from Project start	negative	moderate[(a)]	local	medium-term	periodic	reversible	likely
Beyond 100 years from Project start	neutral - positive	negligible	-	-	-	-	-
Abundance and persistence of lake trout within the Kennady Lake watershed							
Construction to 100 years from Project start	negative	low	local	medium-term	periodic	reversible	likely
Beyond 100 years from Project start	neutral - positive	negligible	-	-	-	-	-
Abundance and persistence of northern pike within the Kennady Lake watershed							
Construction to 100 years from Project start	negative	low	local	medium-term	periodic	reversible	likely
Beyond 100 years from Project start	neutral - positive	negligible	-	-	-	-	-

"-" = not applicable.

[(a)] based on the highest magnitude effect predicted through to completion of Kennady Lake refilling and assumes no mitigation for downstream flows.

There are no changes to the evaluation of environmental significance. Similar to the 2011 EIS Update (De Beers 2011), the projected impacts on the suitability of water downstream of Kennady Lake to support a viable and self-sustaining aquatic ecosystem, and on the abundance and persistence of Arctic grayling, lake trout, and northern pike are considered to be not environmentally significant for both time periods.

9.3 UPDATES TO SECTION 9 APPENDICES

Appendices associated with Section 9 of the 2011 EIS Update (De Beers 2011) are summarized in Table 9.3-1, together with cross-references to those Section 9 appendices revised and presented within this submission.

Table 9.3-1 Revisions to Appendices Associated with Section 9

Appendix Name	Appendix Number from the 2011 EIS Update	Updated/new in 2012?	Reason for Update	Appendix Number within the 2012 EIS Supplement
Time Series Plots	Appendix 9.I	updated	Updated water quality modelling results associated with supplemental mitigation	Appendix 9.II
Fisheries Report	Appendix 9.II	no	-	-
Hydrology Update	n/a	new	Updated hydrology tables and figures resulting from changes in footprint and diversion of A watershed	Appendix 9.I
Aquatic Health	n/a	new	Tables of new results based on revised water quality modelling	Appendix 9.III

Notes: EIS = Environmental Impact Statement; - = appendix not included herein because it is unchanged and available in the July 2011 EIS Update (De Beers 2011); n/a=not applicable.

Appendix 9.I, Hydrology Assessment Update, is a new appendix added to the 2012 EIS Supplement; it includes updated tables and figures that are referred to in Section 9.2.4, Effects to Water Quantity. Appendix 9.II contains the updated water quality time series plots for Lake N11 and Lake 410. Appendix 9.III, Aquatic Health, is a new appendix that includes tables of new results that are referred to in Section 9.2.6, Effects to Aquatic Health.