Atlantic Gold

Appendix G.2

Beaver Dam Mine: Killag River and Moose River Water Quality Predictions and Aquatic Effects Assessment – Reassessment of Killag River based on February 2021 Update (GHD modelling Provided February 12, 2021); Reassessment of Moose River based on March 2021 Update (Stantec modelling of March 11, 2021) – October 13, 2021

Completed for the Updated 2021 Beaver Dam Mine EIS

Memo

Date: October 13, 2021

To: Jim Millard and Veronica Chisholm, Atlantic Mining NS Inc.

From: Christine Moore and Nicholas Maya, Intrinsik

cc : Meghan Milloy, McCallum Environmental Ltd.

Re: Beaver Dam Mine: Killag River and Moose River Water Quality Predictions and Aquatic Effects Assessment – Reassessment of Killag River based on February 2021 Update (GHD modelling Provided February 12, 2021); Reassessment of Moose River based on March 2021 Update (Stantec modelling of March 11, 2021)

This memo outlines changes and updates to the Aquatic Effects Assessment (Appendix G.4 of the Revised 2019 Environmental Impact Assessment [EIS] [Intrinsik 2019 in AMNS 2019]) submitted as part of the Atlantic Mining NS Inc. (AMNS) Revised 2019 EIS for the Beaver Dam Mine Project to the Canadian Environmental Assessment Agency (CEAA) and Nova Scotia Environment (NSE) on February 28, 2019. These changes were in response to updates made to infrastructure and Project Area boundaries in and around the Beaver Dam Mine Site and Information Requests (IRs) from NSE: NSE 1-5 and NSE 1-17b,c (CEAA and NSE 2017) and NSE 2-97, NSE 2-98, NSE 2-99, (CEAA and NSE 2019). These IRs were received by AMNS, Round 1 IRs (CEAA and NSE 2017) were address in the Revised 2019 EIS (AMNS 2019, Table 1-1 Information Request Concordance Table) and responses to Round 2 IRs are provided in the AMNS Beaver Dam Mine Project EIS Information Request Responses, Round 2 submission (AMNS 2021a) and described in this memo.

Remodelling of the aquatic releases and receiving environment in the Killag River was conducted in February 2021 (GHD 2021a in Updated 2021 EIS [AMNS 2021b, Appendix Q.1]). Hardness and chloride values were also predicted for the Beaver Dam Mine Site during End-of-Mine (EOM) and Post-closure (PC) conditions to further evaluate the affect of these potential toxicity modifying factors on other emissions. The remodelling is presented in an additional water quality modelling technical memorandum (GHD, 2021b in AMNS 2021b, Appendix G.3. Remodelling in the Moose River receiving environment was conducted in March 2021 (Stantec 2021a,b in AMNS 2021b, Appendix F.6 and F.8).

The purpose of this memo is to provide Technical Reviewers of the EIS an outline of important changes to the Intrinsik (2019 in AMNS 2019, Appendix G.4) aquatic effects assessment. Only key tables and discussion of critical changes and new results will be provided herein, using the section numbering headings provided in Intrinsik (2019 in AMNS 2019, Appendix G.4). All other information can be found in the Intrinsik (2019 in AMNS 2019, Appendix G.4) report.

This technical memo pertains only to predictions of water quality in the receiving environments of the Killag River and Moose River. All predictions related to water quality within Beaver Dam Mine Site mine pits, or settling ponds is provided in GHD (2021a in AMNS 2021b, Appendix Q.1), whereas water quality associated with effluent discharge from the exhausted Touquoy Mine pit during reclamation/closure phase, as well as predicted water quality of seepage from the Touquoy Pit can be found in Stantec (2021b in AMNS 2021b, Appendix F.8).

Section 3 Killag River Assessment

3.1 Description of the Receiving Environment and Baseline Data

Table 3-1 in Intrinsik (2019 in AMNS 2019, Appendix G.4) only included baseline data from October 2014 to August 2015, as that was all that was available at the time the assessment was conducted. Further investigation indicated that the results from sample SW1 collected in August 2015 were likely influenced by suspended particulate in the surface water, which elevated the concentrations of several elements. Although Total Suspended Sediment (TSS) was not analyzed in this sample, the influence of suspended particulate was suspected as the colour and turbidity of the sample were both elevated, indicating that sampling could have been collected after a rain event, affecting particulate in the sample. Additional baseline data has since been gathered. As such, the statistics in Table 3-1 have been recalculated to include eight of the original nine samples from 2014 to 2015 (all samples except the SW1 sample collected during August 2015), as well as an additional seven sampling intervals from April 2019, June 2019, September 2019, December 2019, April 2020, June 2020 and September 2020. The data in Table 3-1 is for station SW1, the most relevant station to characterize the receiving environment. Note that the data in Table 3-1 are for total metals, as the 2014 to 2015 dataset was limited to total metals. Most water quality guidelines are total metals guidelines, with the exception of zinc (CCME, 2018).

Table 3-1 Baseline Surface Water Concentrations Collected from Killag River (Total Metals; µg/L; N = 7-15)[a]

Parameter[b]	*Min*	*Max*	*Mean[c]*	*75th Percentile[c]*	*90th Percentile[c]*	*# of Non-Detects*	*CCME (µg/L)*	*Nova Scotia Tier 1 (µg/L)*
Silver	<0.10	<0.10	0.05	0.05	0.05	7/7	0.25	0.1
Aluminum	140	370	244	290	326	0/15	5	5
Arsenic	<1.0	3.9	1.81	2.55	3.3	4/15	5	5
Cadmium	<0.010	0.032	0.02	0.024	0.029	1/15	0.04	0.01
Cobalt	<0.40	0.55	0.27	0.2	0.52	12/15	0.78[d]	10
Copper	<0.50	<2.0	0.71	1	1	13/15	2	2
Iron	210	850	489	650	722	0/15	300	300
Mercury	<0.013	0.015	0.01	0.0065	0.0065	14/15	0.026	0.026
Manganese	25	79	44.7	51.5	66	0/15	190	820
Molybdenum	<2.0	22	2.40	1	1	14/15	73	73
Nickel	<2.0	2.6	1.11	1	1	14/15	25	25
Lead	<0.50	0.56	0.31	0.25	0.528	12/15	1	1
Antimony	<1.0	<1.0	0.50	0.5	0.5	15/15	NV	20
Selenium	<0.50	<1.0	0.42	0.5	0.5	15/15	1	1
Thallium	<0.10	<0.10	0.05	0.05	0.05	15/15	0.8	0.8
Uranium	<0.10	<0.10	0.05	0.05	0.05	15/15	15	300
Zinc	<5.0	7.8	3.48	3.75	6.12	11/15	7[e]	30
Nitrate	<50	<50	25.0	25	25	7/7	13,000	NV
Nitrite	<10	<20	5.71	5	7	7/7	60	NV

Parameter[b]	*Min*	*Max*	*Mean*[c]	*75th Percentile*[c]	*90th Percentile*[c]	*# of Non-Detects*	*CCME (µg/L)*	*Nova Scotia Tier 1 (µg/L)*
Ammonia	<50	<50	25.0	25	25	7/7	27,550[f]	
pH	4.59	6.00	5.43	5.71	5.86	0/15	6 – 9.5	6-9.5
Hardness (mg/L as $CaCO_3$)	1.6	5.5	3.44	4.55	5	0/15	NV	NV
DOC (mg/L)	7	20	12.2	15	18.2	0/7	NV	NV

Notes: NV indicates no value provided; reported pH is based on lab analysis, as field measurements were unusually low (range of 2.63 to 6.48); < indicates that the concentration reported is the analytical detection limit (value was not detected)
a. Summary statistics were calculated using the maximum value between duplicate samples and half the detection limit value when a chemical was not detected in a sample; **b**. Concentrations are in µg/L unless noted otherwise; **c.** For parameters measured below the detection limit, half of the detection limit was used when calculating this metric; **d.** Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L, which is the lowest hardness level cited for the FWQG equation. Site specific hardness falls below the accepted range of values for the equation; **e.** Selected guideline represents the Long-term CWQG, SSD 5th percentile at water hardness of 50 mg·L-1, pH of 7.5 and DOC of 0.5 mg·L-1. The CCME equation is valid between hardness of 23.4 and 399 mg $CaCO_3$/L, pH of 6.5 to 8.13, and DOC of 0.3 to 22.9 mg/L. The site specific hardness and pH values in the Killag are slightly below the accepted ranges for these parameters. For screening purposes, the guideline of 7 was used, as site specific DOC will increase the guideline beyond 7 ug/L;; **f.** Selected guideline represents the ammonia (total) CCME guideline value at pH 6.0 and temperature of 25 °C, multiplied by 0.8224 (for the conversion of NH_3 to total ammonia-N).

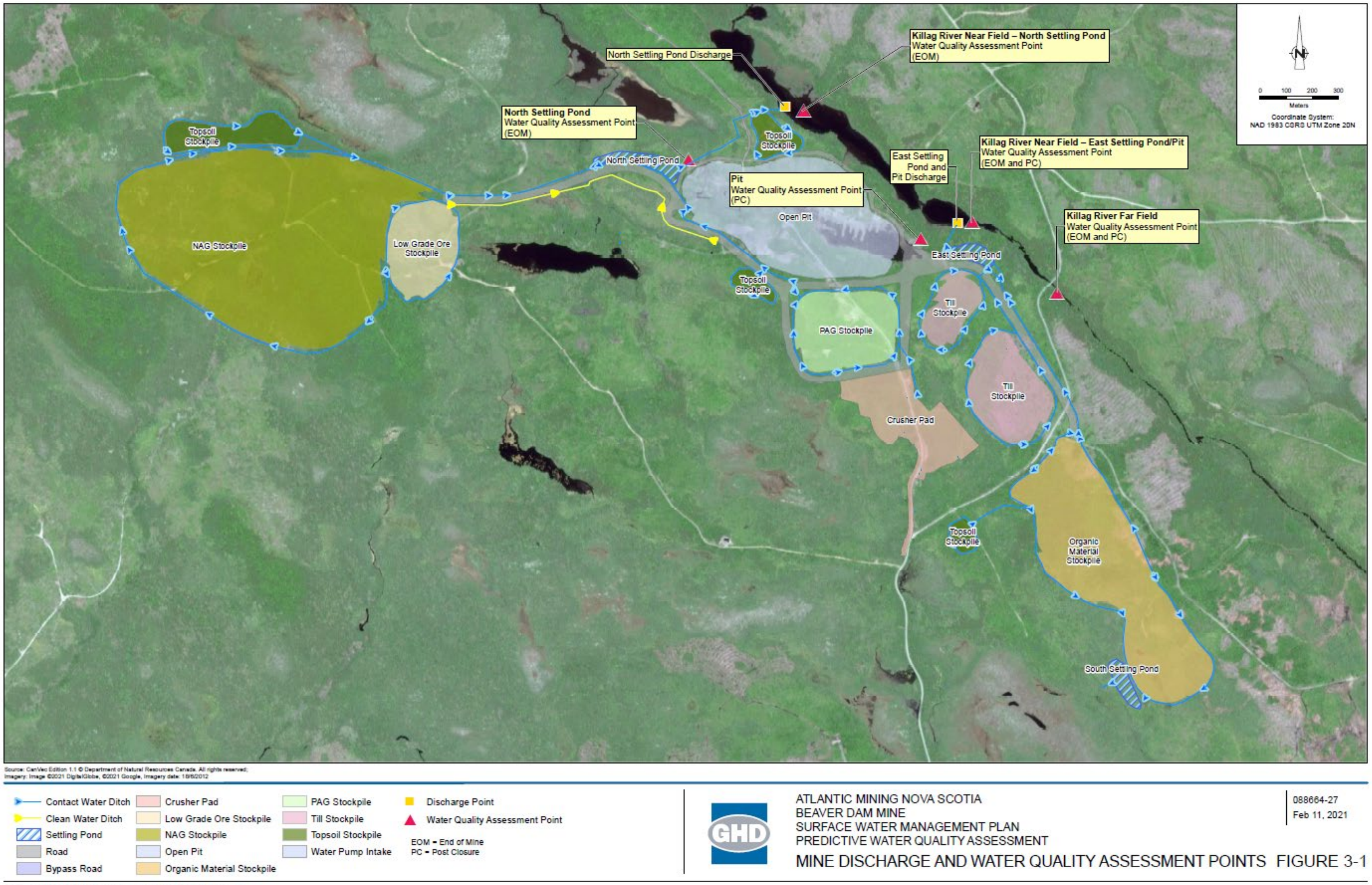
3.2 Description of Water Quality Modelling Conducted

Please see GHD (2021a in AMNS 2021b, Appendix Q.1) for a description of the revised water quality modelling.

3.3 Discharge Points and Receiving Environment Prediction Points

The two scenarios (End of Mine or EOM, and Post Closure or PC) remain the same as in Intrinsik (2019 in AMNS 2019, Appendix G.4). There are now two near-field prediction locations, as outlined in Figure 3-1 (GHD, 2021a in AMNS 2021b, Appendix Q.1). The first is the Killag River Near Field – North Settling Pond discharge point, and the second is the Killag River Near Field – East Settling Pond Discharge point. The near field prediction nodes are 100 m downstream of discharge point; as outlined in Intrinsik (2019 in AMNS 2019, Appendix G.4). The single far field prediction node is 1 km downstream of discharge point, as per Intrinsik (2019 in AMNS 2019, Appendix G.4).

Figure 3-1 is revised and provides a summary of the two near-field prediction nodes, and the far field node.


Killag River Near Field – North Settling Pond
Water Quality Assessment Point
(EOM)
North Settling Pond Discharge
North Settling Pond
Water Quality Assessment Point
(EOM)
Topsoil Stockpile
North Settling Pond
East Settling Pond and Pit Discharge
Killag River Near Field – East Settling Pond/Pit
Water Quality Assessment Point
(EOM and PC)
Pit
Water Quality Assessment Point
(PC)
Open Pit
Killag River Far Field
Water Quality Assessment Point
(EOM and PC)
NAG Stockpile
Low Grade Ore Stockpile
East Settling Pond
Till Stockpile
PAG Stockpile
Crusher Pad
Organic Material Stockpile
South Settling Pond
N
0 100 200 300
Meters
Coordinate System:
NAD 1983 CSRS UTM Zone 20N
Source: CanVec Edition 1.1 © Department of Natural Resources Canada. All rights reserved;
Imagery: Image ©2021 DigitalGlobe, ©2021 Google, Imagery date: 18/8/2012
Contact Water Ditch
Clean Water Ditch
Settling Pond
Road
Bypass Road
Crusher Pad
Low Grade Ore Stockpile
NAG Stockpile
Open Pit
Organic Material Stockpile
PAG Stockpile
Till Stockpile
Topsoil Stockpile
Water Pump Intake
Discharge Point
Water Quality Assessment Point
EOM = End of Mine
PC = Post Closure
GHD
ATLANTIC MINING NOVA SCOTIA
BEAVER DAM MINE
SURFACE WATER MANAGEMENT PLAN
PREDICTIVE WATER QUALITY ASSESSMENT
088664-27
Feb 11, 2021
MINE DISCHARGE AND WATER QUALITY ASSESSMENT POINTS FIGURE 3-1

3.4 Selected Benchmarks

Table 3-2 provides a summary of the selected aquatic effects benchmarks for total metals and general chemistry parameters. Since the 75th percentile of baseline is included in Table 3-2, and since additional baseline data were added into the statistical analysis of baseline, Table 3-2 was revised and is presented below.

Table 3-2 Selected Benchmark Concentrations for Use in the Assessment (µg/L)

Parameter	*Selected Guideline[a]*	*75th Percentile Baseline Concentration[b]*	*Site-Specific Water Quality Objective*	*Selected Benchmark Concentration*
Silver	0.25[c]	0.05	-	0.25
Aluminum	5	290	-	290
Arsenic	5	2.55	30	30
Cadmium	0.04[c]	0.024	-	0.04
Cobalt	0.78[d]	0.2	-	0.78
Copper	2	1	-	2
Iron	300	650	-	650
Mercury	0.026	0.0065	-	0.026
Manganese	190[c]	51.5	-	190
Molybdenum	73	1	-	73
Nickel	25	1	-	25
Lead	1	0.25	-	1
Antimony	20	0.5	-	20
Selenium	1	0.5	-	1
Thallium	0.8	0.05	-	0.8
Uranium	15[c]	0.05	-	15
Zinc	7[e]	3.75	-	7
Nitrate	13,000[c]	25	-	13,000
Nitrite	60[c]	5	-	60
Ammonia	27,550[f]	25	-	27,550

Notes:
- not calculated
a. Selected guidelines represent Nova Scotia Tier 1 guidelines for total metals and general chemistry parameters unless specified otherwise; **b.** For parameters measured below the detection limit, half of the detection limit was used when calculating this metric; **c.** Selected guideline is for dissolved manganese adopted from CCME; **d.** Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L; **e.** Selected guideline represents the Long-term CWQG for dissolved zinc, SSD 5th percentile at water hardness of 50 mg·L-1, pH of 7.5 and DOC of 0.5 mg·L-1; **f.** Selected guideline represents the ammonia (total) CCME guideline value at pH 6.0 and temperature of 25°C, multiplied by 0.8224 (for the conversion of NH_3 to total ammonia-N).

3.5 Predicted Water Quality – No Water Treatment Scenario

All prediction tables in Intrinsik (2019 in AMNS 2019, Appendix G.4) require revision based on revised infrastructure, and hence, updated results tables are provided herein.

3.5.1 Near-field Predictions (100 m downstream of discharge point)

End of Mine (EOM) Predictions – Killag River at North Pond and East Pond Discharge points

Table 3-3 (Killag River at North Pond EOM Base case) and Table 3-4 (Killag River at North Settling Pond EOM Upper case) have been revised to reflect the current infrastructure. Table 3-5 (Killag River at East Pond EOM Base case) and Table 3-6 (Killag River at East Settling Pond EOM Upper case) are new scenarios, and hence, prediction tables are provided, based on GHD (2021a in AMNS 2021b, Appendix Q.1). The revised tables are provided below.

Table 3-3 Revised Constituent Concentrations in Killag River at Near Field North Settling Pond Discharge Point - EOM Conditions Base Case

Constituent	*Selected Benchmark Concentration[a]*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Silver	0.25[b]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Aluminum	290[c]	241.06	241.02	244.11	239.77	236.10	225.42	214.71	211.06	215.84	237.00	241.03	239.37
Arsenic	30[d]	2.09	2.10	1.91	2.18	2.33	2.78	3.20	3.36	3.14	2.22	2.07	2.17
Cadmium	0.04[b]	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
Cobalt	0.78[e]	0.36	0.36	0.34	0.37	0.39	0.45	0.51	0.53	0.50	0.38	0.36	0.37
Copper	2	0.84	0.84	0.84	0.84	0.84	0.83	0.82	0.82	0.82	0.83	0.84	0.84
Iron	650[c]	483.95	483.85	490.14	481.31	473.89	452.25	430.57	423.18	432.86	475.74	483.89	480.52
Mercury	0.026	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Manganese	190[b]	47.65	47.71	47.23	47.87	47.88	48.02	47.97	48.09	47.87	47.42	47.50	47.72
Molybdenum	73	1.71	1.71	1.57	1.80	2.02	2.69	3.37	3.59	3.30	1.99	1.72	1.82
Nickel	25	2.23	2.25	1.85	2.42	2.75	3.76	4.71	5.07	4.59	2.54	2.20	2.41
Lead	1	0.33	0.33	0.33	0.33	0.33	0.32	0.31	0.31	0.32	0.33	0.33	0.33
Antimony	20	0.48	0.48	0.49	0.48	0.48	0.46	0.45	0.44	0.45	0.48	0.48	0.48
Selenium	1	0.49	0.49	0.47	0.49	0.50	0.52	0.54	0.55	0.53	0.49	0.48	0.49
Thallium	0.8	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Uranium	15[b]	1.05	1.06	0.78	1.19	1.49	2.40	3.30	3.62	3.20	1.38	1.04	1.20
Zinc	7[f]	3.59	3.60	3.55	3.62	3.63	3.67	3.70	3.72	3.69	3.59	3.58	3.61
Nitrate	13,000[b]	603	621	363	716	870	1,356	1,789	1,977	1,721	714	566	694
Nitrite	60[b]	11.14	11.25	9.14	12.12	13.81	19.01	23.90	25.78	23.25	12.70	10.93	12.04
Ammonia	27,550[g]	58.2	57.8	54.6	60.5	69.6	96.2	124.2	132.3	121.9	70.5	59.4	62.0

Notes:
All values are presented as µg/L.
a. Selected benchmarks represent Nova Scotia Tier 1 guidelines unless specified otherwise; **b.** Adopted from CCME; **c.** Based on baseline concentration in the Killag River (75th percentile); **d.** Site-specific water quality guideline; **e.** Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L; **f.** Selected guideline represents the Long-term CWQG, SSD 5th percentile at water hardness of 50 mg·L-1, pH of 7.5 and DOC of 0.5 mg·L-1; **g.** Selected guideline represents the ammonia (total) CCME guideline value at pH 6.0 and temperature of 25ºC, multiplied by 0.8224 (for the conversion of NH_3 to total ammonia-N).

Table 3-4 Revised Constituent Concentrations in Killag River at Near Field North Settling Pond Discharge Point - EOM Conditions Upper Case

Constituent	Selected Benchmark Concentration[a]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Silver	0.25[b]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Aluminum	290[c]	241.34	241.30	244.29	240.02	236.50	226.13	215.75	212.18	216.78	237.37	241.27	239.66
Arsenic	30[d]	2.34	2.36	2.08	2.46	2.69	3.38	4.04	4.28	3.94	2.54	2.30	2.45
Cadmium	0.04[b]	0.020	0.020	0.019	0.020	0.020	0.020	0.021	0.021	0.021	0.020	0.020	0.020
Cobalt	0.78[e]	0.40	0.40	0.36	0.42	0.45	0.54	0.63	0.66	0.62	0.42	0.39	0.41
Copper	2	0.87	0.87	0.86	0.88	0.89	0.91	0.94	0.95	0.93	0.88	0.87	0.88
Iron	650[c]	484.04	483.95	490.21	481.40	474.03	452.50	430.93	423.56	433.19	475.87	483.98	480.62
Mercury	0.026	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Manganese	190[b]	48.17	48.25	47.54	48.48	48.64	49.25	49.61	49.90	49.44	48.05	47.98	48.32
Molybdenum	73	2.69	2.69	2.33	2.88	3.41	4.99	6.58	7.10	6.42	3.32	2.71	2.93
Nickel	25	2.59	2.61	2.09	2.83	3.26	4.59	5.85	6.32	5.68	2.99	2.54	2.81
Lead	1	0.34	0.34	0.34	0.34	0.34	0.35	0.35	0.36	0.35	0.34	0.34	0.34
Antimony	20	0.49	0.49	0.49	0.49	0.49	0.48	0.48	0.47	0.48	0.49	0.49	0.49
Selenium	1	0.52	0.52	0.50	0.53	0.55	0.60	0.64	0.66	0.63	0.53	0.52	0.53
Thallium	0.8	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Uranium	15[b]	1.32	1.33	0.98	1.49	1.88	3.04	4.18	4.57	4.05	1.74	1.31	1.50
Zinc	7[f]	3.64	3.65	3.58	3.67	3.70	3.80	3.87	3.91	3.85	3.65	3.63	3.66
Nitrate	13,000[b]	1,096	1,127	666	1,301	1,595	2,519	3,353	3,703	3,226	1,324	1,034	1,266
Nitrite	60[b]	27.19	27.01	23.41	29.35	36.30	56.86	76.53	84.58	76.14	36.06	27.80	30.21
Ammonia	27,550[g]	120.4	118.3	113.3	125.8	155.9	242.8	336.7	362.2	329.8	163.7	126.0	132.0

Notes:
All values are presented as μg/L.
Shaded values indicate an exceedance of the selected benchmark concentration.
a. Selected benchmarks represent Nova Scotia Tier 1 guidelines unless specified otherwise; **b.** Adopted from CCME; **c.** Based on baseline concentration in the Killag River (75th percentile); **d.** Site-specific water quality guideline; **e.** Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L; **f.** Selected guideline represents the Long-term CWQG, SSD 5th percentile at water hardness of 50 mg·L-1, pH of 7.5 and DOC of 0.5 mg·L-1; **g.** Selected guideline represents the ammonia (total) CCME guideline value at pH 6.0 and temperature of 25°C, multiplied by 0.8224 (for the conversion of NH_3 to total ammonia-N).

Table 3-5 Revised Constituent Concentrations in Killag River at Near Field East Settling Pond Discharge Point - EOM Conditions Base Case

Constituent	*Selected Benchmark Concentration*[a]	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Silver	0.25[b]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Aluminum	290[c]	240.58	240.55	243.61	239.28	235.46	224.36	213.22	209.49	214.37	236.27	240.50	238.84
Arsenic	30[d]	2.08	2.09	1.90	2.17	2.31	2.75	3.16	3.32	3.11	2.21	2.06	2.16
Cadmium	0.04[b]	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
Cobalt	0.78[e]	0.36	0.36	0.33	0.37	0.39	0.45	0.50	0.53	0.50	0.38	0.36	0.37
Copper	2	0.84	0.84	0.84	0.84	0.83	0.83	0.82	0.81	0.82	0.83	0.84	0.84
Iron	650[c]	482.98	482.93	489.14	480.33	472.60	450.13	427.59	420.03	429.91	474.27	482.83	479.45
Mercury	0.026	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Manganese	190[b]	47.53	47.59	47.12	47.74	47.70	47.72	47.53	47.61	47.44	47.24	47.36	47.58
Molybdenum	73	1.71	1.70	1.56	1.79	2.01	2.66	3.33	3.54	3.26	1.97	1.72	1.81
Nickel	25	2.22	2.24	1.84	2.41	2.73	3.72	4.65	5.01	4.53	2.52	2.18	2.39
Lead	1	0.33	0.33	0.33	0.33	0.32	0.32	0.31	0.31	0.31	0.32	0.33	0.33
Antimony	20	0.48	0.48	0.49	0.48	0.47	0.46	0.44	0.44	0.45	0.48	0.48	0.48
Selenium	1	0.49	0.49	0.47	0.49	0.50	0.52	0.53	0.54	0.53	0.49	0.48	0.49
Thallium	0.8	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Uranium	15[b]	1.04	1.05	0.77	1.17	1.47	2.38	3.26	3.56	3.16	1.36	1.03	1.19
Zinc	7[f]	3.58	3.59	3.54	3.61	3.61	3.65	3.67	3.69	3.66	3.58	3.57	3.59
Nitrate	13,000[b]	598	616	361	710	862	1,341	1,765	1,949	1,697	707	561	688
Nitrite	60[b]	11.08	11.18	9.09	12.05	13.71	18.82	23.60	25.44	22.96	12.60	10.87	11.96
Ammonia	27,550[g]	57.9	57.5	54.3	60.2	69.1	95.3	122.7	130.6	120.4	70.0	59.1	61.6

Notes:
All values are presented as µg/L.
Shaded values indicate an exceedance of the selected benchmark concentration.
a. Selected benchmarks represent Nova Scotia Tier 1 guidelines unless specified otherwise; **b.** Adopted from CCME; **c.** Based on baseline concentration in the Killag River (75th percentile); **d.** Site-specific water quality guideline; **e.** Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L; **f.** Selected guideline represents the Long-term CWQG, SSD 5th percentile at water hardness of 50 mg·L-1, pH of 7.5 and DOC of 0.5 mg·L-1; **g.** Selected guideline represents the ammonia (total) CCME guideline value at pH 6.0 and temperature of 25°C, multiplied by 0.8224 (for the conversion of NH_3 to total ammonia-N).

Table 3-6 Revised Constituent Concentrations in Killag River at Near Field East Settling Pond Discharge Point - EOM Conditions Upper Case

Constituent	Selected Benchmark Concentration[a]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Silver	0.25[b]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Aluminum	290[c]	240.84	240.82	243.78	239.51	235.83	225.03	214.20	210.54	215.25	236.61	240.72	239.11
Arsenic	30[d]	2.33	2.35	2.07	2.44	2.67	3.35	3.99	4.23	3.89	2.53	2.29	2.44
Cadmium	0.04[b]	0.020	0.020	0.019	0.020	0.020	0.020	0.021	0.021	0.021	0.020	0.019	0.020
Cobalt	0.78[e]	0.40	0.40	0.36	0.41	0.44	0.54	0.62	0.65	0.61	0.42	0.39	0.41
Copper	2	0.87	0.87	0.86	0.88	0.88	0.91	0.93	0.93	0.92	0.87	0.87	0.88
Iron	650[c]	483.06	483.00	489.19	480.40	472.71	450.32	427.88	420.33	430.17	474.37	482.90	479.53
Mercury	0.026	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Manganese	190[b]	48.01	48.09	47.40	48.31	48.41	48.86	49.05	49.30	48.91	47.83	47.82	48.14
Molybdenum	73	2.67	2.67	2.32	2.86	3.38	4.93	6.49	6.99	6.33	3.29	2.69	2.91
Nickel	25	2.57	2.60	2.08	2.81	3.24	4.54	5.77	6.24	5.61	2.97	2.52	2.79
Lead	1	0.34	0.34	0.34	0.34	0.34	0.35	0.35	0.35	0.35	0.34	0.34	0.34
Antimony	20	0.49	0.49	0.49	0.49	0.49	0.48	0.47	0.47	0.47	0.49	0.49	0.49
Selenium	1	0.52	0.52	0.49	0.53	0.54	0.59	0.63	0.65	0.63	0.53	0.51	0.53
Thallium	0.8	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Uranium	15[b]	1.31	1.31	0.97	1.48	1.86	3.00	4.12	4.51	3.99	1.72	1.30	1.49
Zinc	7[f]	3.64	3.64	3.57	3.66	3.69	3.77	3.83	3.87	3.82	3.64	3.62	3.65
Nitrate	13,000[b]	1,087	1,117	660	1,290	1,580	2,490	3,307	3,650	3,182	1,311	1,025	1,254
Nitrite	60[b]	26.98	26.81	23.24	29.12	35.99	56.23	75.51	83.40	75.13	35.73	27.58	29.97
Ammonia[g]	27,550	119.5	117.5	112.5	124.9	154.6	240.2	332.3	357.2	325.5	162.3	125.1	131.0

Notes:
All values are presented as µg/L.
Shaded values indicate an exceedance of the selected benchmark concentration.
a. Selected benchmarks represent Nova Scotia Tier 1 guidelines unless specified otherwise; **b.** Adopted from CCME; **c.** Based on baseline concentration in the Killag River (75th percentile); **d.** Site-specific water quality guideline; **e.** Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L; **f.** Selected guideline represents the Long-term CWQG, SSD 5th percentile at water hardness of 50 mg·L-1, pH of 7.5 and DOC of 0.5 mg·L-1; **g.** Selected guideline represents the ammonia (total) CCME guideline value at pH 6.0 and temperature of 25ºC, multiplied by 0.8224 (for the conversion of NH_3 to total ammonia-N).

Post Closure Predictions – Near Field Pit Discharge

At Post-closure, there will only be a single discharge point, which will be from the pit. In the most recent water quality modelling analysis conducted by GHD (2021b in AMNS 2021b, Appendix G.3), infiltration rate sensitivity analysis was performed for the Potentially Acid Generating (PAG) stockpile during PC conditions. Based on the findings of a recent study utilizing a high-density polyethylene (HDPE) cover system for a waste rock stockpile in Nova Scotia (Power et al., 2017), GHD (2021b in AMNS 2021b, Appendix G.3) concluded that an infiltration rate of approximately 3% through the liner was reasonable, if a similar material were to be used. Table 3-7 and 3-8 provide the near field Pit discharge receiving environment predictions for the Base Case (Table 3-7) and the Upper Case (Table 3-8), with the 3% infiltration rate scenario.

Table 3-7 Revised Constituent Concentrations in Killag River at Near Field Pit Discharge Point - PC Conditions Base Case

Constituent	Selected Benchmark Concentration[a]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Silver	0.25[b]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Aluminum	290[c]	242.76	243.01	243.62	242.34	239.81	232.25	223.68	220.94	223.69	238.55	241.77	241.44
Arsenic	30[d]	1.59	1.59	1.57	1.59	1.60	1.62	1.62	1.63	1.61	1.58	1.58	1.59
Cadmium	0.04[b]	0.020	0.020	0.019	0.020	0.020	0.022	0.023	0.024	0.023	0.020	0.020	0.020
Cobalt	0.78[e]	0.39	0.40	0.35	0.39	0.44	0.56	0.69	0.72	0.65	0.42	0.38	0.40
Copper	2	0.82	0.82	0.82	0.82	0.82	0.81	0.79	0.78	0.79	0.81	0.82	0.82
Iron	650[c]	487.62	488.12	489.33	486.75	481.72	466.60	449.47	443.98	449.47	479.18	485.61	484.96
Mercury	0.026	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Manganese	190[b]	46.59	46.67	46.30	46.62	46.54	46.17	45.57	45.43	45.33	46.03	46.29	46.47
Molybdenum	73	1.45	1.47	1.24	1.52	1.69	2.14	2.57	2.74	2.46	1.54	1.40	1.51
Nickel	25	2.15	2.18	1.77	2.08	2.64	3.86	5.14	5.49	4.74	2.46	1.98	2.20
Lead	1	0.34	0.34	0.33	0.34	0.34	0.35	0.36	0.36	0.35	0.34	0.33	0.34
Antimony	20	0.48	0.48	0.48	0.48	0.47	0.46	0.44	0.44	0.44	0.47	0.48	0.48
Selenium	1	0.45	0.45	0.45	0.45	0.45	0.44	0.43	0.43	0.43	0.44	0.45	0.45
Thallium	0.8	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Uranium	15[b]	0.11	0.11	0.08	0.12	0.14	0.20	0.26	0.28	0.25	0.12	0.10	0.12
Zinc	7[f]	4.12	4.14	3.88	4.05	4.41	5.15	5.94	6.14	5.66	4.29	3.99	4.13
Nitrate	13,000[b]	104	106	84	99	131	199	272	291	249	122	95	106
Nitrite	60[b]	6.48	6.53	6.03	6.35	7.04	8.48	10.00	10.40	9.48	6.82	6.25	6.51
Ammonia	27,550[g]	36.5	36.7	34.0	35.8	39.6	47.4	55.7	57.9	52.9	38.3	35.2	36.6

Notes:
All values are presented as µg/L.
a. Selected benchmarks represent Nova Scotia Tier 1 guidelines unless specified otherwise; **b.** Adopted from CCME; **c.** Based on baseline concentration in the Killag River (75th percentile); **d.** Site-specific water quality guideline; **e.** Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L; **f.** Selected guideline represents the Long-term CWQG, SSD 5th percentile at water hardness of 50 mg·L-1, pH of 7.5 and DOC of 0.5 mg·L-1; **g.** Selected guideline represents the ammonia (total) CCME guideline value at pH 6.0 and temperature of 25ºC, multiplied by 0.8224 (for the conversion of NH_3 to total ammonia-N).

Table 3-8 Revised Constituent Concentrations in Killag River Near Field Pit Discharge Point - PC Upper Case

Constituent	Selected Benchmark Concentration[a]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Silver	0.25[b]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Aluminum	290[c]	242.76	243.01	243.62	242.34	239.82	232.25	223.68	220.94	223.70	238.55	241.77	241.44
Arsenic	30[d]	1.60	1.60	1.57	1.61	1.62	1.64	1.66	1.67	1.64	1.59	1.59	1.60
Cadmium	0.04[b]	0.020	0.021	0.020	0.020	0.021	0.023	0.025	0.026	0.025	0.021	0.020	0.021
Cobalt	0.78[e]	0.42	0.43	0.37	0.41	0.49	0.64	0.80	0.85	0.75	0.46	0.40	0.43
Copper	2	0.84	0.84	0.83	0.84	0.84	0.84	0.84	0.84	0.83	0.83	0.83	0.83
Iron	650[c]	487.96	488.46	489.55	487.05	482.21	467.50	450.80	445.42	450.66	479.62	485.90	485.30
Mercury	0.026	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Manganese	190[b]	46.66	46.74	46.34	46.70	46.65	46.35	45.81	45.70	45.56	46.11	46.35	46.54
Molybdenum	73	1.50	1.52	1.26	1.57	1.75	2.25	2.72	2.90	2.60	1.59	1.44	1.56
Nickel	25	2.68	2.73	2.11	2.58	3.42	5.25	7.16	7.70	6.58	3.15	2.44	2.76
Lead	1	0.36	0.36	0.35	0.35	0.37	0.41	0.44	0.45	0.43	0.36	0.35	0.36
Antimony	20	0.48	0.48	0.48	0.48	0.48	0.46	0.45	0.44	0.45	0.47	0.48	0.48
Selenium	1	0.46	0.46	0.46	0.46	0.47	0.47	0.47	0.48	0.47	0.46	0.46	0.46
Thallium	0.8	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Uranium	15[b]	0.12	0.12	0.09	0.13	0.15	0.22	0.28	0.31	0.27	0.13	0.11	0.13
Zinc	7[f]	4.42	4.45	4.07	4.32	4.84	5.94	7.09	7.39	6.70	4.68	4.25	4.44
Nitrate	13,000[b]	149	152	114	139	197	319	449	483	408	182	133	153
Nitrite	60[b]	7.53	7.60	6.72	7.28	8.56	11.26	14.12	14.86	13.18	8.21	7.13	7.58
Ammonia	27,550[g]	42.2	42.6	37.8	40.9	47.9	62.7	78.3	82.4	73.2	46.0	40.0	42.5

Notes:
All values are presented as µg/L.
Shaded values indicate an exceedance of the selected benchmark concentration.
a. Selected benchmarks represent Nova Scotia Tier 1 guidelines unless specified otherwise; **b.** Adopted from CCME; **c.** Based on baseline concentration in the Killag River (75th percentile); **d.** Site-specific water quality guideline; **e.** Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L; **f.** Selected guideline represents the Long-term CWQG, SSD 5th percentile at water hardness of 50 mg·L-1, pH of 7.5 and DOC of 0.5 mg·L-1; **g.** Selected guideline represents the ammonia (total) CCME guideline value at pH 6.0 and temperature of 25°C, multiplied by 0.8224 (for the conversion of NH_3 to total ammonia-N).

For the near field predictions, in the EOM scenario at the North Settling Pond discharge point, all predicted constituent concentrations were consistently below selected water quality benchmarks in the base case (Table 3-3) and upper case, with the exception of nitrite in the EOM upper case, wherein the guideline is exceeded in July, August and September (Tables 3-4).

In the EOM East Settling Pond discharge point, all predicted constituent concentrations were consistently below benchmarks in the base case (Table 3-5) and upper case, with the exception of nitrite which exceeded the guideline in July, August and September (Table 3-6).

At Post-closure, all predicted constituent concentrations were consistently below selected water quality benchmarks in the base case (Table 3-7). Cobalt and zinc are predicted to marginally exceed water quality guidelines during the months of July and August in the PC upper case (Table 3-8).

These exceedances are discussed further in Section 3.5.2.

3.5.2 Far Field Predictions (1 km downstream of discharge point)

Table 3-9 (Base case) and Table 3-10 (Upper case) provide predictions for the Far Field area for the EOM scenario, resulting from releases upstream. In addition, Table 3-11 (Base case) and Table 3-12 (Upper case) provide predictions for the PC scenario, assuming an infiltration rate of 3%. The revised tables are provided below and in GHD (2021b in AMNS 2021b, Appendix G.3).

Table 3-9 Revised Constituent Concentrations in Killag River at Far Field Discharge Point - EOM Conditions Base Case

Constituent	Selected Benchmark Concentration[a]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Silver	0.25[b]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Aluminum	290[c]	240.73	240.71	243.73	239.45	235.67	224.68	213.64	209.94	214.78	236.47	240.66	239.01
Arsenic	30[d]	2.08	2.09	1.90	2.16	2.31	2.74	3.15	3.31	3.09	2.20	2.06	2.15
Cadmium	0.04[b]	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
Cobalt	0.78[e]	0.36	0.36	0.33	0.37	0.39	0.45	0.50	0.52	0.49	0.37	0.36	0.37
Copper	2	0.84	0.84	0.84	0.84	0.84	0.83	0.82	0.82	0.82	0.83	0.84	0.84
Iron	650[c]	483.29	483.23	489.37	480.67	473.02	450.77	428.44	420.94	430.75	474.67	483.14	479.80
Mercury	0.026	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Manganese	190[b]	47.56	47.62	47.14	47.76	47.74	47.79	47.63	47.73	47.54	47.28	47.39	47.61
Molybdenum	73	1.70	1.70	1.55	1.78	2.00	2.65	3.31	3.52	3.24	1.96	1.71	1.80
Nickel	25	2.21	2.23	1.84	2.39	2.71	3.69	4.62	4.97	4.49	2.51	2.17	2.38
Lead	1	0.33	0.33	0.33	0.33	0.32	0.32	0.31	0.31	0.31	0.32	0.33	0.33
Antimony	20	0.48	0.48	0.49	0.48	0.48	0.46	0.44	0.44	0.45	0.48	0.48	0.48
Selenium	1	0.49	0.49	0.47	0.49	0.50	0.52	0.53	0.54	0.53	0.49	0.48	0.49
Thallium	0.8	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Uranium	15[b]	1.03	1.03	0.77	1.16	1.46	2.35	3.23	3.53	3.13	1.35	1.02	1.17
Zinc	7[f]	3.59	3.59	3.54	3.61	3.62	3.65	3.67	3.69	3.66	3.58	3.57	3.60
Nitrate	13,000[b]	592	609	357	702	853	1,327	1,748	1,930	1,680	700	555	681
Nitrite	60[b]	11.01	11.12	9.05	11.97	13.61	18.68	23.42	25.24	22.78	12.52	10.81	11.89
Ammonia	27,550[g]	57.6	57.2	54.0	59.8	68.7	94.6	121.8	129.6	119.5	69.6	58.8	61.2

Notes:
All values are presented as µg/L.
a. Selected benchmarks represent Nova Scotia Tier 1 guidelines unless specified otherwise; **b.** Adopted from CCME; **c.** Based on baseline concentration in the Killag River (75th percentile); **d.** Site-specific water quality guideline; **e.** Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L; **f.** Selected guideline represents the Long-term CWQG, SSD 5th percentile at water hardness of 50 mg·L-1, pH of 7.5 and DOC of 0.5 mg·L-1; **g.** Selected guideline represents the ammonia (total) CCME guideline value at pH 6.0 and temperature of 25°C, multiplied by 0.8224 (for the conversion of NH_3 to total ammonia-N).

Table 3-10 Revised Constituent Concentrations in Killag River at Far Field Discharge Point - EOM Conditions Upper Case

Constituent	Selected Benchmark Concentration[a]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Silver	0.25[b]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Aluminum	290[c]	241.02	241.00	243.91	239.70	236.08	225.41	214.71	211.09	215.74	236.84	240.90	239.30
Arsenic	30[d]	2.33	2.34	2.06	2.44	2.67	3.34	3.97	4.21	3.87	2.52	2.29	2.43
Cadmium	0.04[b]	0.020	0.020	0.019	0.020	0.020	0.020	0.021	0.021	0.021	0.020	0.019	0.020
Cobalt	0.78[e]	0.39	0.40	0.36	0.41	0.44	0.53	0.62	0.65	0.61	0.42	0.39	0.41
Copper	2	0.87	0.87	0.86	0.88	0.89	0.91	0.93	0.94	0.92	0.88	0.87	0.88
Iron	650[c]	483.40	483.35	489.45	480.77	473.19	451.06	428.85	421.38	431.12	474.82	483.24	479.91
Mercury	0.026	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Manganese	190[b]	48.08	48.16	47.45	48.38	48.51	49.04	49.31	49.58	49.14	47.92	47.88	48.22
Molybdenum	73	2.65	2.65	2.30	2.84	3.36	4.90	6.45	6.94	6.29	3.27	2.67	2.89
Nickel	25	2.55	2.58	2.06	2.79	3.21	4.51	5.72	6.19	5.56	2.95	2.50	2.78
Lead	1	0.34	0.34	0.34	0.34	0.34	0.35	0.35	0.35	0.35	0.34	0.34	0.34
Antimony	20	0.49	0.49	0.49	0.49	0.49	0.48	0.47	0.47	0.47	0.49	0.49	0.49
Selenium	1	0.52	0.52	0.49	0.53	0.54	0.59	0.63	0.65	0.63	0.53	0.51	0.53
Thallium	0.8	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Uranium	15[b]	1.29	1.30	0.96	1.46	1.84	2.97	4.08	4.47	3.96	1.70	1.28	1.47
Zinc	7[f]	3.64	3.64	3.57	3.66	3.69	3.77	3.84	3.87	3.82	3.64	3.62	3.65
Nitrate	13,000[b]	1,075	1,105	653	1,276	1,563	2,464	3,274	3,614	3,150	1,296	1,014	1,241
Nitrite	60[b]	26.73	26.56	23.03	28.85	35.64	55.69	76.32	82.62	74.42	35.39	27.33	29.69
Ammonia[g]	27,550[g]	118.5	116.5	111.5	123.8	153.2	237.9	329.2	353.9	322.5	160.8	124.0	129.9

Notes:
All values are presented as µg/L.
Shaded values indicate an exceedance of the selected benchmark concentration.
a. Selected benchmarks represent Nova Scotia Tier 1 guidelines unless specified otherwise; **b.** Adopted from CCME; **c.** Based on baseline concentration in the Killag River (75[th] percentile); **d.** Site-specific water quality guideline; **e.** Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L; **f.** Selected guideline represents the Long-term CWQG, SSD 5th percentile at water hardness of 50 mg·L-1, pH of 7.5 and DOC of 0.5 mg·L-1; **g.** Selected guideline represents the ammonia (total) CCME guideline value at pH 6.0 and temperature of 25°C, multiplied by 0.8224 (for the conversion of NH_3 to total ammonia-N).

Table 3-11 Revised Constituent Concentrations in Killag River at Far Field Discharge Point - PC Conditions Base Case

Constituent	Selected Benchmark Concentration[a]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Silver	0.25[b]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Aluminum	290[c]	243.43	243.66	244.27	243.03	240.72	233.75	225.80	223.21	225.77	239.54	242.49	242.18
Arsenic	30[d]	1.59	1.60	1.57	1.60	1.61	1.63	1.64	1.64	1.62	1.58	1.58	1.59
Cadmium	0.04[b]	0.020	0.020	0.019	0.020	0.021	0.022	0.023	0.024	0.023	0.020	0.020	0.020
Cobalt	0.78[e]	0.39	0.40	0.35	0.39	0.44	0.56	0.69	0.72	0.65	0.42	0.38	0.40
Copper	2	0.83	0.83	0.82	0.83	0.82	0.81	0.80	0.79	0.79	0.82	0.82	0.82
Iron	650[c]	488.96	489.42	490.63	488.13	483.53	469.60	453.73	448.55	453.64	481.17	487.06	486.45
Mercury	0.026	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Manganese	190[b]	46.70	46.78	46.42	46.74	46.70	46.44	45.96	45.85	45.71	46.20	46.41	46.60
Molybdenum	73	1.45	1.47	1.24	1.52	1.68	2.14	2.57	2.74	2.47	1.54	1.40	1.51
Nickel	25	2.14	2.17	1.76	2.07	2.63	3.85	5.14	5.50	4.74	2.45	1.98	2.19
Lead	1	0.34	0.34	0.33	0.34	0.34	0.35	0.36	0.37	0.36	0.34	0.33	0.34
Antimony	20	0.48	0.48	0.48	0.48	0.48	0.46	0.45	0.44	0.45	0.47	0.48	0.48
Selenium	1	0.45	0.45	0.45	0.45	0.45	0.44	0.44	0.43	0.43	0.45	0.45	0.45
Thallium	0.8	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Uranium	15[b]	0.11	0.11	0.08	0.12	0.14	0.20	0.26	0.28	0.25	0.12	0.10	0.12
Zinc	7[f]	4.12	4.14	3.89	4.05	4.41	5.16	5.96	6.17	5.68	4.30	4.00	4.13
Nitrate	13,000[b]	104	106	84	99	130	199	271	291	249	122	95	106
Nitrite	60[b]	6.48	6.53	6.04	6.36	7.05	8.50	10.03	10.43	9.51	6.83	6.26	6.51
Ammonia	27,550[g]	36.5	36.7	34.1	35.8	39.6	47.5	55.9	58.1	53.0	38.4	35.3	36.6

Notes:
All values are presented as µg/L.
Shaded values indicate an exceedance of the selected benchmark concentration.
a. Selected benchmarks represent Nova Scotia Tier 1 guidelines unless specified otherwise; **b.** Adopted from CCME; **c.** Based on baseline concentration in the Killag River (75th percentile); **d.** Site-specific water quality guideline; **e.** Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L; **f.** Selected guideline represents the Long-term CWQG, SSD 5th percentile at water hardness of 50 mg·L-1, pH of 7.5 and DOC of 0.5 mg·L-1; **g.** Selected guideline represents the ammonia (total) CCME guideline value at pH 6.0 and temperature of 25°C, multiplied by 0.8224 (for the conversion of NH_3 to total ammonia-N).

Table 3-12 Revised Constituent Concentrations in Killag River at Far Field Discharge Point - PC Conditions Upper Case

Constituent	Selected Benchmark Concentration[a]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Silver	0.25[b]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Aluminum	290[c]	242.89	243.13	243.73	242.47	239.97	232.49	224.00	221.29	224.02	238.72	241.90	241.58
Arsenic	30[d]	1.60	1.60	1.57	1.61	1.62	1.64	1.66	1.67	1.64	1.59	1.59	1.60
Cadmium	0.04[b]	0.020	0.021	0.020	0.020	0.021	0.023	0.025	0.026	0.025	0.021	0.020	0.020
Cobalt	0.78[e]	0.42	0.43	0.37	0.41	0.48	0.64	0.80	0.84	0.75	0.46	0.40	0.43
Copper	2	0.84	0.84	0.83	0.84	0.84	0.84	0.84	0.84	0.83	0.83	0.83	0.84
Iron	650[c]	488.20	488.71	489.78	487.30	482.52	467.96	451.42	446.09	451.29	479.96	486.17	485.58
Mercury	0.026	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Manganese	190[b]	46.67	46.75	46.35	46.71	46.66	46.36	45.83	45.72	45.58	46.13	46.36	46.56
Molybdenum	73	1.49	1.51	1.26	1.57	1.74	2.24	2.70	2.88	2.59	1.59	1.43	1.56
Nickel	25	2.66	2.71	2.09	2.57	3.39	5.20	7.10	7.63	6.52	3.13	2.42	2.74
Lead	1	0.36	0.36	0.35	0.35	0.37	0.41	0.44	0.45	0.43	0.36	0.35	0.36
Antimony	20	0.48	0.48	0.48	0.48	0.48	0.46	0.45	0.44	0.45	0.47	0.48	0.48
Selenium	1	0.46	0.46	0.46	0.46	0.47	0.47	0.47	0.48	0.47	0.46	0.46	0.46
Thallium	0.8	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Uranium	15[b]	0.12	0.12	0.09	0.12	0.15	0.22	0.28	0.31	0.27	0.13	0.11	0.13
Zinc	7[f]	4.41	4.44	4.07	4.31	4.83	5.91	7.05	7.35	6.66	4.67	4.24	4.43
Nitrate	13,000[b]	148	151	113	138	195	316	445	479	404	181	132	152
Nitrite	60[b]	7.50	7.57	6.71	7.26	8.53	11.19	14.03	14.76	13.10	8.18	7.11	7.56
Ammonia	27,550[g]	42.1	42.5	37.7	40.7	47.7	62.3	77.8	81.8	72.7	45.8	39.9	42.4

Notes:
All values are presented as µg/L.
Shaded values indicate an exceedance of the selected benchmark concentration.
a. Selected benchmarks represent Nova Scotia Tier 1 guidelines unless specified otherwise; **b.** Adopted from CCME; **c.** Based on baseline concentration in the Killag River (75th percentile); **d.** Site-specific water quality guideline; **e.** Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L; **f.** Selected guideline represents the Long-term CWQG, SSD 5th percentile at water hardness of 50 mg·L-1, pH of 7.5 and DOC of 0.5 mg·L-1; **g.** Selected guideline represents the ammonia (total) CCME guideline value at pH 6.0 and temperature of 25°C, multiplied by 0.8224 (for the conversion of NH_3 to total ammonia-N).

In the Far Field predictions, all predicted constituent concentrations for the EOM scenario were consistently below selected water quality benchmarks in the base case and upper case, with the exception of nitrite in the upper case, where the guideline was exceeded for the months of July, August and September (Table 3-10).

In the PC scenario at the far field in the Killag River, all predicted constituent concentrations were consistently below selected water quality benchmarks in the base case (Table 3-11), and cobalt and zinc concentrations exceeded selected water quality benchmarks for the months of July and August in the upper case (Table 3-12).

Each of the exceedances for either the near field or far field prediction nodes are discussed further, relative to the likelihood of toxicity, as follows:

- **Nitrite:** Predicted concentrations of nitrite exceed guidelines in the near field EOM North Settling Pond upper case (Table 3-4), East Settling Pond upper case (Table 3-6) and the far field EOM upper case (Table 3-10) scenarios, for the months of July, August and September. The guideline exceedances are relatively small, ranging from 1.2- to 1.4-fold (predictions range from 74.42 to 84.58 µg/L; Table 3-4, Table 3-6 and Table 3-10). All of these exceedances occur in the upper case predictions, which represent a reasonable worst case model prediction (90^{th} percentile). From a toxicity perspective, nitrite toxicity varies with chloride levels in the receiving environment (Nordin and Pommen, 2009). Baseline chloride levels in the receiving environment at SW1 average 4.0 mg/L (based on 4 samples taken in 2019 and 3 samples taken in 2020), and modelled chloride concentrations are predicted to marginally increase to 4.3 mg/L in the near field and far field EOM upper case scenarios (GHD, 2021b in AMNS 2021b, Appendix G.3). Therefore, predicted chloride concentrations by GHD (2021b in AMNS 2021b, Appendix G.3) suggest that chloride levels in the receiving environment will not be markedly increased by the release of mine effluent. While toxicity predictions are somewhat uncertain, it is possible that nitrite in surface waters at the predicted concentrations in the upper case could affect some species, if the predicted concentrations were to actually occur. These worst case predictions may have a lower likelihood of occurrence, as they represent a 90^{th} percentile model prediction. Refinement of source terms, and predictive water quality modelling as well as continued expansion of the baseline dataset for chloride (which is currently limited to 7 samples), will assist in refining toxicity predictions, and determining the need for water treatment. Water treatment is planned during operations as described in GHD (2021c in AMNS 2021b, Appendix Q.1). The treatment will allow discharge of nitrate to meet CCME guidelines in the Cameron Flowage/Killag River at the 100 m mixing zone.

- **Cobalt:** The predicted PC cobalt concentration at the near-field location marginally exceeds the Federal Environmental Quality Guideline (FEQG; 0.78 µg/L) in the upper case (0.8 and 0.85 µg/L in July and August; Table 3-8). The concentrations are up to 1.1 times the FEQG. A similar situation occurs with the PC far field location, wherein cobalt concentrations are predicted to range between 0.8 to 0.84 µg/L in July and August (upper case; Table 3-12). Additional water quality modelling was conducted to confirm hardness levels in the receiving environment, following effluent release. This modelling indicates that hardness in the near field receiving environment is predicted to increase to 11.4 mg/L $CaCO_3$ in the PC upper case. These hardness levels are also predicted for the far field location. The FEQG considers hardness as a modifying factor, and was derived for water hardness values ranging between 52 to 396 mg/L. The FEQG of 0.78 µg/L represents the guideline value using a water hardness of 52 mg/L. Given that the water hardness in the near field receiving environment is predicted to be below this range, there is some uncertainty associated with the use of this guideline value. However, the SSD model developed by Environment Canada in this guideline setting approach is very conservative, and the data used in the assessment do not fit the selected model of the SSD in the lower quartile of the dataset well (see Figure 1; ECCC, 2017). This results in the estimated HC5 value being considerably lower than it should be, relative to the toxicity dataset. This indicates that the selected guideline is over predicting toxicity of cobalt, and hence, the marginal exceedances predicted are unlikely to pose a risk in the receiving environment. In addition, Dissolved Organic Carbon (DOC) is an additional modifying factor for cobalt toxicity (Stubblefield et al, 2020). This factor was not considered in the development of the FEQG, and would assist in mitigating potential for toxicity, based values that cobalt is largely non-detect in the baseline data, at a detection limit of 0.4 µg/L (Table 3-1). The predicted concentrations have been added to a mean value which may be biased high due to the non-detect samples. For additional context, it is interesting to note that Stubblefield et al (2020) published two water quality guidelines for cobalt recently as follows:

- European-based approach and EC_{10} values and a species sensitivity distribution (SSD), yielding a median hazardous concentration for 5% of the organisms (HC5, 50%) of 1.8 µg/L; and
- A US EPA-style approach, using EC_{20} values in a SSD to derive a final chronic value (FCV) of 7.13 µg/L (note: this approach is more relaxed than typical Canadian approaches for deriving water quality standards, and hence, it is not recommended to use this value).

Neither of these approaches used hardness, or other water quality factors as modifiers. Based on the marginal degree of exceedance, the presence of elevated DOC concentrations, and increased hardness levels associated with the release of effluent, cobalt is considered unlikely to pose a risk to aquatic life.

- **Zinc**: The predicted concentrations do not exceed the new CCME guideline for zinc (7 µg/L) in the EOM scenarios for near field or far field. Additionally, predicted concentrations do not exceed the CCME guideline for zinc in the PC scenarios for near or far field in the base case, but do in the upper case. In the near field PC scenario, upper case predicted exceedances from the pit are 7.09 and 7.39 µg/L in July and August, respectively (Table 3-8). In the far field PC scenario, upper case predicted exceedances are 7.05 and 7.35 µg/L in July and August, respectively (Table 3-12). The Lowest observed effect concentration (LOEC) listed in the CCME (2018) fact sheet is 9.89 µg/L (11 week study; development; Chironomid sp.; normalized to 50 mg/L $CaCO_3$ and Dissolved Organic Carbon (DOC) of 0.5 mg/L). The predicted concentrations are within the range of background (<5 to 7.8 µg/L; based on sample size N=15). The waters of the Killag River are soft (<10 mg/L $CaCO_3$), but the DOC is reasonably high (ranging from 7 to 20 mg/L; mean of 12.2 mg/L, based on 2019 and 2020 data), and would be expected to provide adequate protection, for several of the months where predictions indicate elevated levels. Additional water quality modelling was conducted to confirm hardness levels in the receiving environment, following effluent release. This modelling indicates in the PC base case, hardness in the near field receiving environment is predicted to increase to 11.4 mg/L $CaCO_3$ in the PC upper case. These hardness levels are also predicted for the far field location. Based on these hardness levels, and accounting for site specific pH and DOC, the zinc guideline changes to 33 µg/L (based on an assumed mean hardness: 11.4 mg/L; mean pH: 5.43; mean DOC: 12.2 mg/L). None of the predicted concentrations exceed this guideline value, and hence, predicted zinc concentrations are considered to have a low potential for toxicity.

3.6 Predicted Water Quality – Assessment of Treatment

Table 3-13 summarizes the scenarios evaluated above in Section 3.5 which had exceedances over the selected benchmarks, relative to the need for water treatment.

Table 3-13 Summary of Metals Exceeding Selected Aquatic Life Benchmarks in Killag River and Comments Related to Water Treatment Needs

Scenario	Exceedances over Benchmarks		Comments Related to Water Treatment Needs
	Metal/Metalloid/Chemical	Frequency (months)	
Near Field			
EOM Base Case – North Pond	NE	NE	No apparent need for treatment
EOM Upper Case – North Pond	Nitrite	3	Further refinement of source terms; increased baseline understanding of chloride levels and supplemental predictive water quality monitoring will assist in determining the possible need for nitrite treatment. Water treatment is planned during operations. The treatment will allow discharge of nitrate to meet CCME guidelines in the Cameron Flowage/Killag River downstream at the 100 m mixing zone.
EOM Base Case – East Pond	NE	NE	No apparent need for treatment
EOM Upper Case – East Pond	Nitrite	3	See above discussion
PC Base Case	NE	NE	No apparent need for treatment
PC Upper Case	Co; Zn	2;2[a]	Zinc is predicted to exceed the guideline based on *in situ* hardness, but when hardness is remodeled to account for effluent contributions, the zinc guideline is no longer exceeded. Predictions are slightly more elevated for Co, but conclusions above remain the same.
Far Field			
EOM Base Case	NE	NE	No apparent need for treatment
EOM Upper Case	Nitrite	3	See above discussion
PC Base Case	NE	NE	No apparent need for treatment
PC Upper Case	Co; Zn	2;2[a]	See above discussion for PC Upper Case

NE = No exceedance
[a] Exceeds newer CCME guideline, but in some instances, predicted values are within baseline range. When hardness is adjusted, and DOC and pH are included, zinc no longer exceeds the new CCME guideline

Based on the outcomes of the predictive modelling there is a potential need for some form of water quality treatment, focused on nitrite. Zinc and cobalt are unlikely to require treatment, based on available data, but continued refinement of source terms, expansion of the baseline dataset, and monitoring during operations will assist in confirming treatment needs for these substances.

AMNS has indicated that a water treatment system will be designed to ensure that all site effluent water meets MDMER (at point of release) and CCME or Site Specific objectives (100 m downstream mixing zone). Water quality will be continuously measured in the North Settling and East Pond, during EOM conditions, and the pit lake, during PC conditions, so that a treatment system, if required, can be scaled as needed to meet effluent discharge guidelines. Sufficient freeboard will be provided in both the North Settling and East Pond and the pit lake to allow for adequate timing to adjust the treatment process as needed.

3.7 Summary – Killag River

Under the EOM scenarios, predicted near-field (North and East pond discharge) and far-field chemical concentrations in the base case and upper case are consistently below selected water quality benchmarks without water treatment, with the exception of nitrite, which exceeds the guideline only in the upper case scenarios in 3 months/year. Under the PC scenarios, there is little difference between predicted chemical concentrations at near-field (pit lake discharge) and far-field locations for each assessment each case. In base case PC scenarios, all predicted constituent concentrations were consistently below selected water quality benchmarks. In the upper case PC scenarios, both cobalt and zinc are predicted to exceed their respective guidelines in 2 months/year.

Nitrite toxicity can be modified in the receiving environment by chloride, depending upon concentrations. Baseline chloride levels in the receiving environment at SW1 average 4.0 mg/L (based on 4 samples taken in 2019 and 3 samples taken in 2020), and modelled chloride concentrations are predicted to marginally increase to 4.3 mg/L in the near field and far field EOM-Upper Case scenarios (GHD, 2021a in AMNS 2021b, Appendix G.3. The upper case predictions for nitrite could potentially affect some species, if they were actually to occur in the environment, but toxicity predictions are somewhat uncertain. Cobalt predictions marginally exceed the guideline, and DOC is a known modifying factor for cobalt, but is not considered in the current water quality guideline. In addition, the guideline is considered to be biased low, based on the available toxicity data. Therefore, consideration of the presence of elevated DOC concentrations in the receiving environment, and increased hardness levels associated with the release of effluent, as well as the toxicity data, suggest that cobalt is unlikely to pose a risk to aquatic life in the receiving environment. Zinc exceedances are concluded to have a low potential for toxicity, based on consideration of hardness in the receiving environment.

While the toxicity potential is considered to be low, AMNS is committed to water treatment, if necessary, to meet appropriate guidelines or site specific water quality objectives in the receiving environment following an appropriate degree of mixing.

4.0 Moose River Assessment

4.1 Description of Receiving Environment and Baseline Data

Moose River is the largest watercourse at the Touquoy site, and it flows along the western border of the property and is adjacent to the Mine Pit at surface water monitoring station SW-2, which is the most relevant surface water monitoring station for the assessment of potential aquatic effects associated with discharge from the Touquoy Pit. A study area including site map is presented in Figure 4-1.

Table 4-1 in Intrinsik (2019 in AMNS 2019, Appendix G.4) provides the baseline data for surface waters associated with the Moose River at surface water monitoring station SW-2, which is where discharge from the Mine Pit at Touquoy will be released, once the pit fills. This station is the most representative of the receiving environment conditions for the assessment of aquatic effects. As discussed in Intrinsik (2019 in AMNS 2019, Appendix G.4), dissolved ions are low and the water is very soft, indicating little mineral content and influence from weathered rock. Alkalinity is low at all sampling locations throughout the Project Area (PA). This is anticipated due to the surficial geology being resistant to weathering and containing little carbonate. pH was generally low in all sampling locations and outside the range identified in the CCME. In addition, arsenic was noted to consistently exceed the Nova Scotia Tier 1 EQS (5 µg/L) at SW-2 downstream of the open pit in both 2016 and 2017. These elevated arsenic concentrations are not attributed to operation and may be from historical tailing piles and/or the Touquoy ore body itself. In general, water quality exceedances for aluminum, iron, arsenic, cadmium are commonplace in the environment, even at surface water quality monitoring stations upgradient of the mine ("background" stations) (Stantec 2021b in AMNS 2021b, Appendix F.8). Background data for station SW-2 are provided in Table 4-1.

Table 4-1 Baseline Surface Water Concentrations Collected from Moose River (Total Metals mg/L)

Chemical	*Min*	*Max*	*Mean*	*75th Percentile*	*# of Non-Detects*	*CCME (mg/L)*	*Nova Scotia Tier 1 (mg/L)*
Aluminium	0.073	0.35	0.169	0.187	0/22	0.005	0.005
Arsenic	0.004	0.03	0.012	0.018	0/22	0.005	0.005
Calcium	0.84	1.7	1.2	1.3	0/22	NV	NV
Cadmium	<0.00001	0.00004	0.000014	0.000019	7/22	0.00004	0.00001
Cobalt	<0.0004	0.00071	<0.0004	<0.0004	21/22	NV	0.01
Chromium	<0.001	0.0017	<0.001	<0.001	20/22	8.9	NV
Copper	<0.002	<0.002	<0.002	<0.002	22/22	0.002	0.002
Iron	0.19	0.85	0.48	0.62	0/22	0.3	0.3
Lead	<0.0005	0.00086	<0.0005	<0.0005	20/22	0.001	0.001
Mercury	<0.000013	0.00002	<0.000013	<0.000013	20/22	0.000026	0.000026
Magnesium	0.35	0.75	0.488	0.52	0/22	NV	NV
Manganese	0.029	0.18	0.06	0.07	0/22	NV	0.82
Molybdenum	<0.002	<0.002	<0.002	<0.002	22/22	0.073	0.073
Nickel	<0.002	<0.002	<0.002	<0.002	22/22	0.025	0.025
Tin	<0.002	<0.002	<0.001	<0.001	22/22	NV	NV
Selenium	<0.001	<0.001	<0.001	<0.001	22/22	0.001	0.001
Silver	<0.0001	<0.0001	<0.0001	<0.0001	22/22	0.00025	0.0001
Dissolved Sulphate	<2	2.6	<2	<2	19/22	NV	NV
Thallium	<0.0001	<0.0001	<0.0001	<0.0001	22/22	0.0008	0.0008
Uranium	<0.0001	<0.0001	<0.0001	<0.0001	22/22	0.015	0.3
Zinc	<0.005	0.0061	<0.005	<0.005	19/22	0.007	0.03
WAD Cyanide	<0.003	0.004	<0.003	<0.003	21/22	NV	0.005
Total Cyanide (based on Strong Acid Dissociated)	<0.001	0.002	<0.005	<0.005	19/22	NV	0.005
Nitrate (as N)	<0.05	0.18	<0.05	0.054	15/22	13	NV
Nitrite (as N)	<0.01	<0.01	<0.01	<0.01	22/22	0.06	NV
Ammonia	<0.05	0.14	<0.05	0.062	13/21	23.7	NV
pH	4.9	6.89	6.05	6.24	22/22	6-9	NV
Hardness (mg/L $CaCO_3$)	3.5	7.3	5.0	5.25	22/22	NV	NV

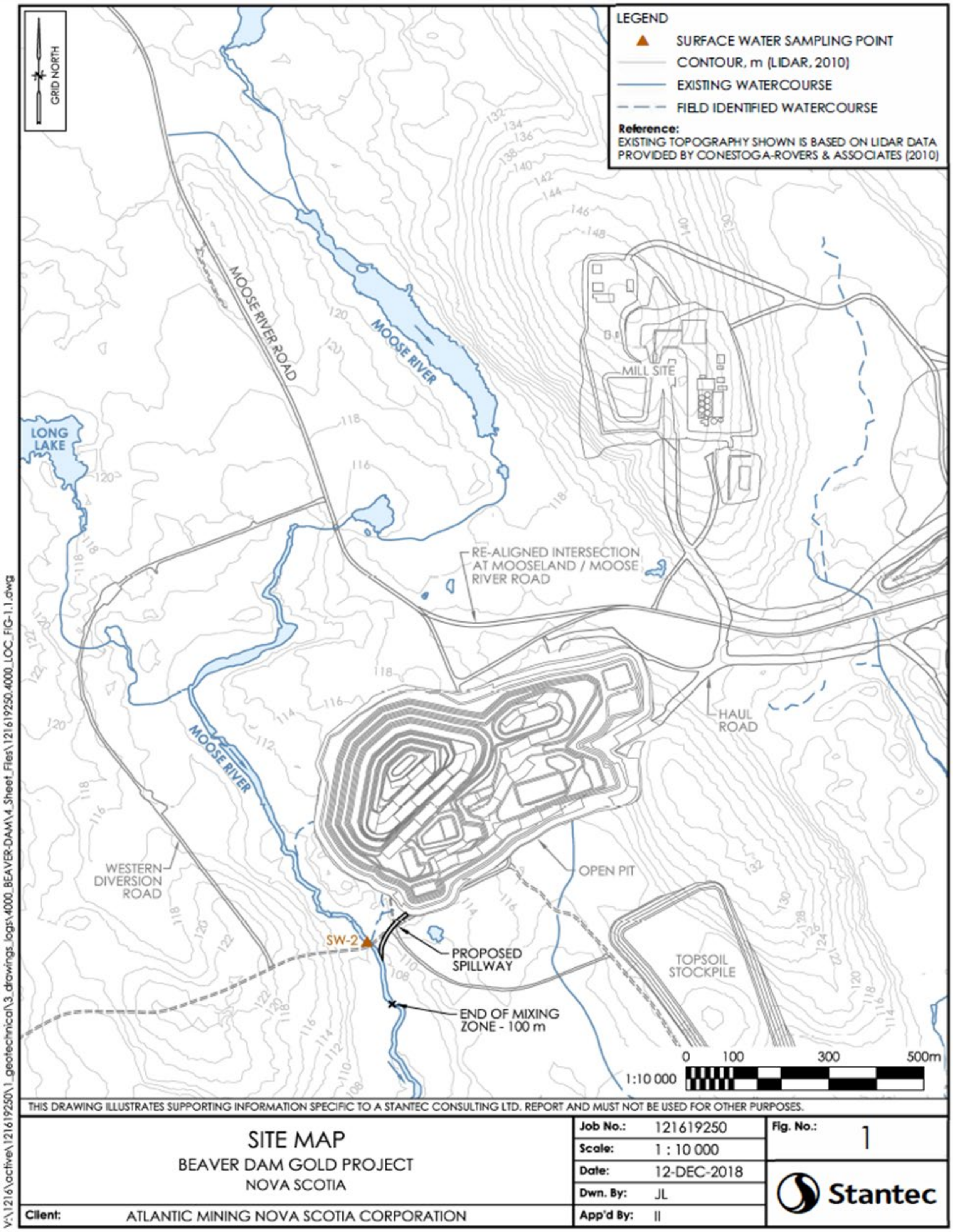


Figure 4-1 Site Map of Beaver Dam Gold Project

4.2 Description of Water Quality Modelling Conducted

Stantec (2021b in AMNS 2021b, Appendix F.8) conducted an assimilative capacity modelling exercise, to predict future water quality in the receiving environment, Moose River. This update to the modelling was due to updated groundwater modelling associated with the Touquoy Mine Site. The methodology used followed CCME (2003), which is a framework established for assessing assimilative capacity of receiving environments.

The specific details of the hydrology of the receiving environment are presented in Stantec (2021b in AMNS 2021b, Appendix F.8). A water balance model was developed to predict the Open pit effluent overflow to Moose River at mine closure. Effluent water quality was predicted using the water quality and quantity model and groundwater flow model (Stantec 2021a in AMNS 2021b, Appendix F.6). Water quality modelling considered pore water within the tailings, groundwater inflow quality in the pit floor and walls, dilution from surface runoff, and direct precipitation and process water surplus, etc (Stantec 2021a in AMNS 2021b, Appendix F.6). Both an average concentration within the open pit and a maximum concentration were predicted for two modelling scenarios;

- Base Scenario: included tailings deposited in the Touquoy pit from processing ore from the Beaver Dam mine deposit only;
- Cumulative Effects Scenario: included tailings deposited in the Touquoy pit from processing Beaver Dam ore with ore from the Touquoy Mine Project and ore concentrates from the Fifteen Mile Stream and Cochrane Hill Projects.

Based on the modelling conducted, only aluminium, arsenic, cobalt, copper, WAD cyanide and nitrate were predicted to be present in effluent discharge from the Open Pit at concentrations exceeding NS Tier 1 EQS (2014) or CCME FWAL guidelines, and hence, only these compounds were carried forward for receiving environment predictions (see Stantec, 2021; Table 5). The modelling effort also examined the potential seepage from the Open Pit via groundwater to the Moose River receiving environment, and none of the elements were predicted to be present in groundwater at concentrations approaching either NS Tier 1 (2013) or CCME FWAL guidelines (see Table 5 (Base scenario) and Table 6 (Cumulative Effects Scenario [Stantec 2021b]; Appendix F.8 in AMNS 2021b). In addition, the effluent concentrations of arsenic and ammonia are predicted to slightly exceed the 2021 MDMER discharge limit for an existing mine, therefore, arsenic and ammonia treatment will be required prior to release of the effluent to environment and were assessed further.

Receiving environment concentrations of the selected compounds of potential concern (aluminium, arsenic, cobalt, copper, nitrate, and cyanide) were predicted using CORMIX, version 11, and all assumptions and model inputs are provided in Stantec [2021b] Appendix F.8 in AMNS 2021b).

4.3 Selected Benchmarks

Benchmark concentrations used for comparison against predicted water concentrations are presented in Table 4-2, and are identical to those presented previously in Intrinsik (2019 in AMNS 2019, Appendix G.4). These benchmark concentrations were based on the greater of either the water quality guideline selected for use in the assessment, or the 75th percentile of the baseline surface water concentrations collected from the Moose River (Table 4-2), except for arsenic for which a site-specific water quality objective was calculated and adopted (see Intrinsik 2019 in AMNS 2019, Appendix G.4; Section 2.3). As discussed previously, only those chemicals determined to merit further evaluation in the receiving environment by Stantec (2021; Appendix G6) are listed in Table 4-2. Note that the Stantec (2021b; Appendix F.8 in AMNS 2921b) modelling was provided in mg/L. The units used by the authors of these reports were retained in this assessment, to allow comparisons to the original reports, as needed, without confusion.

Table 4-2 Selected Benchmark Concentrations for Use in the Moose River Assessment (mg/L)

Parameter	*Selected Guideline[a]*	*75th Percentile Baseline Concentration*	*Site-Specific Water Quality Objective*	*Selected Benchmark Concentration*
Aluminum	0.005	0.187	-	0.187
Arsenic	0.005	0.018	0.030	0.030
Cobalt	0.00078[b]	<0.0004	-	0.00078[b]
Copper	0.002	<0.002	-	0.002
WAD Cyanide	0.005[c,d]	<0.003	-	0.005[c,d]
Total Cyanide (based on Strong Acid Dissociated)	0.005[c,d]	<0.005	-	0.005[c,d]
Nitrite (as N)	0.06[c]	<0.01	-	0.06

Notes:
- not calculated
[a] Selected guidelines represent Nova Scotia Tier 1 guidelines unless specified otherwise
[b] Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L.
[c] Selected guideline adopted from CCME.
[d] Based on free cyanide; the application of this guideline for Total Cyanide is overly conservative, and is applied for discussion purposes

4.4 Predicted Water Quality in Moose River

Water quality modelling results for effluent and predicted concentrations at end of 100 m mixing zone in the receiving environment of Moose River are provided in Table 4-3 (Base Scenario) and Table 4-4 (Cumulative Scenario). The parameters in the effluent identified by Stantec (2021b; Appendix F.8 in AMNS 2021b) as being in exceedance of regulatory limits included aluminium, arsenic, WAD and Total cyanide, cobalt, copper, and nitrite. Where predicted concentrations exceed regulatory guidelines, they are further discussed relative to background concentrations in the receiving environment, and available site specific water quality objectives (arsenic) or other toxicity data and information. For the purposes of predicting receiving environment concentrations at the end of the 100 m mixing zone, arsenic was assumed to meet the MDMER limit of 0.3 mg/L, as treatment will be provided to meet this requirement (Stantec 2021b; Appendix F.8 in AMNS 2021b). The predicted water quality concentrations at the edge of a 100 m mixing zone in the receiver are presented in Table 4-3 (Base Scenario) and Table 4-4 (Cumulative Effects Scenario), relative to the selected benchmarks in Table 4-2.

Table 4-3 Water Quality Modelling Results for Effluent and Predicted Concentrations at end of 100 m Mixing Zone in Receiving Environment of Moose River, Relative to Selected Benchmarks – Base Scenario (mg/L)

Water Quality Parameter[a]	Effluent Maximum mg/L[a]	Receiver, 75th percentile[a]	Concentration at end of 100 m mixing zone[a]	Concentration at 120 m Fully Mixed[a]	Selected Benchmarks
Aluminum	0.03	0.187	0.1837	0.1840	0.187
Arsenic	0.3	0.018	0.0233	0.0228	0.030
WAD Cyanide	0.087	<0.003	0.0032	0.0030	0.005[b,c]
Total Cyanide	0.249	<0.003	0.0074	0.0069	0.005[b,c]
Cobalt	0.046	<0.0004	0.00110	0.00102	0.00078[d]
Copper	0.026	<0.002	0.00148	0.00144	0.002
Nitrite (as N)	0.693	<0.01	0.019	0.017	0.06

Notes:
[a] From table 10 of Stantec, 2021.
[b] Selected guideline adopted from CCME.
[c] Based on free cyanide; the application of this guideline for Total Cyanide is overly conservative and is applied for discussion purposes.
[d] Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L.

Table 4-4 Water Quality Modelling Results for Effluent and Predicted Concentrations at end of 100 m Mixing Zone in Receiving Environment of Moose River, Relative to Selected Benchmarks – Cumulative Scenario (mg/L)

Water Quality Parameter[a]	Effluent Maximum mg/L[a]	Receiver, 75th percentile[a]	Concentration at end of 100 m mixing zone[a]	Concentration at 120 m Fully Mixed[a]	Selected Benchmarks
Aluminum	0.04	0.187	0.1839	0.1841	0.187
Arsenic	0.3	0.018	0.0238	0.0233	0.030
WAD Cyanide	0.121	<0.003	0.0044	0.0041	0.005[b,c]
Total Cyanide	0.345	<0.003	0.011	0.010	0.005[b,c]
Cobalt	0.064	<0.0004	0.00172	0.00158	0.00078[d]
Copper	0.035	<0.002	0.00183	0.00175	0.002
Nitrite (as N)	0.566	<0.01	0.019	0.017	0.06

Notes:
[a] From table 11 of Stantec, 2021.
[b] Selected guideline adopted from CCME.
[c] Based on free cyanide; the application of this guideline for Total Cyanide is overly conservative, and is applied for discussion purposes.
[d] Selected guideline represents Environment Canada (2017) FEQG for the protection of aquatic life at water hardness of 52 mg/L.

Based on the predicted future concentrations for the Base Scenario (Table 4-3) and the Cumulative Effects Scenario (Table 4-4), relative to available water quality guidelines, total cyanide and cobalt merit further evaluation.

Total Cyanide:

The chemistry of cyanide is complex, and the toxicity of various cyanide complexes varies widely. So, the form of cyanide in the environment greatly affects the toxicity of the compound. The most toxic form of cyanide is free cyanide, which includes the cyanide ion ($^{-}$CN) and HCN (ICMC, 2018). Cyanide is highly reactive, and readily forms simple salts with earth cations and ionic complexes. The strength of the bonds of these associations vary depending upon the salt, and the pH of the environment. Weak or moderately stable complexes are known as WAD (weak acid dissociable), and typically involve cations such as cadmium, copper and zinc. WAD cyanide is less toxic than free cyanide, but when they dissociate, they release free cyanide and the metal cation. Typically, WAD complexes dissociate and release HCN under mildly acidic conditions such as those ranging from pH 3 – 6 (OI, 2009). Cyanide can also form very stable complexes with gold, mercury, cobalt and iron. The stability of these complexes in the environment depends on pH in the environment, but strong metals-cyanide complexes (SAD) typically require strongly acidic conditions (pH<2) to dissociate and release HCN (OI, 2009). The term “total cyanide” typically refers to the sum of all cyanide species that are converted to HCN following digestion in a strong acid solution (Total cyanide = free cyanide + WAD + SAD). Other cyanide compounds, such as thiocyanate and cyanate, are markedly less toxic than free cyanide (ICMC, 2018).

With this in mind, a measured or estimated Total Cyanide concentration can range from including 100% SAD forms of cyanide, to 100% free cyanide, depending upon the chemistry of the effluent, and the receiving environment. Some SAD forms of cyanide (iron cyanide complexes) can dissociate in sunlight and release free CN (ICMC, 2018). Other environmental fate processes, such as volatilization, wherein the amount of cyanide lost increases with decreasing pH, and biodegradation, where aerobic conditions result in microbial degradation of cyanide to ammonia, and subsequently, nitrate (ICMC, 2018). Therefore, environmental fate of cyanides in the receiving environment is modified by a number of factors.

It is important to note that the NS Tier 1 guideline of 5 µg/L (which is based on the CCME guideline), is for free cyanide. This guideline is not a relevant guideline to compare Total cyanide, SAD or even WAD forms of cyanide to, as it is based on the free ion, as opposed to bound forms of cyanide, which have far lower toxic potential. Based on the receiving environment predictions in Table 4-3 and 4-4, WAD cyanide is less than half of the Total Cyanide predicted concentration (0.0032 mg/L WAD, compared to 0.0074 mg/L Total; Base Scenario, Table 4-3; 0.0041 mg/L WAD, compared to 0.010 mg/L Total; Cumulative Effects Scenario, Table 4-4). This implies that the majority of the Total Cyanide prediction would be SAD, and hence, unlikely to dissociate in the receiving environment (mean pH in receiving environment is 6.05; see Table 4-1). Predicted WAD concentrations in the receiving environment are below the NS Tier 1 guideline, indicating acceptable levels of risk to aquatic life. The predicted Total Cyanide concentration in the receiving environment only marginally exceeds the free cyanide guideline, and since the majority of the predicted cyanide is anticipated to be SAD, risk to aquatic life are predicted to be low.

Cobalt

Predicted cobalt levels in the receiving environment for the Base Scenario range from 0.0011 mg/L (100 m from discharge) to 0.00102 mg/L (120 m from discharge) (see Table 4-3), which marginally exceed the new FEQG for cobalt (0.00078 mg/L), but are less than the NS Tier 1 cobalt value of 0.01 mg/L. Similarly, in the Cumulative Effects Scenario predicted cobalt levels in the receiving environment range from 0.00172 mg/L (100 m from discharge) to 0.00158 mg/L (120 m from discharge) (see Table 4-4). As discussed in Section 3.5.2 of this memo, the FEQG considers hardness as a modifying factor, but the SSD model developed by Environment Canada is very conservative, and the data used in the assessment do not fit the selected model of the SSD in the lower quartile of the dataset well (see Figure 1; ECCC, 2017). This results in the estimated HC5 value being considerably lower than it should be, relative to the toxicity dataset. This indicates that the selected guideline is over predicting toxicity of cobalt, and hence, the marginal exceedance indicated in Table 4-3 and Table 4-4 are not considered to represent a concern, with respect to toxicity to aquatic species. Cobalt concentrations are predicted to decrease to 0.00102 mg/L (Base Scenario) and 0.00158 mg/L (Cumulative Effects Scenario) by 120 m from the effluent discharge point (see Tables 4-3 and 4-4), which are within 1.3 to 2 fold of the FEQG. Risks to aquatic life at these predicted concentrations are anticipated to be low.

In addition, Dissolved Organic Carbon (DOC) is an additional modifying factor for cobalt toxicity (Stubblefield et al, 2020). This factor was not considered in the development of the FEQG, and would assist in mitigating potential for toxicity. DOC data for SW-2 in the baseline dataset is not available, but Total Organic Carbon (TOC) ranges from 3.9 to 19 mg/L at this station, and hence, DOC is likely present, and somewhat lower than the measured TOC concentrations (Appendix A of Stantec, 2021b in AMNS 2021b, Appendix F.8). For additional context, it is interesting to note that Stubblefield et al (2020) published two water quality guidelines for cobalt recently as follows:

- European-based approach and EC_{10} values and a species sensitivity distribution (SSD), yielding a median hazardous concentration for 5% of the organisms (HC5, 50%) of 0.0018 mg/L; and
- A US EPA-style approach, using EC_{20} values in a SSD to derive a final chronic value (FCV) of 0.00713 mg/L (note: this approach is more relaxed than typical Canadian approaches for deriving water quality standards, and hence, it is not recommended to use this value).

Neither of these approaches used hardness, or other water quality factors as modifiers. Based on the marginal degree of exceedance, the likely presence of elevated DOC concentrations, and the added perspective from additional guidelines derived by Stubblefield et al (2020), cobalt at the predicted concentrations is considered unlikely to pose a risk to aquatic life.

Summary – Moose River

Predicted concentrations in the receiving environment of Moose River met aquatic life benchmarks selected for this assessment, with the exception of Total Cyanide and cobalt. Additional evaluation of the toxicity of these two compounds in the receiving environment indicates that predicted concentrations of these substances are considered unlikely to pose a risk to aquatic life in Moose River.

Uncertainties and limitations associated with this assessment are presented in Intrinsik (2019 in AMNS 2019, Appendix G.4).

Closure

Intrinsik Corp. (Intrinsik) has provided this report to AMNS solely for the purpose stated in the report. The information contained in this report was prepared and interpreted exclusively for Atlantic Mining NS and may not be used in any manner by any other party. Intrinsik does not accept any responsibility for the use of this report for any purpose other than as specifically intended by AMNS. Intrinsik does not have, and does not accept, any responsibility or duty of care whether based in negligence or otherwise, in relation to the use of this report in whole or in part by any third party. Any alternate use, including that by a third party, or any reliance on or decision made based on this report, are the sole responsibility of the alternative user or third party. Intrinsik does not accept responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The assessment has been performed in accordance with accepted practice and usual standards of thoroughness and competence for the profession of toxicology and risk assessment. Any information or facts provided by others and referred to or utilized in the preparation of this report, is believed to be accurate without any independent verification or confirmation by Intrinsik. The information, opinions and recommendations provided within the aforementioned report have been developed using reasonable and responsible practices, and the report was completed to the best of our knowledge and ability.

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