Appendix F.6

Groundwater Flow and Solute Transport Modelling to Evaluate Disposal of Beaver Dam Tailings in Touquoy Open Pit

Groundwater Flow and Solute Transport Modelling to Evaluate Disposal of Beaver Dam Tailings in Touquoy Open Pit – Beaver Dam Gold Project

February 8, 2019

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A three-dimensional steady-state groundwater flow model and solute transport model was constructed using MODFLOW to simulate current groundwater conditions in the Study Area, baseline conditions (i.e., when Beaver Dam operations begin at the Touquoy mine site), changes to groundwater inflows during operations (i.e., when the Beaver Dam tailings are filling the open pit), and to evaluate potential changes to water quality in the receiving environment due to the subaqueous disposal of tailings in the Touquoy pit post-closure (i.e., when the pit is full). The model was prepared using a conceptual model and hydrostratigraphic framework developed from regional and site-specific data, and assumed homogeneous properties within the units. A good calibration of model parameters was obtained, as evaluated by comparing simulated and observed groundwater levels and estimated baseflow. The parameter values for hydraulic conductivity are similar to those obtained from other analyses of field observations.

At baseline, the open pit will be fully dewatered, and is simulated to intercept groundwater seepage at a rate of 475 m^3/d. The extent of the corresponding drawdown cone, as delineated by the 0.5 m drawdown contour, extends approximately 350 m south of the site and about 50 m west of the site toward Moose River. The inflow to the open pit decreases as it is filled with tailings and water during Beaver Dam operations, until the open pit stage reaches the maximum level of 108 m asl. At this stage, the groundwater seepage decreases to 251 m^3/d, and the corresponding drawdown cone is about the same as the baseline condition. Groundwater baseflow to Moose River is reduced by less than 1% in all cases.

Upon the filling of the open pit to its ultimate lake stage at 108 m asl, groundwater flow is anticipated to flow from the pit to Moose River through the glacial till and weathered fractured bedrock. Solute transport in this case is dominated by advection (movement with the flow of groundwater). Solute transport modelling using the calibrated model simulates a slow migration of solutes to Moose River, with concentrations approaching a steady state after about 150 years of travel. Mass loadings for various parameters of concern are simulated by the model for inclusion in a surface water mixing model of Moose River (Stantec 2019).

The presence of preferential pathways, such as fractures and faults not characterized in previous field assessment, were assessed with sensitivity analyses in the model to predict the potential migration of solutes from pit into the receiving environment. The results of the sensitivity analyses indicated that should the faults have higher hydraulic conductivity, solute transport to Moose River would occur more quickly, and would also be predicted extend to Watercourse #4. Therefore the potential for higher permeability faults should be considered in the development of management, mitigation and contingency plans.

Abbreviations

AMNSC	Atlantic Mining NS Corp.
asl	above sea level
°C	degrees Celsius
cm	centimetres
g/d	grams per day
K_H	horizontal hydraulic conductivity
K_V/K_H	anisotropy ratio
km	kilometres
km^2	square kilometres
m	metres
m/s	metres per second
m^3/d	cubic metres per day
m^3/s	cubic metres per second
mg/L	milligrams per litre
mm	millimetres
mm/yr	millimetres per year

NSDL&F	Nova Scotia Department of Lands and Forestry
RMS	root mean squared
RSS	residual sum of squares

1.0 INTRODUCTION

Atlantic Mining NS Corp. (AMNSC) proposes the construction, operation, decommissioning, and closure of an open pit gold mine and associated ancillary activities as the Beaver Dam Project (the Project). The Project is located in Moose River, Nova Scotia. As part of the project, ore removed from the open pit at Beaver Dam will be transported to the Touquoy mill for processing. Tailings from the processing of the Beaver Dam ore are proposed to be disposed of in the mined out open pit that will be developed for the Touquoy Project.

AMNSC retained Stantec Consulting Ltd. (Stantec) to conduct a feasibility level assessment of the disposal of tailings from Beaver Dam ore into the open pit at Touquoy. Stantec constructed a groundwater flow and solute transport model to assist in the evaluation of the potential changes to water quality in the receiving environment that are likely to result from this activity. The groundwater flow and solute transport model would also allow for the future assessment of potential mitigation measures that could be implemented to minimize the potential release of contaminants.

1.1 STUDY OBJECTIVES

This Report was conducted to assess the environmental effects associated with the disposal of tailings from the Beaver Dam gold mine in the open pit developed for the Touquoy Gold Project. A groundwater flow and solute transport model has been developed to evaluate:

- the dewatering rate from the Touquoy open pit and changes in groundwater flow conditions and discharges as the baseline conditions
- the groundwater seepage rates to the Touquoy open pit as it is filled with Beaver Dam tailings
- the identification of areas where water in contact with the Beaver Dam tailings disposed in the Touquoy open pit are discharged to the receiving environment, and the potential for surface and groundwater interactions

This report forms part of the supporting documentation for the environmental impact study completed for the Beaver Dam Gold Project. The documentation and modelling were conducted following the guidelines prepared by Wels et al. (2012).

2.0 BACKGROUND

2.1 PROJECT AREA DESCRIPTION AND SURROUNDING LAND USES

The Touquoy processing and tailings management facility is a fully permitted and approved facility currently operating as part of the Touquoy Gold Mine Project in Moose River, Halifax County, Nova Scotia. It is located on land owned by Atlantic Gold and Nova Scotia Department of Lands and Forestry (NSDL&F), and centered at 504599 E and 4981255 N (UTM Zone 20 NAD 83 CSRS). Access to Crown land for the construction of the Touquoy Project has been granted through a Crown Land Lease Agreement with NSDL&F (Lease No. 2794371 and Petition No. 37668).

The areas surrounding the Touquoy mine site is zoned mixed use under the Musquodoboit Valley and Dutch Settlement Land Use By-law. The Touquoy mine site location is shown on Figure 2.1.

Camp Kidston, which operates only in the summer months, is located 3.5 kilometres (km) northeast of the Touquoy mine site. The nearest permanent full-time occupied residences are located approximately 5.8 km to the north of the open pit along Caribou Road. The next closest permanent residences to the Touquoy processing and tailings management facility are approximately 7.4 km to the northwest and 11.7 km to the southeast.

2.2 CLIMATE

Project site climatic and hydrologic conditions are required for the water balance analysis. Baseline climate and hydrology conditions at the Atlantic Gold mine site and relevant data required for water balance analysis are presented in this section.

The climate for the mine site is continental with temperature extremes moderated by the ocean. The coldest temperature recorded was −41.1 °C on January 31, 1920, at Upper Stewiacke (Environment Canada 2015c). Precipitation is well distributed throughout the year. July and August are the driest months on average.

Environment Canada’s Middle Musquodoboit climate station (Station ID 8203535), was used to characterize the climatic conditions at the mine site. This station is located approximately 20 km northwest of the mine site, and reports data collected between 1961 and 2011. As presented in Table 4.1, the climate normal precipitation is approximately 1357.7 millimetres (mm) and the average snowfall of 172.2 centimetres (cm), based on a period of record 1981-2010 (climate normal period, Environment Canada 2015a). The extreme one-day precipitation amount of 173 mm for the period of record of the selected climate station occurred in 1961. Temperatures typically drop below zero between the months of December through March each year.

Average annual lake evaporation is 515 mm for the mine site area based on average lake evaporation at Environmental Canada’s Truro climate station (2015b) and corresponding monthly evaporation rates are presented in Table 2.1.

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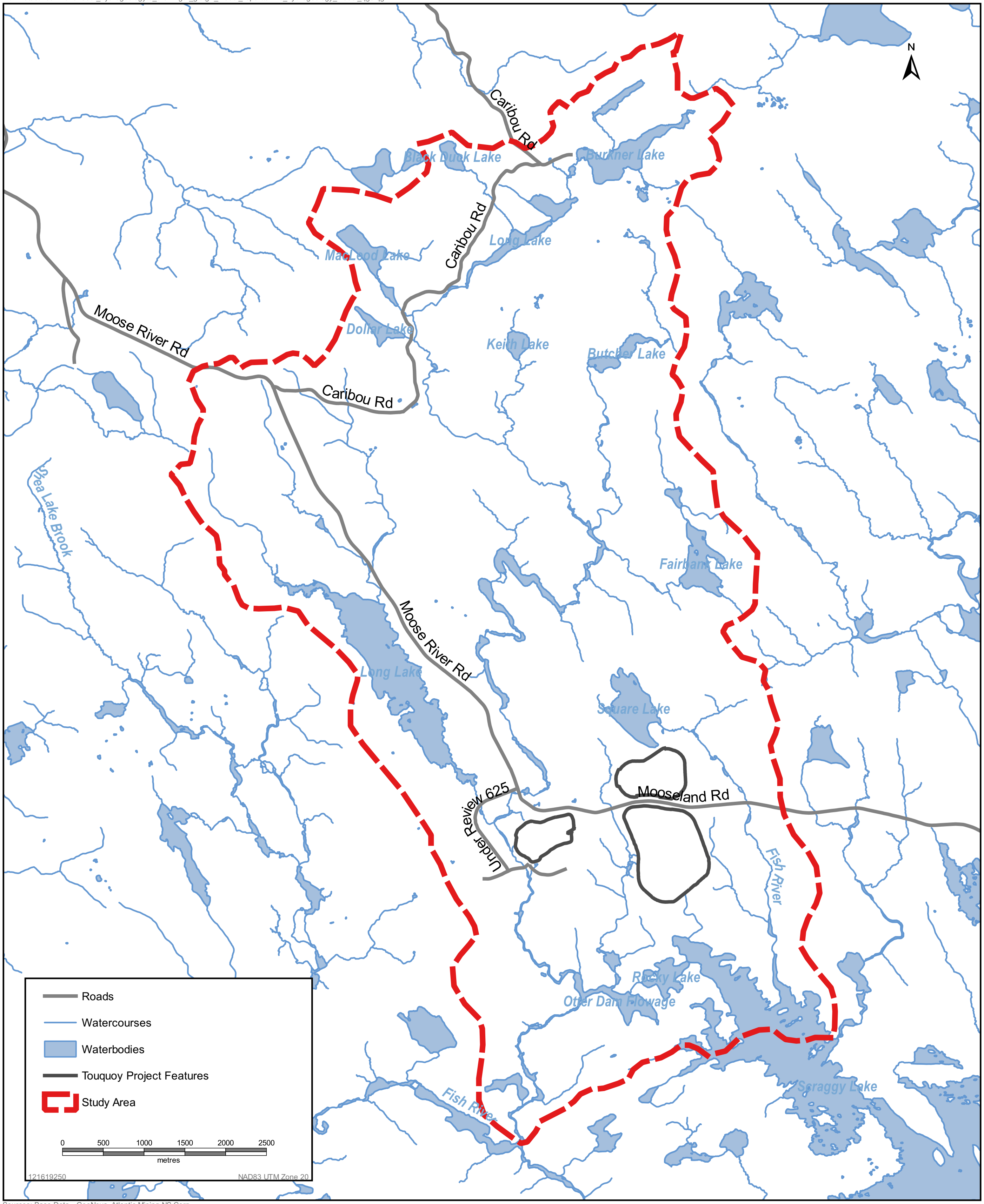


Sources: Base Data - GeoNova, Atlantic Mining NS Corp.

Touquoy Mine Site Location Plan

Stantec

Beaver Dam Gold Project

Figure 2.1

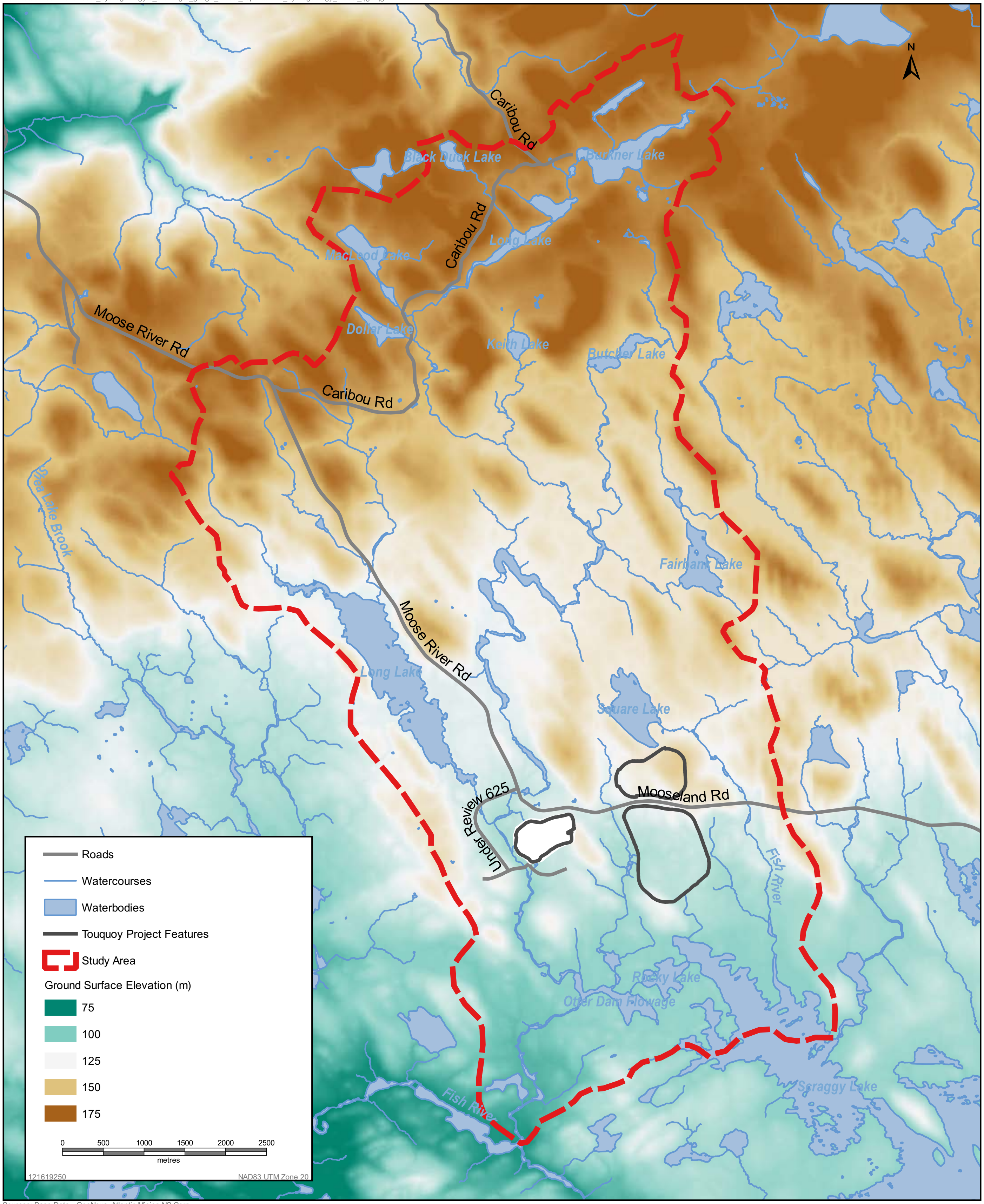
Table 2.1 Representative Climate Values for the Mine Site

Climate Normal for the 30-year period (1981-2010) at Middle Musquodoboit Climate Station													
Parameter	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Temperature (°C)	-6.2	-5.2	-1.3	4.4	9.9	14.8	18.5	18.4	14.2	8.5	3.5	-2.4	6.4
Rainfall (mm)	80.4	62.1	92.8	99.5	104.9	99.8	103.8	91.9	110.7	116.7	128.6	97.2	1188.3
Snowfall (cm)	49.4	41.3	31.4	9.5	0.5	0.0	0.0	0.0	0.0	0.0	8.2	31.9	172.2
Precipitation (mm)	129.8	100.5	124.2	109.0	105.4	99.8	103.8	91.9	110.7	116.7	136.8	129.1	1357.7
Snow Depth (cm)	40	67	64	22	6	1	0	0	0	0	25	28	21.1
Monthly Lake Evaporation at Truro Climate Station for 30 year period (1981-2010)													
Lake Evaporation (mm/day)	0	0	0	0	89.9	102	117.8	96.1	69	40.3	0	0	515.1

2.3 PHYSIOGRAPHY, TOPOGRAPHY, AND DRAINAGE

The Project is located within the Atlantic Maritime Ecozone and the South-Central Nova Scotia Uplands Ecoregion (Environment Canada undated). This ecoregion is classified as having an Atlantic high cool temperature ecoclimate. This mixed wood forest region is composed of intermediate to tall, closed stands of red and white spruce, balsam fir, yellow birch, and eastern hemlock. Yellow birch, beech, and red and sugar maple can be found at higher elevations. Eastern white pine is found on sandy areas. The ecoregion has extensive wetland and rock barrens, which support stunted black spruce, larch, and heath.

The topography of the area is presented on Figure 2.2. The elevation varies from a high of about 189.6 metres (m) above sea level (asl) in the north of the study area, to a low of about 81.6 m asl in the southwest of the study area at the outlet of Moose River at Fish River. The topography in the study area is undulating, with several drumlins covering the land, as discussed in Section 2.4, and shown on Figure 2.3.



Sources: Base Data - GeoNova, Atlantic Mining NS Corp.

Touquoy Mine Site Topography

Stantec

Beaver Dam Gold Project

Figure 2.2

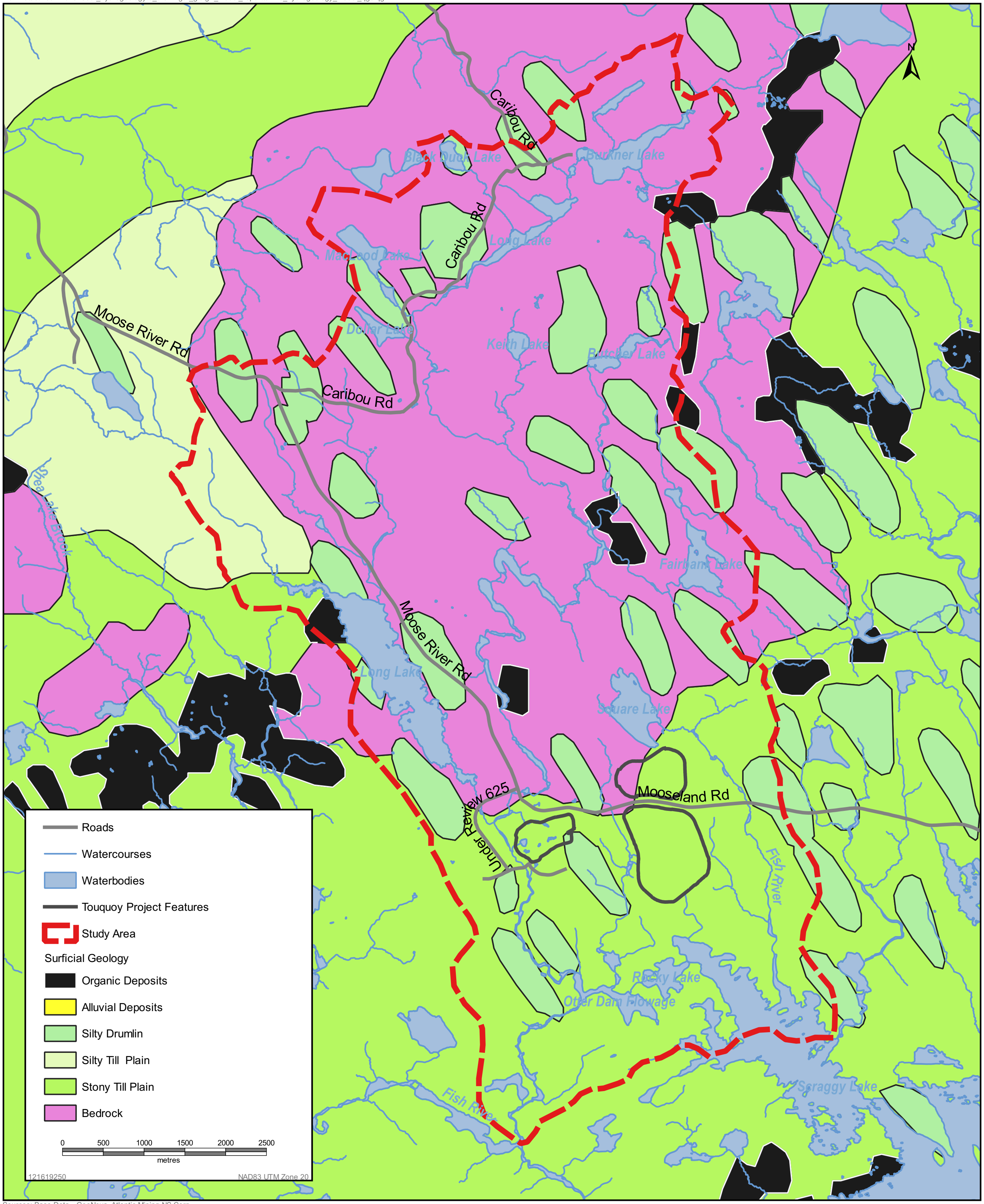
2.4 REGIONAL GEOLOGICAL CONTEXT

2.4.1 Overburden Geology

The regional surficial geology of Nova Scotia has been mapped by the Nova Scotia Department of Natural Resources (Stea et al. 1992) and consists of a veneer of stony till overlying bedrock in the south of the study area, or as exposed bedrock in the north of the study area, as shown on Figure 2-3. Organic deposits were observed in low lying areas and areas associated with wetlands. Silty drumlins are noted throughout the study are, as shown on Figure 2.3.

2.4.2 Bedrock Geology

The geology in central Nova Scotia, including the area around the Touquoy mine site, is composed dominantly by Cambrian to Ordovician age greywackes and argillites of the Meguma Group, as shown on Figure 2.4 from the geological maps presented in Ausenco (2015). At the Touquoy mine site and the southern portion of the study area, the underlying bedrock is composed of the Moose River, Tangier and Moose River, and Taylor's Head members of the Goldenville Formation. Bedrock in northern portions of the study area consists of the Cunard and Beaverbank members of the Halifax Formation. These formations have undergone significant alteration by a series of northeast-trending, tightly-folded anticlines and synclines, and are further altered by a number of northwest trending faults, as shown on Figure 2.4. The Moose River member is composed dominantly of argillite, while the other members of the Goldenville Formation are dominantly greywacke.



Sources: Base Data - GeoNova, Atlantic Mining NS Corp.

Touquoy Mine Site Surficial Geology

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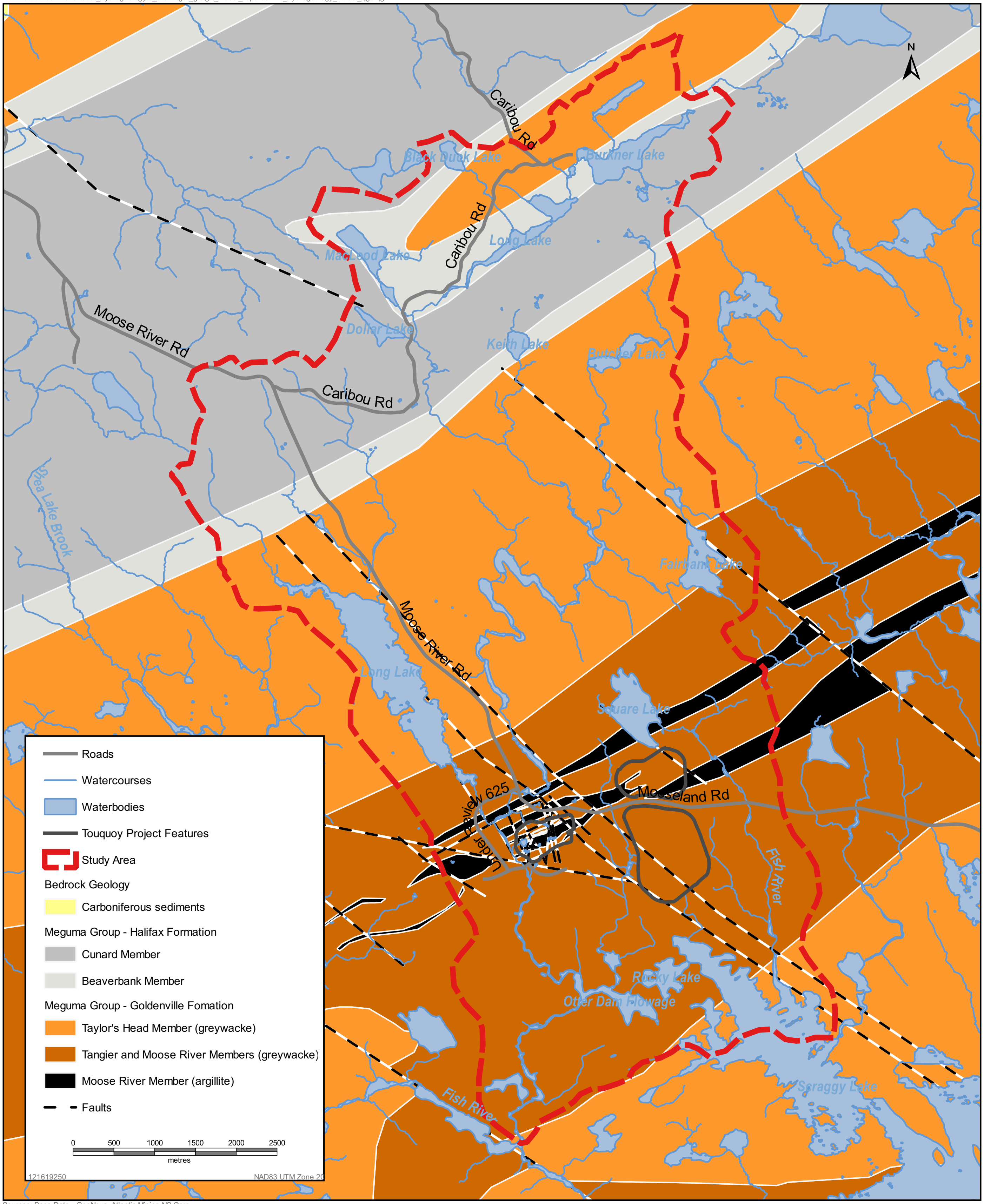
Beaver Dam Gold Project

Figure 2.3



Sources: Base Data - GeoNova, Atlantic Mining NS Corp.

Touquoy Mine Site Bedrock Geology

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Beaver Dam Gold Project

Figure 2.4

3.0 CONCEPTUAL MODEL

3.1 MODELLING APPROACH

The development of a conceptual model is the fundamental first step in the preparation of a numerical groundwater model. The conceptual model combines the available hydrologic and hydrogeologic data from a site, and allows for the interpretation of the hydrostratigraphy and boundary conditions so they can be entered into a numerical groundwater flow model. The general approach used to develop the conceptual and numerical model was to add complexity as warranted by the available data to achieve the objectives of the numerical modelling (see Section 1.1).

3.2 CONCEPTUAL MODEL BOUNDARIES

The conceptual model boundaries were defined to coincide with or extend beyond the proposed limits for the groundwater flow model. Natural hydrologic and hydrogeologic boundaries such as watershed boundaries and surface water bodies were used to define the lateral extent of the conceptual model. The boundaries of the conceptual model correspond with the extent of the study area illustrated on Figure 2.1. The boundaries coincide with watershed boundaries for Moose River, Square Lake and the northern arm of Scraggy Lake. The limits of the conceptual model were constrained vertically by ground surface topography and extended several hundred meters to below the base of the open pit.

3.3 HYDROSTRATIGRAPHY

Previous work by Conestoga-Rovers & Associates (CRA 2007a, 2007b) and Peter Clifton & Associates (PCA 2007) identified three hydrostratigraphic units based on lithology and hydraulic properties: glacial till, weathered fractured bedrock, and competent fractured bedrock. These hydrostratigraphic units were further subdivided into zones based on the surficial geology in the overburden shown on Figure 2.3. The weathered fractured bedrock and competent fractured bedrock were further subdivided to include the bedrock units identified on Figure 2.4.

3.3.1 Overburden Hydrostratigraphic Units

The overburden hydrostratigraphic units include:

- Stony Till
- Silt Till
- Organics
- Silty Drumlin

The stony till is the dominant overburden unit, consisting of cobbly silt-sand grading to sandier assumed to be approximately 4 m thick on average across the study area. The silt till is present in the northwestern portion of the study area, however no specific testing of this unit has been performed, so it is assumed to have similar hydraulic conductivity as the stony till unit. The hydraulic conductivity of the till is estimated to range from 3×10^{-7} to 1×10^{-5} metres per second (m/s), based on estimates from shallow test pits at the western end of the pit (PCA 2007) and slug tests conducted on monitoring wells installed at the Touquoy Mine Site (GHD Limited 2016a, 2016b).

3.3.2 Bedrock Hydrostratigraphic Units

Ten bedrock hydrostratigraphic units were identified in the Touquoy Mine Site study area. These are based on the five stratigraphic members (Cunard, Beaverbank, Taylor's Head, Tangier and Moose River, and Moose River) presented on Figure 2.4, each subdivided into a weathered fractured bedrock unit, and a competent fractured bedrock unit.

Weathered fractured bedrock consisting of Meguma Group sandstones and mudstones that has undergone alterations due to weathering and is therefore more permeable than the underlying bedrock. This unit is assumed to be 10 m thick based on the distribution of hydraulic conductivity estimates from packer testing conducted within the footprint of the proposed Touquoy pit.

Competent fractured bedrock consisting of Meguma Group sandstones and mudstones that have not undergone alterations due to weathering. This unit was assumed to extend from the base of the weathered fractured bedrock to below the extent of the open pit.

Hydraulic conductivity testing of greywacke and argillite observed at the Touquoy Mine Site did not identify distinct hydraulic differences between these units, although weathered fractured bedrock was observed to be more permeable than the deeper, more competent bedrock. The variability of hydraulic conductivity estimates in bedrock units is shown on Figure 3.2. Hydraulic conductivity estimates in weathered fractured bedrock range between 4×10^{-9} m/s and 4×10^{-4} m/s. Fewer measurements are available in the competent fractured bedrock, where the hydraulic conductivity ranges between 4×10^{-10} m/s and 1×10^{-7} m/s.

Faults in the bedrock were not specifically tested to assess the hydraulic conductivity at the Touquoy Mine Site. However, regular observations of the faults exposed in the Touquoy open pit have identified some discrete seepage at these faults. The total flow from these exposed faults are generally very low. The faults with seepage were located on pit walls that were generally located away from Moose River, and do not suggest a strong connection with the river.

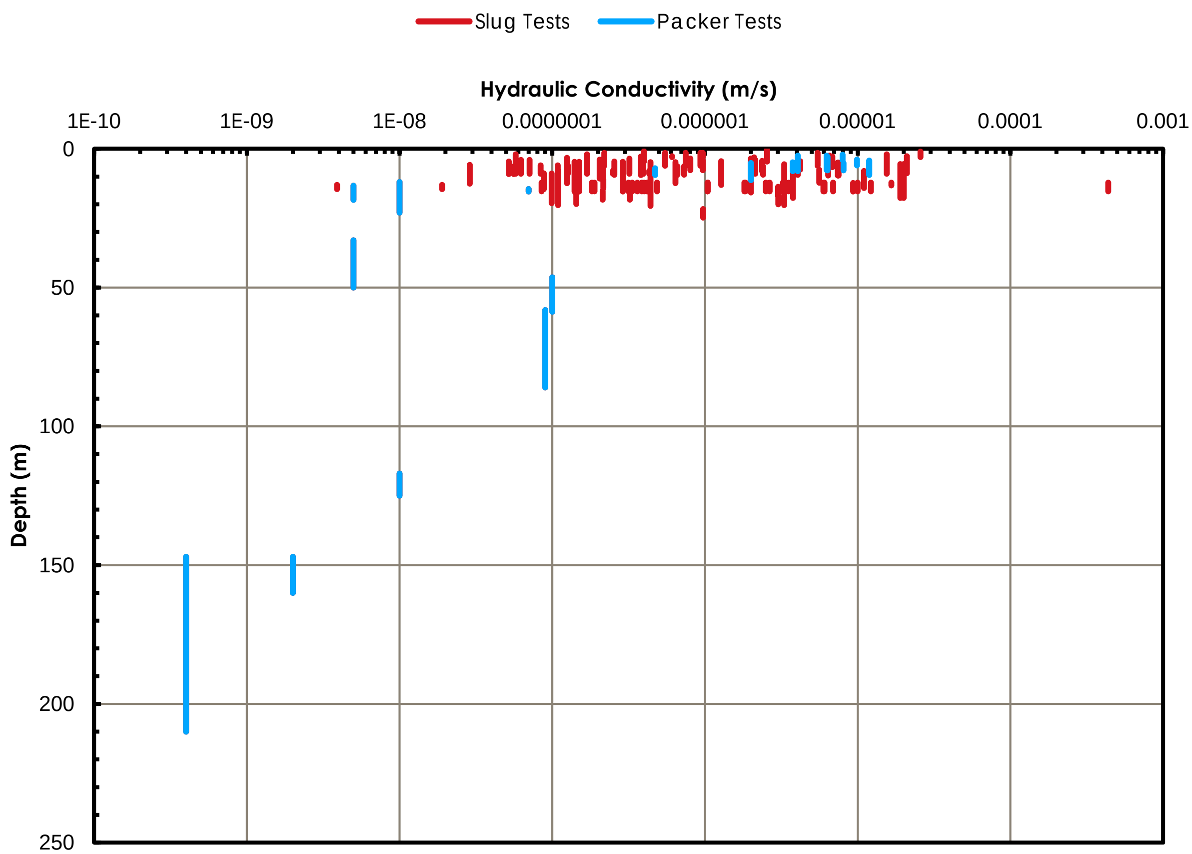

Figure 3.1 Hydraulic Conductivity Estimates in Bedrock

4.0 MODEL CONSTRUCTION AND CALIBRATION

MODFLOW was chosen as the numerical groundwater-software application for this evaluation because it is considered an international standard for simulating and predicting groundwater flow. The MODFLOW-NWT (Niswonger et al. 2012) numerical groundwater flow code was used to simulate the hydrogeologic conditions in the study area. The MODFLOW-NWT code was selected as it is able to efficiently solve the saturated groundwater flow equations under complex hydrogeological conditions without encountering numerical difficulties associated with drying out of model cells that are commonly encountered in dewatering scenarios.

MT3DMS (Zheng and Wang 1999) was chosen as the numerical solute transport model. MT3DMS is a modular three-dimensional multispecies transport code for simulation of advection, dispersion and chemical reactions of contaminants in groundwater systems.

Groundwater Vistas version 7 (Environmental Simulations International 2018) was chosen as the graphical user interface with MODFLOW-NWT and MT3DMS. Groundwater Vistas is a pre- and post-processor for MODFLOW-NWT and MT3DMS models and other technologies for sensitivity analysis and model calibration.

4.1 MODEL DOMAIN

The model grid was constructed to encapsulate the Study Area. The grid is composed of 543 rows and 520 columns for a total area of 117.6 square kilometres (km^2). Cells outside the Study Area are designated “inactive.” The total active area of the model is approximately 58.2 km^2.

A uniform row and column spacing of 50 m was initially applied across the domain. The grid was refined to 10 m spacing (columns and rows) around the Touquoy Mine Site project features, including the open pit, tailings management facility, and waste rock storage area. This refinement extends across the whole model domain and to all layers.

The model was discretized into ten model layers using the hydrostratigraphic units presented in Figure 4.1. Competent fractured bedrock is divided into eight 20-m-thick layers (Layers 3 through 10) based on the pit bench design and two additional layers below the proposed pit floor.

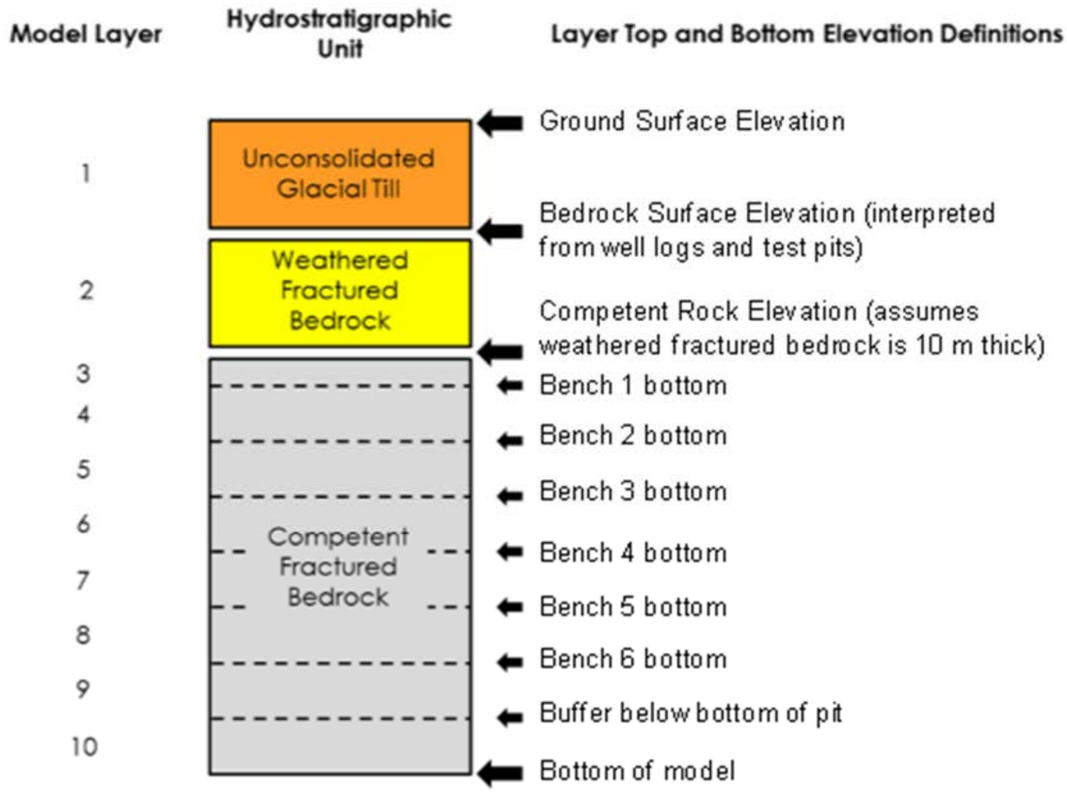

Figure 4.1 Model layer top and bottom elevation definitions and hydrostratigraphy

4.2 DISTRIBUTION OF HYDROGEOLOGICAL PARAMETERS

The hydraulic conductivity, porosity, and recharge rate were assigned in the model based on the hydrostratigraphic units as defined in the conceptual model. The geometric mean hydraulic conductivity values for each unit determined from the field testing programs were used in the initial model set-up, and the hydrostratigraphic units were assumed to be uniform and isotropic. The bulk hydraulic conductivity of the isotropic bedrock hydrostratigraphic units are interpreted to include the fractures and faults described in Section 3.3.2.

4.3 BOUNDARY CONDITIONS

4.3.1 Model Boundary

The model limits were assigned based on local watershed boundaries but were extended into neighbouring watersheds based on anticipated effects from the presence of the open pit. In all cases the model was extended to natural hydrologic/hydrogeologic boundaries, including watershed boundaries (assumed to be coincident with groundwater flow divides) or surface water features (also assumed to be coincident with groundwater flow divides). The model domain limits are presented on Figure 2.1.

4.3.2 Recharge

The type of soil and vegetation present at surface is an important factor in determining whether precipitation will become runoff or groundwater recharge. Recharge rates were assigned based on the hydrostratigraphic units exposed at the top of the model domain and consideration of the surficial geology mapping for the area. The groundwater recharge rate was adjusted for each of these major groups during the model calibration process. However, at the end of calibration, the recharge was found to be relatively uniform, so a uniform recharge rate was specified for the entire model domain.

4.3.3 Lakes

As shown on Figure 2.1, several lakes and watercourses are located within the model domain. Lakes and watercourses were assigned as boundary conditions in the model using a head-dependent flux boundary. This type of boundary conditions determines the flow rate between the boundary condition and the aquifer based on the head assigned to the boundary condition. The vertical extent of the lakes was determined using available bathymetric data collected at the lakes, and the reference head for each cell was obtained from the digital elevation model.

The interaction between the surface water in the lakes and watercourses and the groundwater in the underlying aquifers is defined by a “conductance” term. This term represents the presence of a layer of sediment on the lakebed or streambed that can affect the rate of water transferred between the lake or watercourse and the underlying model layer. The conductance term was used as a calibration parameter.

4.3.4 Watercourses

Watercourses in the groundwater model are assigned to Layer 1 using the River package. The river package allows water to exit the groundwater system when the head in the aquifer is greater than the assigned head (stage) of the river, and allows water to enter the groundwater system with the head in the aquifer is lower than the assigned stage of the river. Two types of drains are defined within the model, based on river width estimates obtained from satellite imagery. Type 1 river cells define most river reaches in the domain with an assumed width of 3 m and depth of 0.3 m. Type 2 river cells define Moose River south of Dollar Lake to the downstream end of the catchment at Melvin Dam Flowage near Davis Lake and the tributaries from Bulcher Lake and Fairbank Lake. A river width of 8 m and depth of 1 m is assumed. The conductance term was used as a calibration parameter.

4.4 CALIBRATION

4.4.1 Calibration Methodology

Model calibration was conducted using an iterative approach under steady-state conditions, followed by additional iterations to evaluate transient conditions. This involved a process where a flow simulation was carried out, the resulting groundwater levels, vertical hydraulic gradients, and baseflow rates to watercourses were compared to measured values, and the model input parameters were re-adjusted to achieve better agreement with observed (field measured) conditions and the overall interpreted groundwater flow directions. The process of model calibration involves the adjustment of model parameter values to match field-measured values within a pre-established range of error. A hybrid calibration approach was used that combined automated parameter estimation, facilitated using the

Parameter Estimation (PEST) code (Doherty 2018), together with professional judgement and interpretation of the calibration results.

The calibration was completed using the following steps:

1. Prepare model files and input parameters
2. Run PEST to estimate parameter values that provide the best average fit to the observations
3. Review the model results
4. Adjust insensitive parameters from the PEST calibration (if any can be identified)
5. Repeat steps 2 through 4 until the model is determined to be adequately calibrated within acceptable ranges of error

Several parameters were adjusted during the calibration of the model, including:

- Horizontal hydraulic conductivity
- Vertical hydraulic conductivity
- Recharge
- River and lake bed conductance

These parameters were adjusted automatically using PEST over the ranges determined from field observations or literature values. A total of 38 parameters were adjusted during the calibration process.

4.4.2 Calibration to Water Levels

Model calibration was assessed by comparing model simulated water levels to observations collected from three water level datasets:

- Water level data collected from onsite monitoring wells (Stantec 2018).
- Periodic manual water level data collected from historical monitoring wells and boreholes.
- One-time manual water level data reported in water well records (NSE 2018).

The water level target at each location was calculated as the average water level observed during the period of record available for each location. Water well records had only one water level measurement from the time of completion and were considered the least reliable measurements in the calibration process. Water level observations from onsite wells were considered the most reliable as they have a longer period of record under current land use conditions and varying climatic conditions and provide an average water level appropriate for calibration of a steady state groundwater flow model. The calculated water level targets are presented in Table 4.1. The locations of the monitoring wells used for water level targets are shown on Figure 4.2.

A plot of the simulated (modelled) versus observed (measured) groundwater levels is shown in Figure 4.3. A line of perfect fit (e.g., a line having a slope of 1.0) is shown for comparison. Simulated groundwater levels that match the observed groundwater levels exactly will fall on this line. As shown on Figure 4.3 and in Table 4.1, there is generally good agreement with the automated and manual water level targets.

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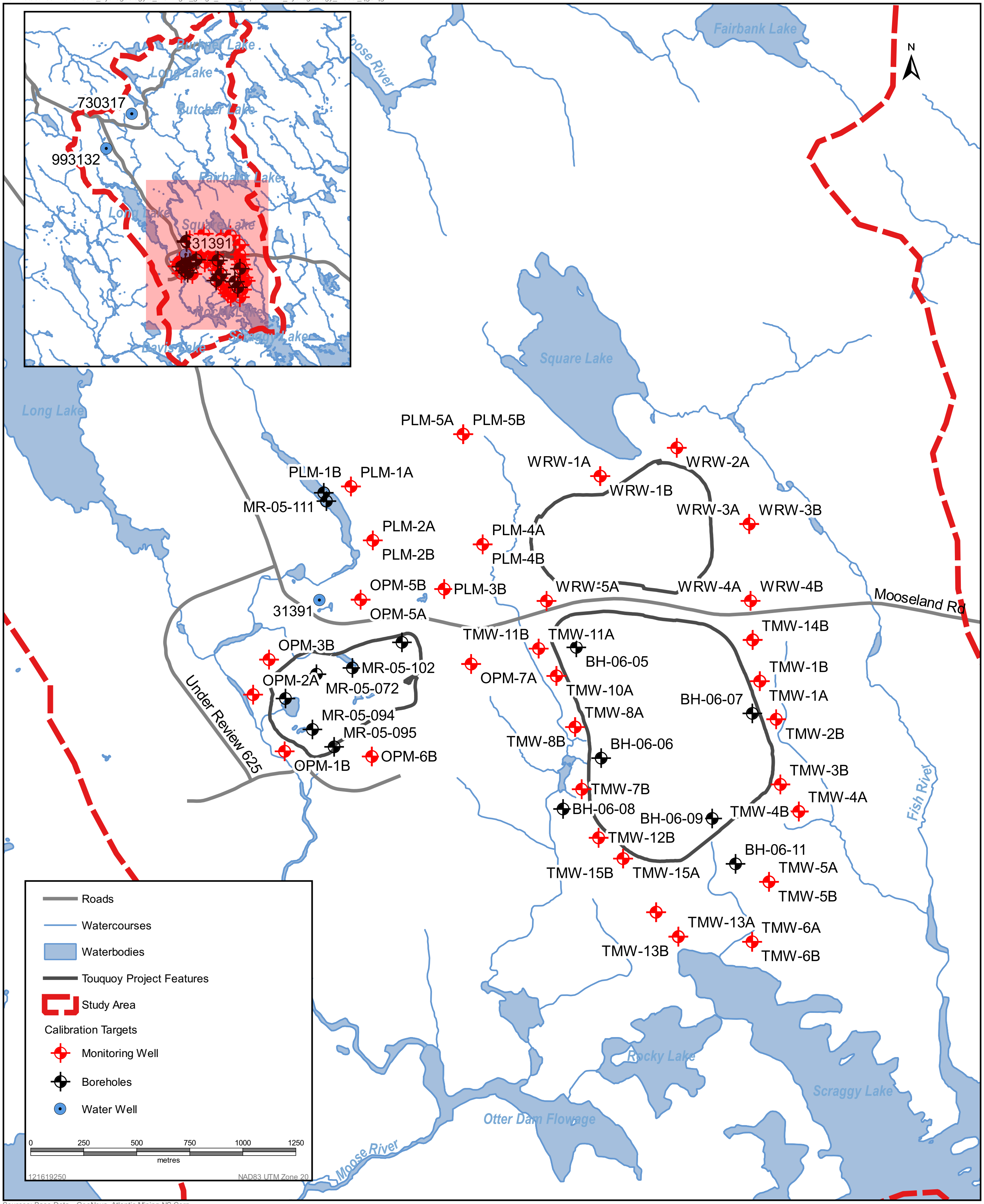

Sources: Base Data - GeoNova, Atlantic Mining NS Corp.

Location of Calibration Targets

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Beaver Dam Gold Project

Figure 4.2

Table 4.1 Water Level Calibration Residuals and Statistics

Location	Average Annual Target Water Level (m AMSL)	Simulated Average Annual Water Level (m AMSL)	Residual (m)	Target Type
PLM-1A	130.991	131.098	-0.107	Monitoring Well
PLM-1B	128.788	130.488	-1.700	Monitoring Well
PLM-2A	119.522	117.684	1.838	Monitoring Well
PLM-2B	118.250	117.835	0.415	Monitoring Well
PLM-3A	129.370	126.458	2.912	Monitoring Well
PLM-3B	125.195	124.910	0.285	Monitoring Well
PLM-4A	125.613	123.961	1.652	Monitoring Well
PLM-4B	124.579	123.906	0.673	Monitoring Well
PLM-5A	126.023	127.107	-1.084	Monitoring Well
PLM-5B	126.075	127.107	-1.032	Monitoring Well
WRW-1A	131.201	128.641	2.560	Monitoring Well
WRW-1B	130.509	128.655	1.854	Monitoring Well
WRW-2A	134.681	128.837	5.844	Monitoring Well
WRW-2B	131.785	129.183	2.602	Monitoring Well
WRW-3A	125.189	124.970	0.219	Monitoring Well
WRW-3B	125.710	125.531	0.179	Monitoring Well
WRW-4A	129.497	126.240	3.257	Monitoring Well
WRW-4B	126.486	126.087	0.399	Monitoring Well
WRW-5A	120.007	118.905	1.102	Monitoring Well
WRW-5B	119.923	118.848	1.075	Monitoring Well
OPM-1A	108.293	107.794	0.499	Monitoring Well
OPM-1B	108.323	107.832	0.491	Monitoring Well
OPM-2A	109.182	108.843	0.339	Monitoring Well
OPM-2B	108.427	108.829	-0.402	Monitoring Well
OPM-3A	114.753	112.472	2.281	Monitoring Well
OPM-3B	114.535	112.441	2.094	Monitoring Well
OPM-5A	118.121	117.513	0.608	Monitoring Well
OPM-5B	118.091	117.445	0.646	Monitoring Well
OPM-6A	114.393	113.198	1.195	Monitoring Well
OPM-6B	114.365	113.172	1.193	Monitoring Well
OPM-7A	115.668	117.229	-1.561	Monitoring Well
OPM-7B	115.756	117.217	-1.461	Monitoring Well
TMW-1A	115.773	113.874	1.899	Monitoring Well

Table 4.1 Water Level Calibration Residuals and Statistics

Location	Average Annual Target Water Level (m AMSL)	Simulated Average Annual Water Level (m AMSL)	Residual (m)	Target Type
TMW-1B	115.457	113.873	1.584	Monitoring Well
TMW-2A	113.741	112.553	1.188	Monitoring Well
TMW-2B	113.319	112.560	0.759	Monitoring Well
TMW-3A	108.763	109.902	-1.139	Monitoring Well
TMW-3B	108.623	109.891	-1.268	Monitoring Well
TMW-4A	107.327	108.160	-0.833	Monitoring Well
TMW-4B	107.326	108.155	-0.829	Monitoring Well
TMW-5A	107.221	108.360	-1.139	Monitoring Well
TMW-5B	107.232	108.355	-1.123	Monitoring Well
TMW-6A	104.862	105.201	-0.339	Monitoring Well
TMW-6B	104.457	105.246	-0.789	Monitoring Well
TMW-7A	108.674	109.485	-0.811	Monitoring Well
TMW-7B	108.548	109.478	-0.930	Monitoring Well
TMW-8A	108.782	110.018	-1.236	Monitoring Well
TMW-8B	108.775	109.986	-1.211	Monitoring Well
TMW-10A	114.291	114.008	0.283	Monitoring Well
TMW-10B	114.048	114.015	0.033	Monitoring Well
TMW-11A	113.697	115.356	-1.659	Monitoring Well
TMW-11B	112.340	115.409	-3.069	Monitoring Well
TMW-12A	113.775	112.061	1.714	Monitoring Well
TMW-12B	113.038	112.146	0.892	Monitoring Well
TMW-13A	109.095	108.722	0.373	Monitoring Well
TMW-13B	107.218	107.679	-0.461	Monitoring Well
TMW-14A	121.416	117.968	3.448	Monitoring Well
TMW-14B	121.193	117.607	3.586	Monitoring Well
TMW-15A	120.573	117.600	2.973	Monitoring Well
TMW-15B	116.129	116.893	-0.764	Monitoring Well
TMW-16A	115.703	115.161	0.542	Monitoring Well
TMW-16B	115.016	114.258	0.758	Monitoring Well
31391	112.880	115.763	-2.883	Water Well
730317	169.520	168.571	0.949	Water Well
993132	138.280	141.601	-3.321	Water Well
BH-15-01	116.700	115.842	0.858	Borehole

Table 4.1 Water Level Calibration Residuals and Statistics

Location	Average Annual Target Water Level (m AMSL)	Simulated Average Annual Water Level (m AMSL)	Residual (m)	Target Type
BH-15-02	113.400	113.779	-0.379	Borehole
BH-15-03	109.400	111.309	-1.909	Borehole
BH-15-04	109.000	112.081	-3.081	Borehole
BH-15-05	113.400	112.636	0.764	Borehole
BH-15-06	108.900	111.208	-2.308	Borehole
BH-15-07	109.000	109.883	-0.883	Borehole
BH-15-08	107.200	110.402	-3.202	Borehole
BH-15-09	111.400	110.919	0.481	Borehole
BH-15-10	111.300	110.626	0.674	Borehole
BH-15-11	117.600	115.821	1.779	Borehole
BH-15-12	109.500	112.265	-2.765	Borehole
BH-15-13	110.600	112.242	-1.642	Borehole
BH-15-15	109.700	111.771	-2.071	Borehole
BH-15-16	112.600	111.558	1.042	Borehole
BH-15-17	110.900	110.730	0.170	Borehole
BH-15-18	114.900	112.265	2.635	Borehole
BH-15-19	115.900	114.161	1.739	Borehole
MR-05-072	115.610	114.490	1.120	Borehole
MR-05-086	111.820	111.743	0.077	Borehole
MR-05-094	111.570	111.338	0.232	Borehole
MR-05-095	113.710	111.578	2.132	Borehole
MR-05-098	118.580	119.219	-0.639	Borehole
MR-05-102	117.340	116.559	0.781	Borehole
MR-05-111	119.960	118.531	1.429	Borehole
MR-05-116	119.390	119.209	0.181	Borehole
BH-06-05	115.020	116.495	-1.475	Borehole
BH-06-06	109.370	110.857	-1.487	Borehole
BH-06-07	112.800	113.630	-0.830	Borehole
BH-06-08	105.380	108.744	-3.364	Borehole
BH-06-09	112.260	111.825	0.435	Borehole
BH-06-11	108.340	109.902	-1.562	Borehole
Residual Statistics				
Sum of Squared Error (m^2)			283	

Table 4.1 Water Level Calibration Residuals and Statistics

Location	Average Annual Target Water Level (m AMSL)	Simulated Average Annual Water Level (m AMSL)	Residual (m)	Target Type
Mean Error (m)			-0.154	
Absolute Mean Error (m)			1.366	
Root Mean Squared Error (m)			1.709	
Normalized Mean Squared Error (%)			2.6	

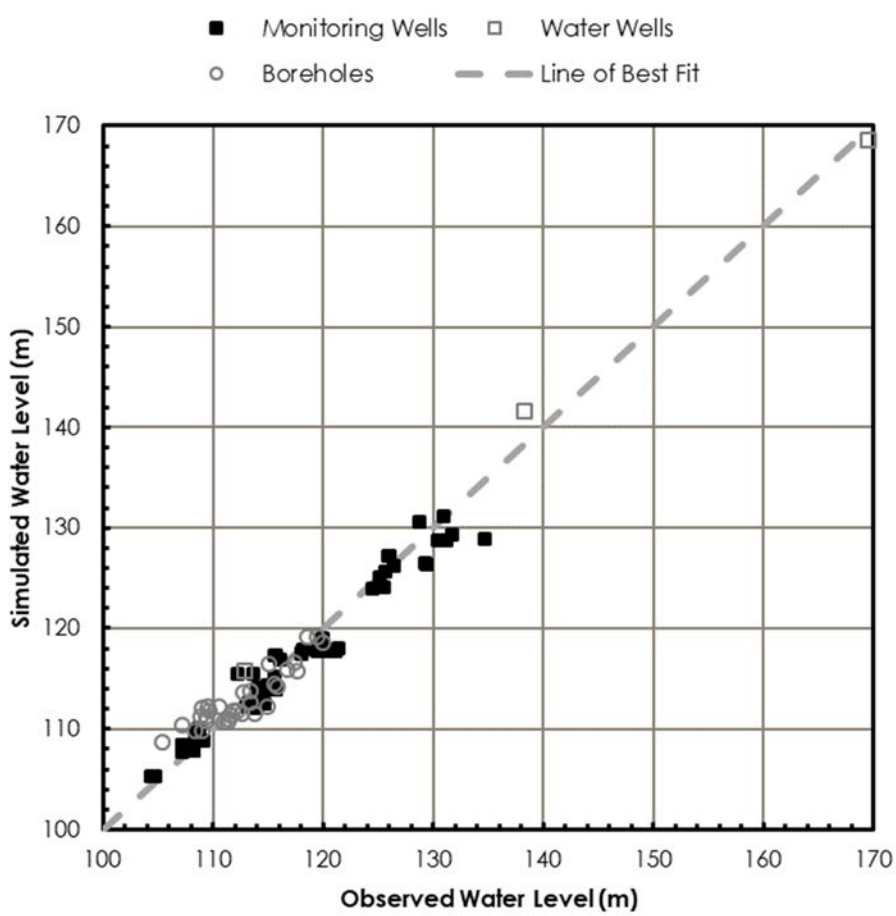

Figure 4.3 Scatterplot showing match of observed and simulated water levels

The statistical measures of the calibration to the water level data are reported in Table 4.1. These measures include the standard error of the estimate and the root mean squared (RMS) error. In evaluating the fit between the observed and the simulated water levels, the RMS error is usually regarded as the best measure (Anderson and Woessner 1991). The RMS error is essentially a standard deviation calculated as the average of the squared differences between the measured and the simulated water levels. If the ratio of the RMS error to the total water level differential over the model area is small (e.g., less than 10%; Spitz and Moreno 1996), then the errors are only a small part of the overall hydraulic response of the model. In this simulation, the ratio of the RMS error to the total water level differential (2.6%) is less than the recommended 10% threshold.

In addition to the water level data, the net baseflow in Moose River at SW-2 was estimated using the model to be 23,348 cubic metres per day (m^3/d). This baseflow rate represents 22% of the mean annual flow of 1.23 cubic metres per second (m^3/s) (106,580 m^3/d) in Moose River at SW-2 based on regional flow regressions analysis, described by Stantec (2019).

4.4.3 Calibrated Model Parameters

The values of the hydrogeologic parameters that were determined from the calibration process are presented in Table 4.2. The hydraulic conductivity values for the various hydrostratigraphic units generated by the model are within the ranges expected for the materials based on measured and literature values.

Table 4.2 Calibrated Model Parameters

Parameter	Value at End of Calibration	Expected Range	
Groundwater Recharge (mm/yr)			
Recharge	215	135	405
Hydraulic Conductivity (m/s)			
Stony Till Plain	0.0001	1.0E-08	1.0E-04
Silt Till Plain	0.0001	1.0E-08	1.0E-04
Organics	0.0001	1.0E-08	1.0E-04
Drumlin	4.5E-06	1.0E-08	1.0E-04
Weathered Cunard Member	5.6E-08	3.9E-09	4.4E-04
Weathered Beaverbank Member	3.7E-07	3.9E-09	4.4E-04
Weathered Taylor's Head Member	3.7E-07	3.9E-09	4.4E-04
Weathered Tangier & Moose River Members	2.4E-07	3.9E-09	4.4E-04
Weathered Moose River Member	1.3E-08	3.9E-09	4.4E-04
Competent Cunard Member	3.9E-09	3.9E-09	4.4E-04
Competent Beaverbank Member	1.1E-08	3.9E-09	4.4E-04
Competent Taylor's Head Member	6.7E-09	3.9E-09	4.4E-04
Competent Tangier & Moose River Members	4.9E-09	3.9E-09	4.4E-04

Table 4.2 Calibrated Model Parameters

Parameter	Value at End of Calibration	Expected Range	
Competent Moose River Member	7.4E-09	3.9E-09	4.4E-04
Vertical Anisotropy (K_v/K_h)			
Stony Till Plain	1.0	0.001	5.0
Silt Till Plain	1.0	0.001	5.0
Organics	1.0	0.001	5.0
Drumlin	2.0	0.001	5.0
Cunard Member	0.23	0.001	5.0
Beaverbank Member	0.98	0.001	5.0
Taylor's Head Member	4.3	0.001	5.0
Tangier & Moose River Members	0.81	0.001	5.0
Moose River Member	0.30	0.001	5.0
Cunard Member	1.0	0.001	5.0
Beaverbank Member	0.34	0.001	5.0
Taylor's Head Member	1.0	0.001	5.0
Tangier & Moose River Members	0.84	0.001	5.0
Moose River Member	0.53	0.001	5.0

As shown on Table 4.2, the hydraulic conductivity of the overburden units with the exception of the drumlins was at the high-end of the expected range. This may conservatively overestimate the flow into the overburden from groundwater recharge, but provides a reasonable match of water levels in the overburden across the site, and was therefore considered acceptable for this model.

4.4.4 Calibration Uncertainty

An evaluation of the potential uncertainty in the model was conducted by reviewing the relative sensitivity of the parameters adjusted during the calibration to the results of the final calibration. These values were determined using PEST, and are presented on Figure 4.4. The relative sensitivity is provided on a scale from 0 to 1 as a ratio of the sensitivity of the parameter to the calibration of the model, with the sum of the sensitivity values totaling 1. A sensitivity of 0 indicates that varying the parameter does not affect the outcome of the calibration, while a sensitivity approaching 1 indicates that the outcome of the calibration is completely dependent on the value of this parameter.

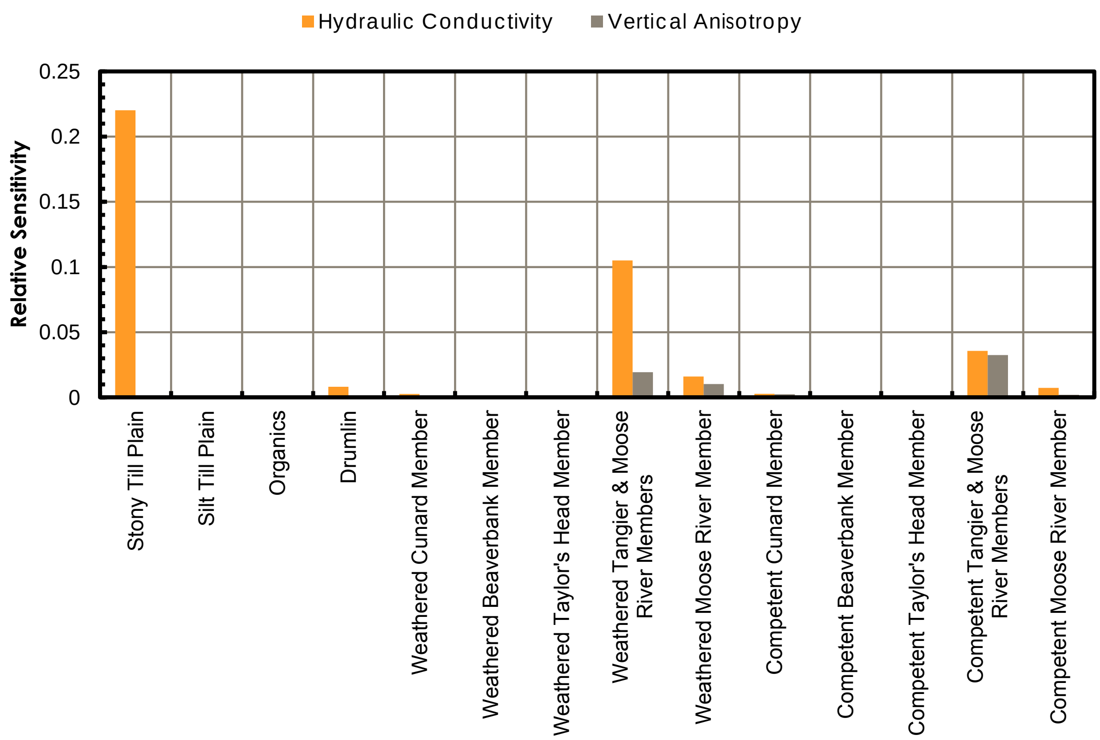

Figure 4.4 Calibration Sensitivity to Parameter Estimates

As shown on Figure 4.4, the model calibration was most sensitive to the hydraulic conductivity within the stony till plain unit (0.23) and the hydraulic conductivity of the weathered Tangier & Moose River Members fractured bedrock units (0.11). While it may be possible to vary the hydraulic conductivity of the shallow bedrock unit, adjusting this parameter away from its calibrated value would also require an alteration to the calibrated recharge rates, which are also sensitive parameters. Therefore, it is not possible to adjust one of these sensitive parameters independently without affecting the calibration of the model. Other parameters varied during the calibration had relatively small effects on the calibration (i.e., the calibration was less sensitive to these parameters over the range adjusted)

In addition to the above, a sensitivity analysis of the calibrated model was conducted to evaluate the effects of changes to individual model input parameters on model calibration. Each model input parameter that was adjusted during model calibration was adjusted individually during model sensitivity analysis while holding all other input parameter values at their calibrated value. The value of each parameter was adjusted compared to the value specified in the calibrated model. In general, the input parameter value adjustments are within the range of parameter values specified during automatic and manual model calibration simulations.

For each parameter adjustment the model fit between observed and simulated groundwater elevations are calculated, as shown on Table 4.3. The difference between each the model fit for each parameter adjustment and calibrated model are also presented on the table. In the event that a significant improvement in overall model calibration is identified through the sensitivity analysis the model calibration with be updated to incorporate that improvement or a justification will be provided to describe why the parameter change resulting in calibration improvement should not be incorporated into the calibrated model (i.e., a parameter change that results in an improvement in model calibration based on the residual sum of squares(RSS) metric, but is inconsistent with the conceptual site model may not be justified). The results presented on Table 4.3 are consistent with the observations of model sensitivities presented in Figure 4.4.

Table 4.3 Calibrated Model Parameters

Sensitivity Analysis Simulation Number	Parameter	Parameter Value for Sensitivity Analysis	Sensitivity Simulation RSS	Percent change in RSS from calibrated model
Horizontal Hydraulic Conductivity (m/s)				
1-1	K_H Stony Till Plain	1.00E-04	283.464	-
1-2	K_H Stony Till Plain	2.00E-05	960.330	239%
1-3	K_H Stony Till Plain	4.00E-06	14056.509	4859%
2-1	K_H Silt Till Plain	1.00E-04	283.464	-
2-2	K_H Silt Till Plain	2.00E-05	283.868	0.1%
2-3	K_H Silt Till Plain	4.00E-06	284.310	0.3%
3-1	K_H Organics	1.00E-04	283.464	-
3-2	K_H Organics	2.00E-05	283.476	0.0%
3-3	K_H Organics	4.00E-06	283.522	0.0%
4-1	K_H Drumlin	2.25E-05	292.176	3.1%
4-2	K_H Drumlin	4.50E-06	283.464	-
4-3	K_H Drumlin	9.00E-07	322.015	13.6%
5-1	K_H Weathered Cunard Member	2.80E-07	290.633	2.5%
5-2	K_H Weathered Cunard Member	5.60E-08	283.464	-
5-3	K_H Weathered Cunard Member	1.12E-08	282.388	-0.4%
6-1	K_H Weathered Beaverbank Member	1.85E-06	282.881	-0.2%
6-2	K_H Weathered Beaverbank Member	3.70E-07	283.464	-
6-3	K_H Weathered Beaverbank Member	7.40E-08	283.674	0.1%
7-1	K_H Weathered Taylor's Head Member	1.85E-06	283.372	0.0%
7-2	K_H Weathered Taylor's Head Member	3.70E-07	283.464	-
7-3	K_H Weathered Taylor's Head Member	7.40E-08	283.490	0.0%
8-1	K_H Weathered Tangier & Moose River Members	1.20E-06	426.133	50.3%
8-2	K_H Weathered Tangier & Moose River Members	2.40E-07	283.464	-
8-3	K_H Weathered Tangier & Moose River Members	4.80E-08	284.646	0.4%
9-1	K_H Weathered Moose River Member	6.50E-08	283.528	0.0%
9-2	K_H Weathered Moose River Member	1.30E-08	283.464	-

Table 4.3 Calibrated Model Parameters

Sensitivity Analysis Simulation Number	Parameter	Parameter Value for Sensitivity Analysis	Sensitivity Simulation RSS	Percent change in RSS from calibrated model
9-3	K_H Weathered Moose River Member	2.60E-09	283.403	0.0%
10-1	K_H Competent Cunard Member	1.95E-08	306.664	8.2%
10-2	K_H Competent Cunard Member	3.90E-09	283.464	-
10-3	K_H Competent Cunard Member	7.80E-10	279.625	-1.3%
11-1	K_H Competent Beaverbank Member	5.50E-08	283.806	0.1%
11-2	K_H Competent Beaverbank Member	1.10E-08	283.464	-
11-3	K_H Competent Beaverbank Member	2.20E-09	283.651	0.1%
12-1	K_H Competent Taylor's Head Member	3.35E-08	283.356	0.0%
12-2	K_H Competent Taylor's Head Member	6.70E-09	283.464	-
12-3	K_H Competent Taylor's Head Member	1.34E-09	283.559	0.0%
13-1	K_H Competent Tangier & Moose River Members	2.45E-08	291.046	2.7%
13-2	K_H Competent Tangier & Moose River Members	4.90E-09	283.464	-
13-3	K_H Competent Tangier & Moose River Members	9.80E-10	287.168	1.3%
14-1	K_H Competent Moose River Member	3.70E-08	284.207	0.3%
14-2	K_H Competent Moose River Member	7.40E-09	283.464	-
14-3	K_H Competent Moose River Member	1.48E-09	284.554	0.4%
Vertical Anisotropy				
15-1	K_V/K_H Stony Till Plain	1	283.464	-
15-2	K_V/K_H Stony Till Plain	0.2	283.488	0.0%
15-3	K_V/K_H Stony Till Plain	0.04	283.454	0.0%
16-1	K_V/K_H Silt Till Plain	1	283.464	-
16-2	K_V/K_H Silt Till Plain	0.2	283.472	0.0%
16-3	K_V/K_H Silt Till Plain	0.04	283.465	0.0%
17-1	K_V/K_H Organics	1	283.464	-
17-2	K_V/K_H Organics	0.2	283.451	0.0%
17-3	K_V/K_H Organics	0.04	283.488	0.0%
18-1	K_V/K_H Drumlin	10	283.487	0.0%
18-2	K_V/K_H Drumlin	2	283.464	-
18-3	K_V/K_H Drumlin	0.4	283.482	0.0%
19-1	K_V/K_H Weathered Cunard Member	1.15	281.738	-0.6%
19-2	K_V/K_H Weathered Cunard Member	0.23	283.464	-

Table 4.3 Calibrated Model Parameters

Sensitivity Analysis Simulation Number	Parameter	Parameter Value for Sensitivity Analysis	Sensitivity Simulation RSS	Percent change in RSS from calibrated model
19-3	K_V/K_H Weathered Cunard Member	0.046	294.003	3.7%
20-1	K_V/K_H Weathered Beaverbank Member	4.9	283.434	0.0%
20-2	K_V/K_H Weathered Beaverbank Member	0.98	283.464	-
20-3	K_V/K_H Weathered Beaverbank Member	0.196	283.548	0.0%
21-1	K_V/K_H Weathered Taylor's Head Member	21.5	283.462	0.0%
21-2	K_V/K_H Weathered Taylor's Head Member	4.3	283.464	-
21-3	K_V/K_H Weathered Taylor's Head Member	0.86	283.475	0.0%
22-1	K_V/K_H Weathered Tangier & Moose River Members	4.05	286.674	1.1%
22-2	K_V/K_H Weathered Tangier & Moose River Members	0.81	283.464	-
22-3	K_V/K_H Weathered Tangier & Moose River Members	0.162	285.789	0.8%
23-1	K_V/K_H Weathered Moose River Member	1.5	283.628	0.1%
23-2	K_V/K_H Weathered Moose River Member	0.3	283.464	-
23-3	K_V/K_H Weathered Moose River Member	0.06	283.647	0.1%
24-1	K_V/K_H Competent Cunard Member	5	280.134	-1.2%
24-2	K_V/K_H Competent Cunard Member	1	283.464	-
24-3	K_V/K_H Competent Cunard Member	0.2	297.089	4.8%
25-1	K_V/K_H Competent Beaverbank Member	1.7	282.689	-0.3%
25-2	K_V/K_H Competent Beaverbank Member	0.34	283.464	-
25-3	K_V/K_H Competent Beaverbank Member	0.068	283.991	0.2%
26-1	K_V/K_H Competent Taylor's Head Member	5	283.454	0.0%
26-2	K_V/K_H Competent Taylor's Head Member	1	283.464	-
26-3	K_V/K_H Competent Taylor's Head Member	0.2	283.504	0.0%
27-1	K_V/K_H Competent Tangier & Moose River Members	4.2	288.148	1.7%
27-2	K_V/K_H Competent Tangier & Moose River Members	0.84	283.464	-
27-3	K_V/K_H Competent Tangier & Moose River Members	0.168	287.640	1.5%
28-1	K_V/K_H Competent Moose River Member	2.65	283.314	0.0%
28-2	K_V/K_H Competent Moose River Member	0.53	283.464	-
28-3	K_V/K_H Competent Moose River Member	0.106	283.777	0.1%

5.0 MODEL APPLICATIONS

The calibrated groundwater flow model was used to quantify baseline groundwater levels and flow and groundwater discharge to the receiving environment under baseline conditions. The baseline condition is defined as the conditions that exist prior to disposal of Beaver Dam tailings into the Touquoy open pit, i.e., the conditions associated with the fully dewatered open pit at Touquoy. The baseline model results were then used to compare to model predictions for the end of operation (i.e, the completion of placement of Beaver Dam tailings into the Touquoy open pit), during closure (i.e., the filling of the remainder of the Touquoy open pit with water), and after post-closure (i.e., after the Touquoy pit is full of water).

Section 5.1 presents the results from the existing conditions simulation using the calibrated model. Model modifications completed to allow simulation of the other phases of the Beaver Dam project, including baseline conditions when the Touquoy open pit is fully dewatered, operating conditions as the pit is filled with Beaver Dam tailings, and the post-closure phase following the filling of the open pit are discussed in Sections 5.2 to 5.4.

5.1 EXISTING CONDITIONS

5.1.1 Model Setup

The existing conditions for the Touquoy mine site, excluding the effects of the Touquoy project components are prepared from the calibrated flow model. The existing conditions are presented to evaluate the relative changes for drawdown comparisons for the Beaver Dam operations at the Touquoy mine site.

5.1.2 Results

The water table elevation under existing conditions from the calibrated groundwater flow model are shown on Figure 5.1. The model provides a good representation of groundwater flow conditions with groundwater in the area of the open pit flowing from the water table high near east of the pit toward Moose River.

The model was used to estimate the groundwater discharge to Moose River and its tributaries upstream of surface water monitoring location SW-2. The net baseflow to Moose River at SW-2 is simulated to be 23,348 m^3/d, which represents 22% of the mean annual flow estimated to be 1.23 m^3/s (106,580 m^3/d) at this location. The baseflow rate is used to quantify changes to groundwater discharge during the baseline, operation and closure phases, as presented in Sections 5.2 to 5.4.

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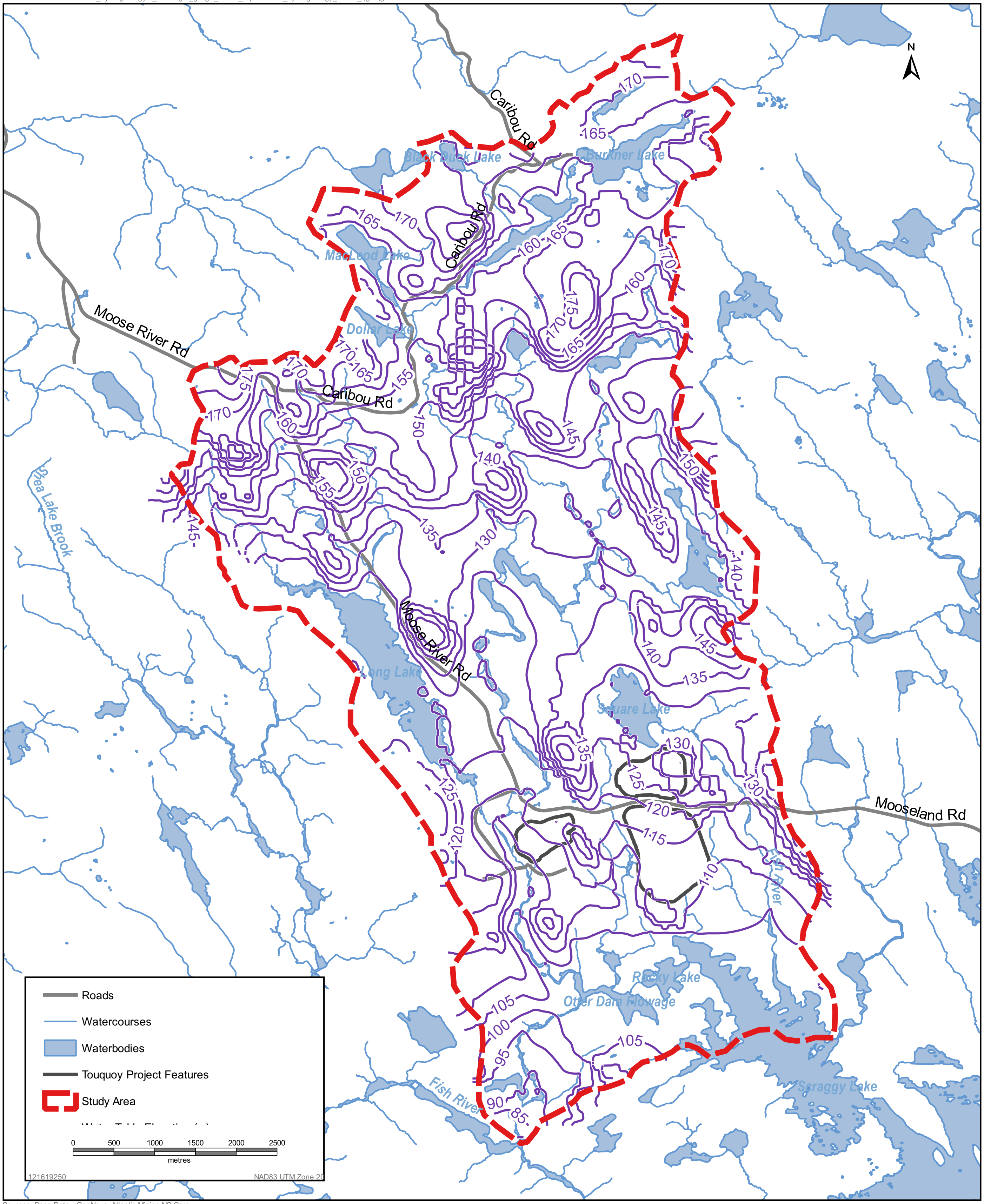


Sources: Base Data - GeoNova, Atlantic Mining NS Corp.

Water Table Elevation Contours under Existing Conditions

Stantec

Beaver Dam Gold Project

Figure 5.1

5.2 BASELINE CONDITIONS

5.2.1 Model Setup

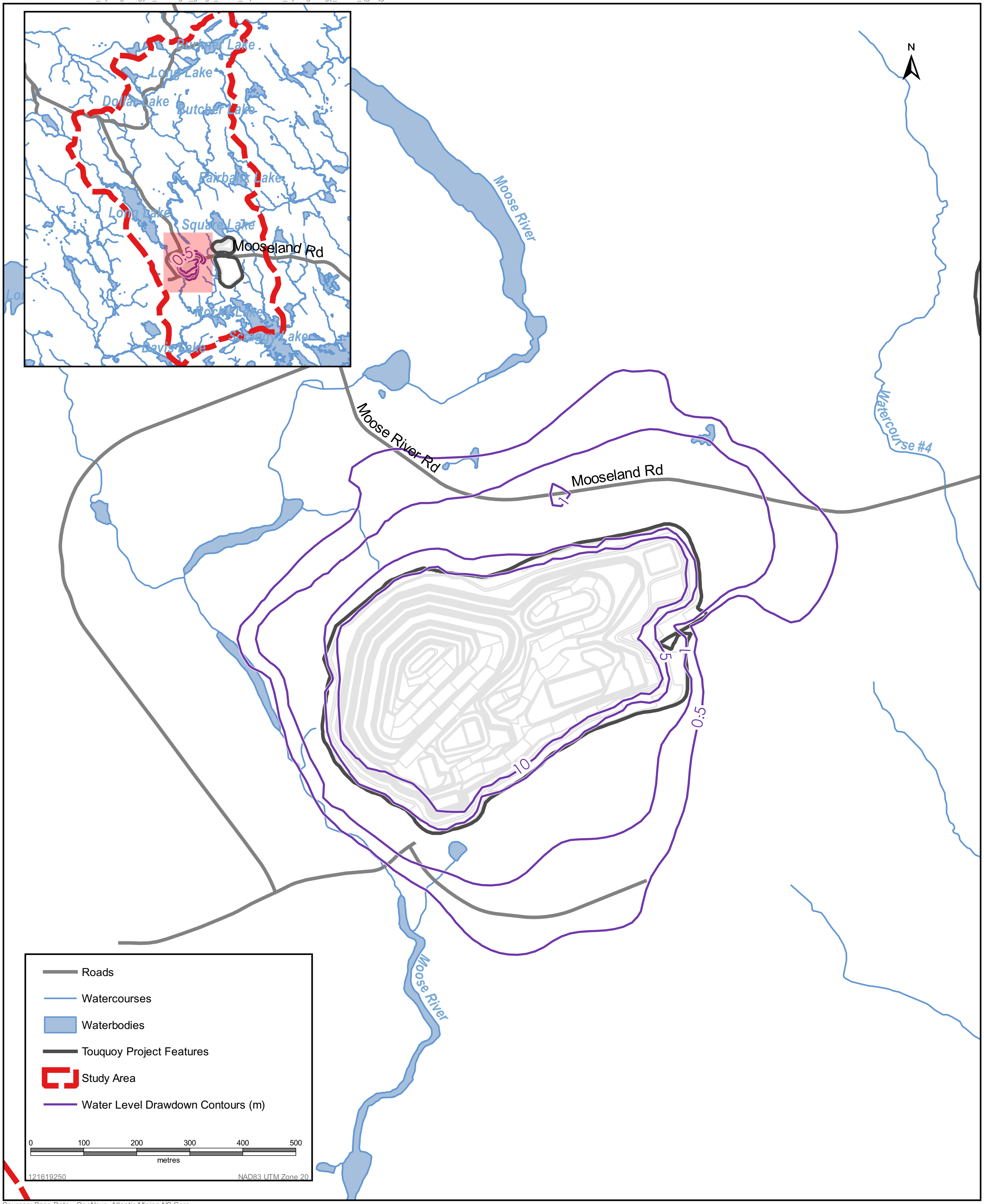
Baseline conditions for the operation of the Touquoy open pit as a tailings management area will not be the existing conditions, but to the conditions when the pit has been completely dewatered. Model cells that were intersected by the walls or floor of the open pit were identified and assigned as a seepage face boundary condition in the model. The seepage face was assigned using the MODFLOW DRAIN package at these locations. Model cells that were located above the DRAIN cells within the footprint of the open pit were set as inactive cells.

The conductance of the DRAIN cells was specified based on the hydraulic conductivity in the cells multiplied by the width, length and thickness of the cell. Blasting effects on the hydraulic conductivity of the bedrock were assumed to be localized to the first 5 m of the exposed bedrock face, coinciding with the width of the drain cells, and were incorporated as part of the conductance value for the drains. While increased inflows due to storage in the aquifer material and the slightly higher hydraulic gradients during the initial dewatering period may be expected, the use of the multiple steady-state model runs is expected to reduce this potential effect and the model will provide a good long-term representation of groundwater inflows over the life of mine.

5.2.2 Results

Groundwater inflows to the open pit under the baseline (fully dewatered) conditions are simulated to be 475 m^3/d. The predicted steady-state groundwater drawdown contours for baseline conditions are presented on Figure 5.2. The extent of the drawdown cone, as delineated by the 0.5 m drawdown contour, extends approximately 350 m south of the site and about 50 m west of the site toward Moose River.

The net baseflow to Moose River at SW-2 under baseline conditions is simulated to be 23,166 m^3/d. Compared to the existing conditions, the dewatering of the open pit is anticipated to reduce the baseflow in Moose River at SW-2 by 282 m^3/d. This accounts for approximately 0.2% of the mean annual flow at Moose River.



Sources: Base Data - GeoNova, Atlantic Mining NS Corp.

Drawdown at Baseline Conditions (Fully Dewatered Pit)

Stantec

Beaver Dam Gold Project

Figure 5.2

5.3 OPERATION

5.3.1 Model Setup

The operation of the Touquoy open pit as a tailings management area for the Beaver Dam Tailings will result in the deposition of tailings and associated tailings slurry water to the open pit. As the pit fills, the dewatering rate to the open pit will decrease. The groundwater inflow to the open pit after dewatering is terminated was simulated to provide estimated volumes for use in the water balance model. Groundwater inflow was simulated by adjusting the stage of the DRAIN cells representing the seepage faces described in Section 5.1, and the addition of tailings to layers below those stages. The stage of the water level forming a pit lake was specified at intervals corresponding to the model layer thicknesses over the entire depth of the open pit.

5.3.2 Results

The predicted inflow rates to the Touquoy open pit compared to the pit lake stage are presented on Figure 5.3. As shown on the figure, the inflow rates decrease from 475 m^3/d when the pit stage elevation is at -25 m asl, to 251 m^3/d at a pit stage of 108 m asl, at which point the pit lake will overflow to Moose River through a constructed spillway.

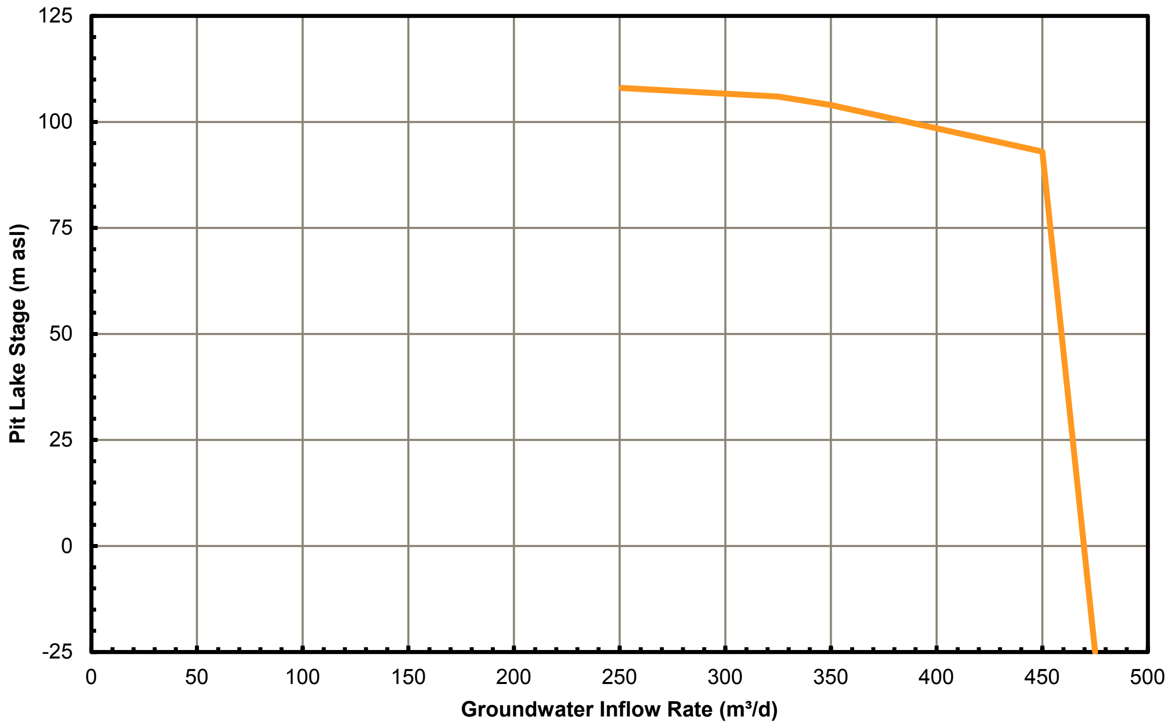


Figure 5.3 Simulated Groundwater Inflow Rates by Pit Lake Stage

The predicted steady-state groundwater drawdown contours for the pit full conditions are presented on Figure 5.4. The extent of the drawdown cone, as delineated by the 0.5 m drawdown contour, extends approximately 350 m south of the site and about 50 m west of the site toward Moose River. As presented on Figure 5.4, the groundwater flow to the open pit remains at 251 m^3/d because the 108 m asl level is below the natural groundwater elevation within the footprint of the open pit. However, at this elevation, there are both groundwater inflows to and outflows from the open pit that are not observed with the fully dewatered open pit where no outflows are observed and the inflow condition dominates.

The net baseflow to Moose River at SW-2 under pit full conditions is simulated to be 23,240 m^3/d. Compared to the existing conditions, the dewatering of the open pit is anticipated to reduce the baseflow in Moose River at SW-2 by 208 m^3/d. This accounts for less than 0.2% of the mean annual flow at Moose River at SW-2.

5.4 POST-CLOSURE

5.4.1 Model Setup

The disposal of tailings from Beaver Dam in the Touquoy open pit has the potential to degrade the water quality in the open pit. This water can then be released to the receiving environment through groundwater and degrade the water quality elsewhere. Therefore, the potential receptors of water in the Touquoy open pit was simulated by use of a solute transport model (MT3DMS).

The model was used to simulate the release of water from the pore spaces in the deposited tailings, and the pit lake quality based on a relative concentration basis. This process simulates the transport of a conservative solute with a source concentration of 1 mg/L through the groundwater to the receiving environment over time.

The solute transport model was set up using the transport parameters shown on Table 5.1. Porosity for each geologic material is based on the mid-range of expected values from the literature. Dispersivity is assumed based on the spatial scale of solute transport. The solute is assumed to have the diffusion coefficient of chloride, a conservative tracer.

The water quality associated with the tailings pore water was prepared by Lorax Environmental Services (Lorax 2018), based on this assumption that the Beaver Dam tailings would have the same characteristics as Touquoy based on the general rock characteristics, and that the tailings will be produced by the same mill at the Touquoy site. The source terms for various parameters of concern prepared by Lorax are presented on Table 5.2. These source terms are multiplied by the relative concentrations generated by the model to estimate the mass loading and average concentrations of groundwater discharging to surface water receptors.

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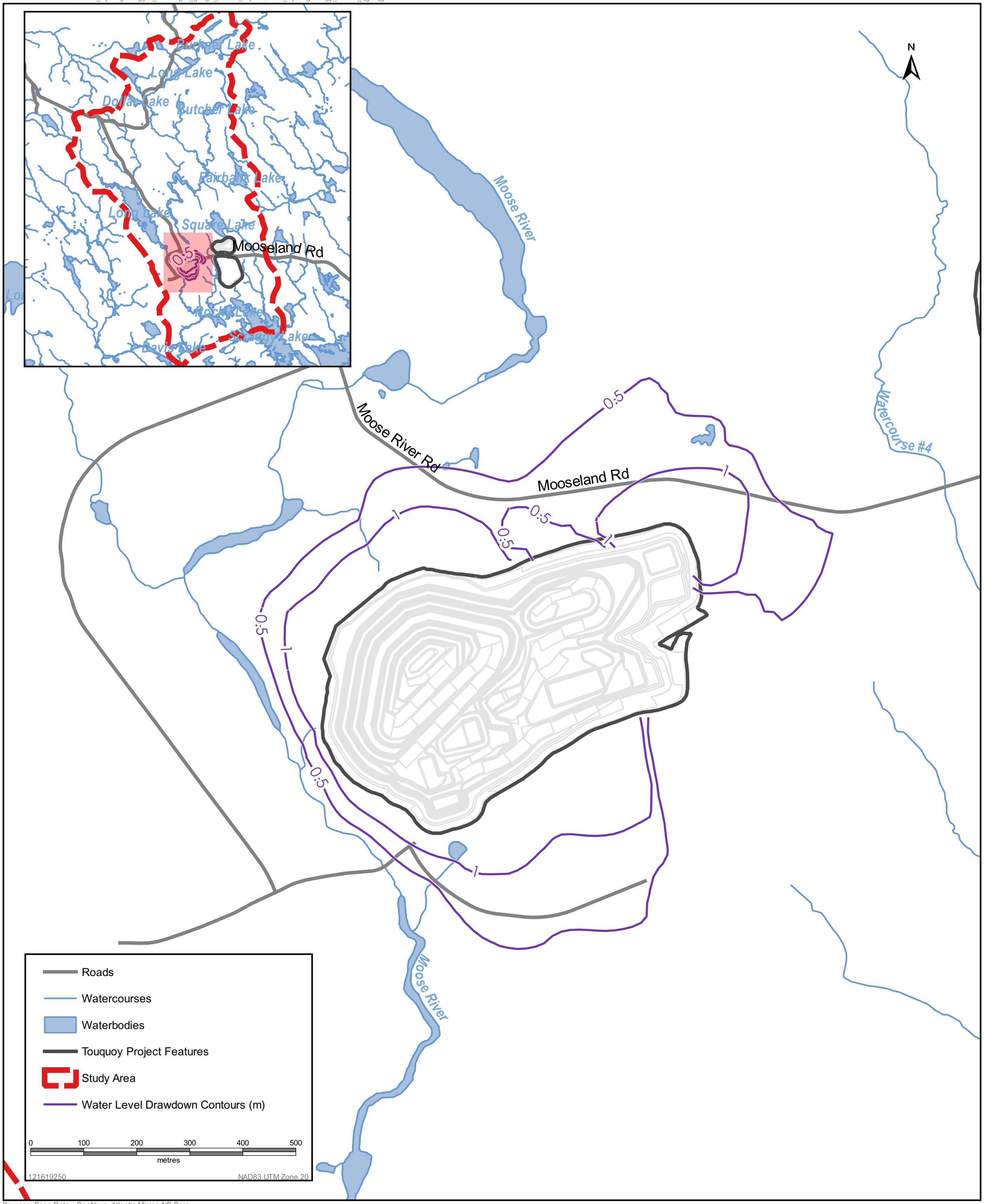


Sources: Base Data - GeoNova, Atlantic Mining NS Corp.

Drawdown at End of Beaver Dam Operations (Pit Lake Full)

Stantec

Beaver Dam Gold Project

Figure 5.4

Table 5.1 Assigned and calibrated solute transport model parameter values

Parameter	Assigned Value
Porosity	
Overburden Units	0.3
Weathered Bedrock Units	0.1
Competent Bedrock	0.05
Tailings	0.3
Longitudinal Dispersivity, Transverse and Vertical Dispersivity (m)	
All Geologic Media	5, 1
Solute Species	
Diffusion Coefficient[1] (m^2/s)	1.4×10^{-9}

Notes:

1. Diffusion coefficient is the product of the free-water diffusion coefficient (2.8×10^{-9} m^2/s for chloride) and an assumed value of tortuosity (0.5).

5.4.1.1 Sensitivity of Solute Transport to Mapped Faults

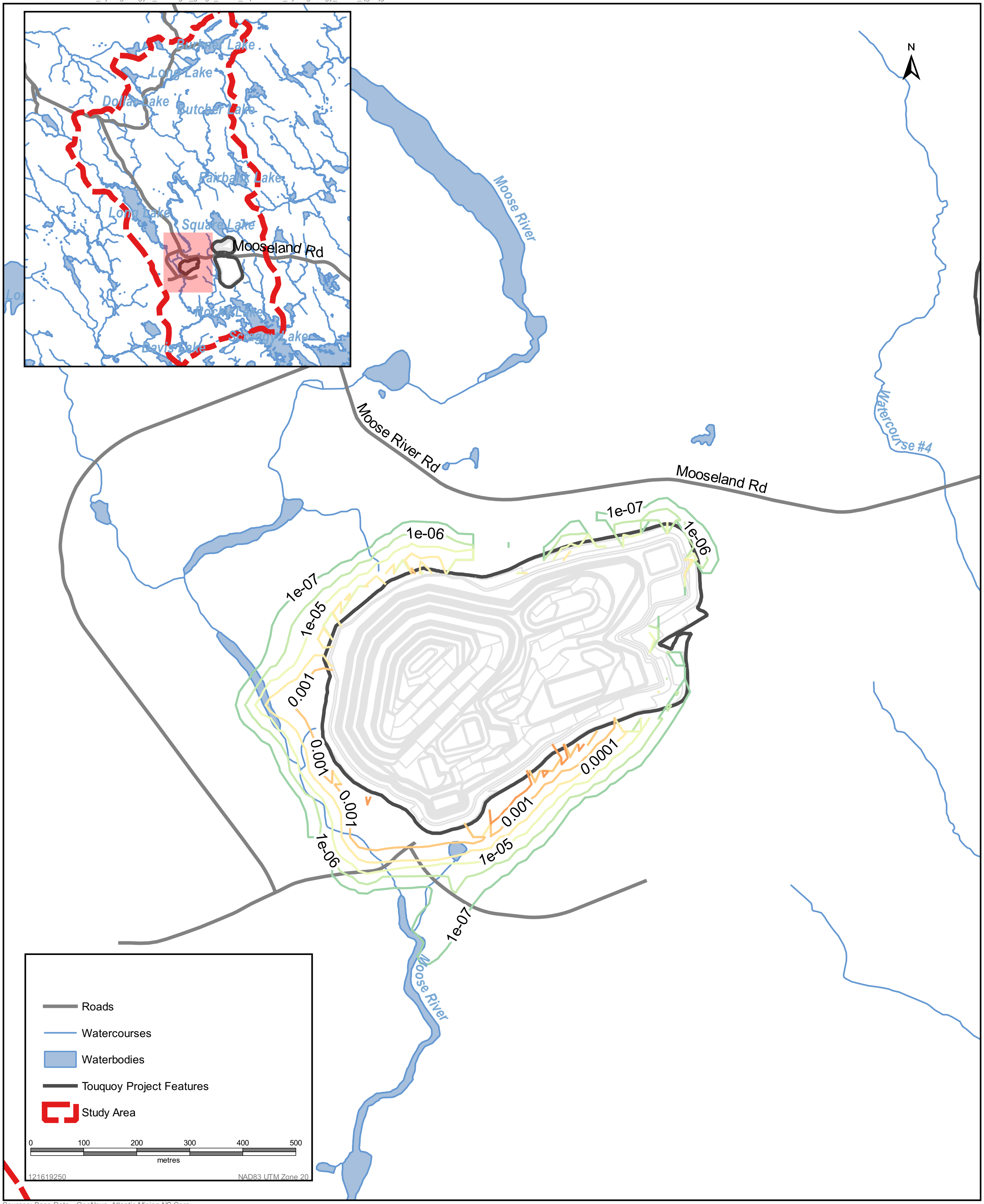
Several mapped faults were identified on Figure 2.4. As discussed in Section 3.3.2, the hydrogeologic properties of the faults have not been characterized. As the groundwater flow model was able to calibrate without assigning differing properties in the faults compared to the native bedrock, it is predicted that the bulk properties of the hydraulic conductivity in the bedrock units from the model are appropriate, as discussed in Section 4.2.

In order to assess the potential impacts from the faults on the predicted water quality loadings to Moose River, the groundwater flow model was modified to include these fault features. The hydraulic conductivity of the fault alignments presented on Figure 2.4 was assigned to be an order of magnitude higher and an order of magnitude lower than the native bedrock, and the flow and transport simulations were re-run to predict the extent of the plume originating from the open pit.

5.4.2 Results

The predicted relative concentrations in groundwater originating from the filled open pit are presented on Figures 5.5 to 5.7. The relative concentrations are multiplied by the source term concentrations for the parameters of primary concern in the open pit to predict the concentrations and mass loadings to the receiving environment over time. The distributions of the concentrations after 60 years are shown on Figure 5.6, after 150 years on Figure 5.7, and after 300 years on Figure 5.8. These relative concentrations were multiplied by the source term concentrations for the various parameters of concern provided by Lorax (2018) to estimate the mass loading to, and average concentration in, Moose River over time, as shown on Tables 5.2 and 5.3, respectively.

The average concentrations of arsenic discharged to Moose River over the 500-year simulation period are shown on Figure 5.8. As shown on the figure, the average concentrations of arsenic (and other parameters) in the discharge to the river stabilize after about 150 years.



Sources: Base Data - GeoNova, Atlantic Mining NS Corp.

Relative Concentration Contours in Groundwater 60 Years Following Pit Lake at Stage 108 m

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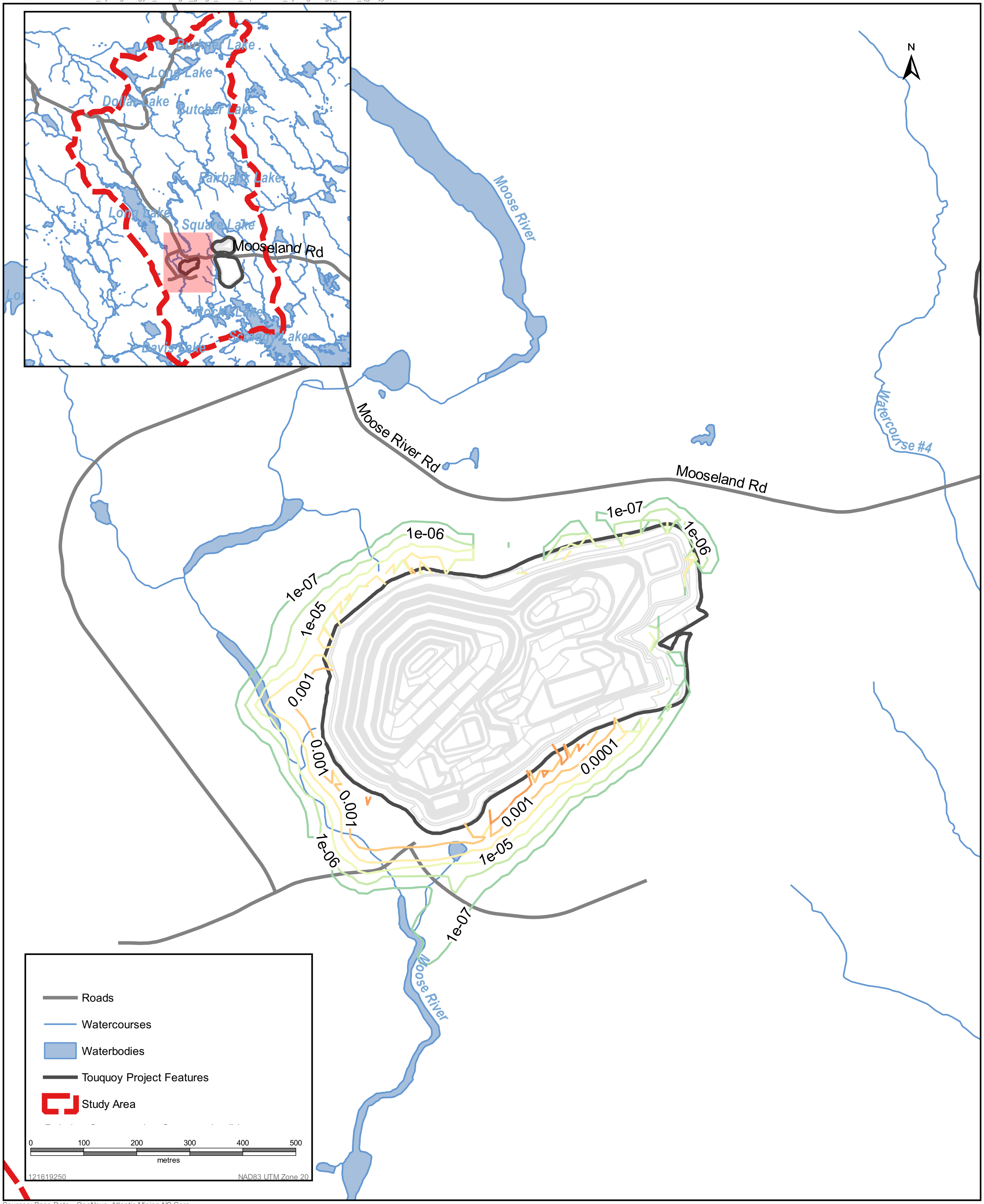
Beaver Dam Gold Project

Figure 5.5



Sources: Base Data - GeoNova, Atlantic Mining NS Corp.

Relative Concentration Contours in Groundwater 150 Years Following Pit Lake at Stage 108 m

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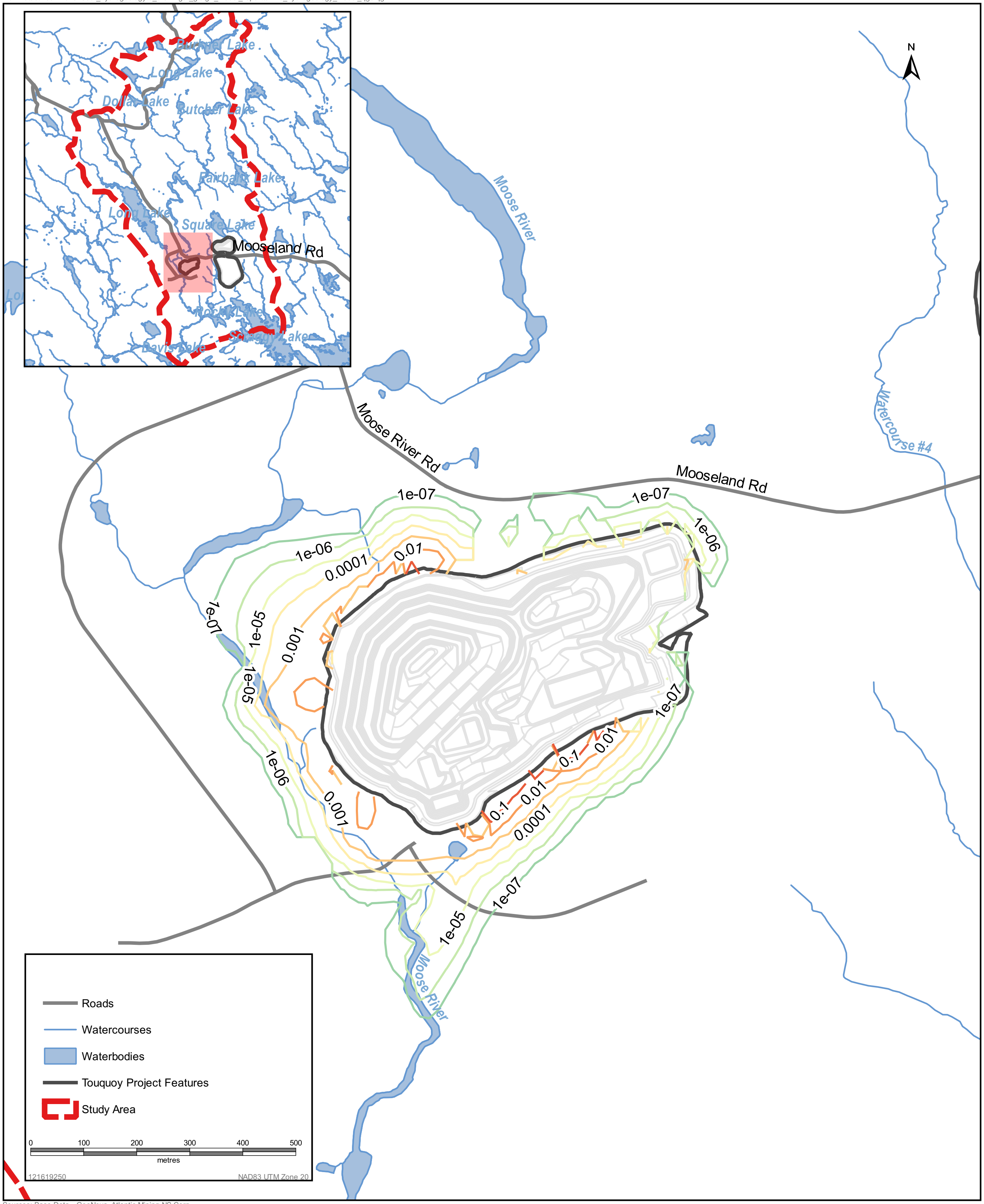
Figure 5.6



Sources: Base Data - GeoNova, Atlantic Mining NS Corp.

Relative Concentration Contours in Groundwater 500 Years Following Pit Lake at Stage 108 m

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Beaver Dam Gold Project

Figure 5.7

Table 5.2 Predicted Mass Loading to Moose River from Groundwater

Parameter	Source Term Concentration (mg/L)	Mass Loading (g/d)			
Elapsed Time (years)		5	60	150	500
Sulphate	897	8.87	194	304	438
Aluminum	0.0469	0.000464	0.0102	0.0159	0.0229
Silver	0.00001	9.89E-08	0.00000217	0.00000339	0.00000488
Arsenic	3.07	0.0303	0.665	1.04	1.5
Calcium	86.9	0.859	18.8	29.4	42.4
Cadmium	0.00002	0.000000198	0.00000433	0.00000677	0.00000977
Cobalt	0.0262	0.000259	0.00568	0.00887	0.0128
Chromium	0.0002	0.00000198	0.0000433	0.0000677	0.0000977
Copper	0.00937	0.0000926	0.00203	0.00317	0.00458
Iron	0.0326	0.000322	0.00706	0.011	0.0159
Mercury	0.000005	4.94E-08	0.00000108	0.00000169	0.00000244
Magnesium	14.8	0.146	3.21	5.01	7.23
Manganese	0.37	0.00366	0.0802	0.125	0.181
Molybdenum	0.0603	0.000596	0.0131	0.0204	0.0295
Nickel	0.00685	0.0000677	0.00148	0.00232	0.00335
Lead	0.0000248	0.000000245	0.00000537	0.0000084	0.0000121
Tin	0.00604	0.0000597	0.00131	0.00205	0.00295
Selenium	0.000193	0.00000191	0.0000418	0.0000654	0.0000943
Tellurium	0.0000154	0.000000152	0.00000334	0.00000522	0.00000752
Uranium	0.00203	0.0000201	0.00044	0.000688	0.000991
Zinc	0.0096	0.0000949	0.00208	0.00325	0.00469
WAD CN	0.005	0.0000494	0.00108	0.00169	0.00244
Total CN	0.087	0.00086	0.0188	0.0295	0.0425
Nitrate (as N)	0.053	0.000524	0.0115	0.0179	0.0259
Nitrite (as N)	0.11	0.00109	0.0238	0.0373	0.0537
Ammonia	34	0.336	7.37	11.5	16.6

Table 5.3 Predicted Average Groundwater Concentration Discharging to Moose River

Parameter	Source Term Concentration (mg/L)	Average Concentration (mg/L)			
Elapsed Time (years)		5	60	150	500
Sulphate	897	0.0234	0.626	0.852	0.857
Aluminum	0.0469	0.00000122	0.0000327	0.0000446	0.0000448
Silver	0.00001	2.61E-10	6.98E-09	9.5E-09	9.56E-09
Arsenic	3.07	0.00008	0.00214	0.00292	0.00293
Calcium	86.9	0.00226	0.0607	0.0826	0.0831
Cadmium	0.00002	5.21E-10	0.000000014	0.000000019	1.91E-08
Cobalt	0.0262	0.000000683	0.0000183	0.0000249	0.000025
Chromium	0.0002	5.21E-09	0.00000014	0.00000019	0.000000191
Copper	0.00937	0.000000244	0.00000654	0.0000089	0.00000896
Iron	0.0326	0.00000085	0.0000228	0.000031	0.0000312
Mercury	0.000005	1.3E-10	3.49E-09	4.75E-09	4.78E-09
Magnesium	14.8	0.000386	0.0103	0.0141	0.0141
Manganese	0.37	0.00000964	0.000258	0.000352	0.000354
Molybdenum	0.0603	0.00000157	0.0000421	0.0000573	0.0000576
Nickel	0.00685	0.000000179	0.00000478	0.00000651	0.00000655
Lead	0.0000248	6.46E-10	1.73E-08	2.36E-08	2.37E-08
Tin	0.00604	0.000000157	0.00000422	0.00000574	0.00000577
Selenium	0.000193	5.03E-09	0.000000135	0.000000183	0.000000184
Tellurium	0.0000154	4.01E-10	1.07E-08	1.46E-08	1.47E-08
Uranium	0.00203	5.29E-08	0.00000142	0.00000193	0.00000194
Zinc	0.0096	0.00000025	0.0000067	0.00000912	0.00000918
Weak Acid Dissociable Cyanide	0.005	0.00000013	0.00000349	0.00000475	0.00000478
Total Cyanide	0.087	0.00000227	0.0000607	0.0000827	0.0000832
Nitrate (as N)	0.053	0.00000138	0.000037	0.0000504	0.0000507
Nitrite (as N)	0.11	0.00000287	0.0000768	0.000105	0.000105
Ammonia (as N)	34	0.000886	0.0237	0.0323	0.0325

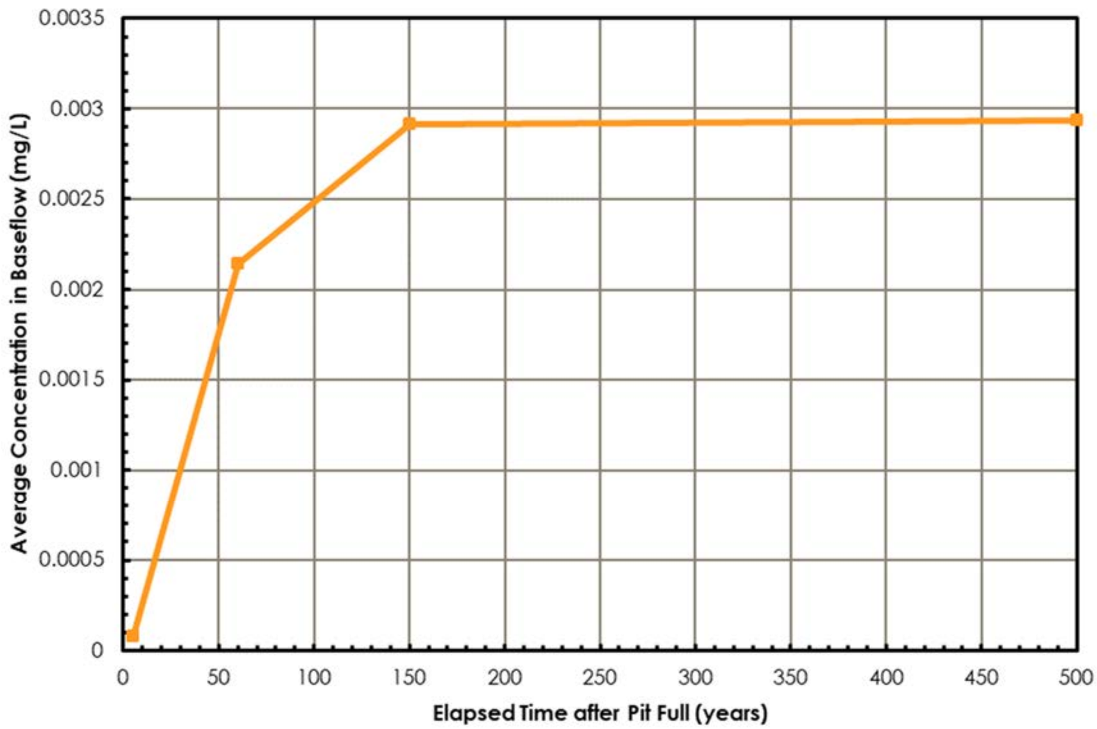

Figure 5.8 Simulated average concentrations of arsenic discharged to Moose River in groundwater seepage

The mass loading and average concentration of the parameters of concern listed in Tables 5.2 and 5.3 are combined with surface water concentrations and discharges from the open pit to predict the water quality in Moose River, as detailed in Stantec (2019).

5.4.2.1 Sensitivity of Solute Transport to Mapped Faults

Two simulations were conducted to assess the sensitivity of the solute transport model to the potential hydraulic conductivity of the mapped faults. The first scenario considered the faults to be 10 times more permeable than the native bedrock, and the results are discussed below. A second scenario considered the faults to be 10 times less permeable than the native bedrock. However, this scenario failed to generate a converged flow solution, indicating that it is unlikely for the faults to be less permeable at this site. Therefore, the model sensitivity only considered increased permeability of the faults.

The predicted relative concentrations in groundwater originating from the filled open pit with faults simulated are presented on Figure 5.9 and Figure 5.10 for 5 and 500 years following the filling of the open pit, respectively. As shown on Figure 5.9, the addition of higher permeability faults indicates that solute transport may proceed more quickly to Moose River than simulated in the case without higher permeability faults. As shown on Figure 5.10, if the faulting continues to the southeast with relatively higher permeability, there is the potential for the water quality in the open pit to affect water quality in Watercourse #4 in addition to Moose River.

Based on the sensitivity of the mapped faults to the predicted water quality in Moose River and Watercourse #4, additional testing of the hydraulic conductivity of the faults is recommended to assess the actual permeabilty of the faults compared to the native bedrock. The development of management, mitigation and contingency plans should therefore consider the potential for higher permeability faulting in the absence of this testing.

5.5 PREDICTION CONFIDENCE

The approach used in model simulations completed for this Project was to incorporate conservative assumptions for predicting effects that may result from the Project. This report presents the assumptions made in developing these conservative predictions and discusses the high-level confidence of these predictions.

The modelling was conducted using an EPM approach. As discussed in Section 4.0, this is appropriate based on the regional scale of the modelling, and considering that flow was predicted to occur primarily through the shallow weathered bedrock, which is highly fractured, and therefore behaves like a porous medium.

The groundwater flow modelling was conducted using a model calibrated to water levels, and baseflow targets to establish baseline conditions. Predictions made using the model are based on several conservative assumptions to reduce the influence of uncertainty in the predictions. Therefore, the confidence in the predictions made using the model is considered high.

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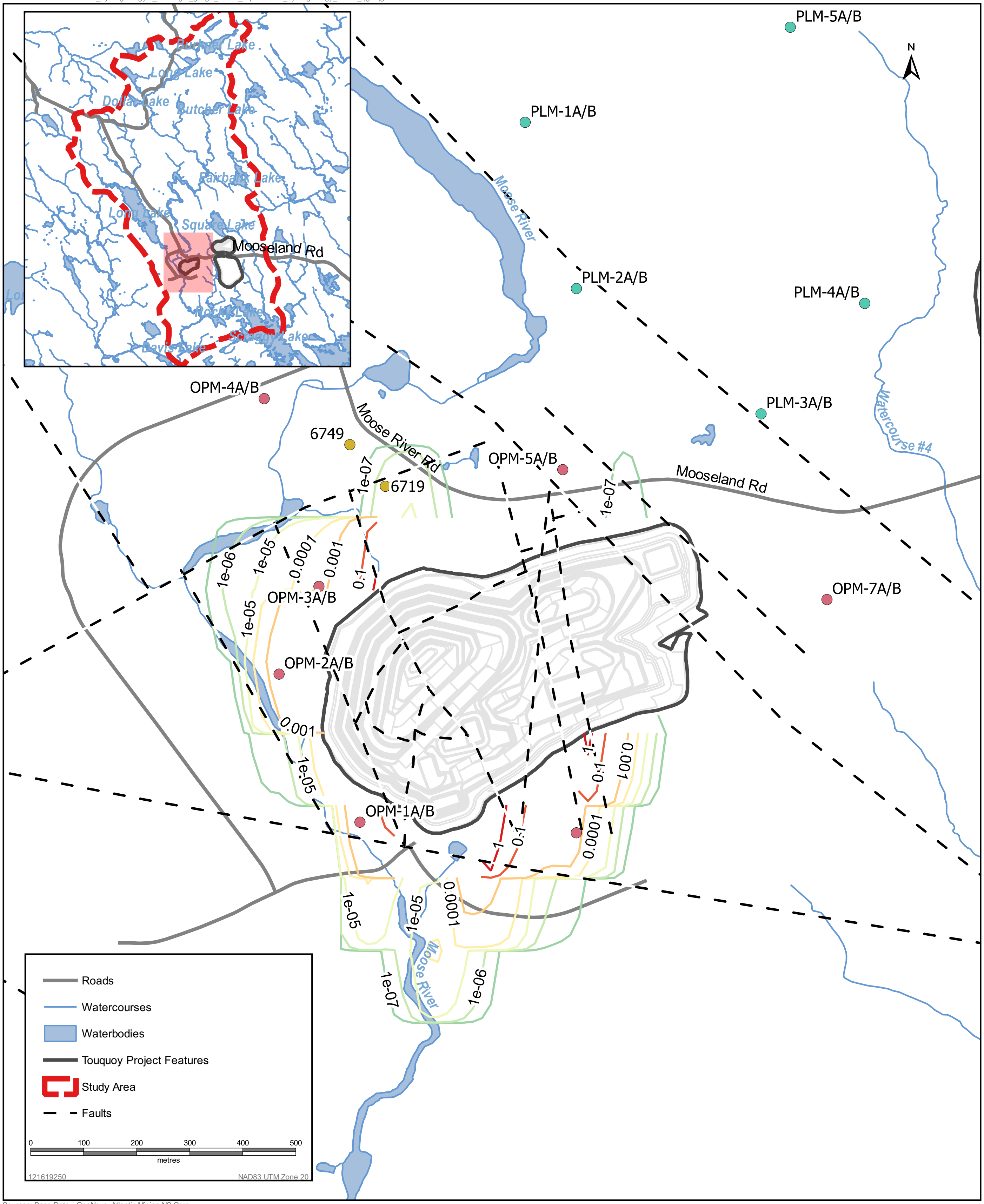


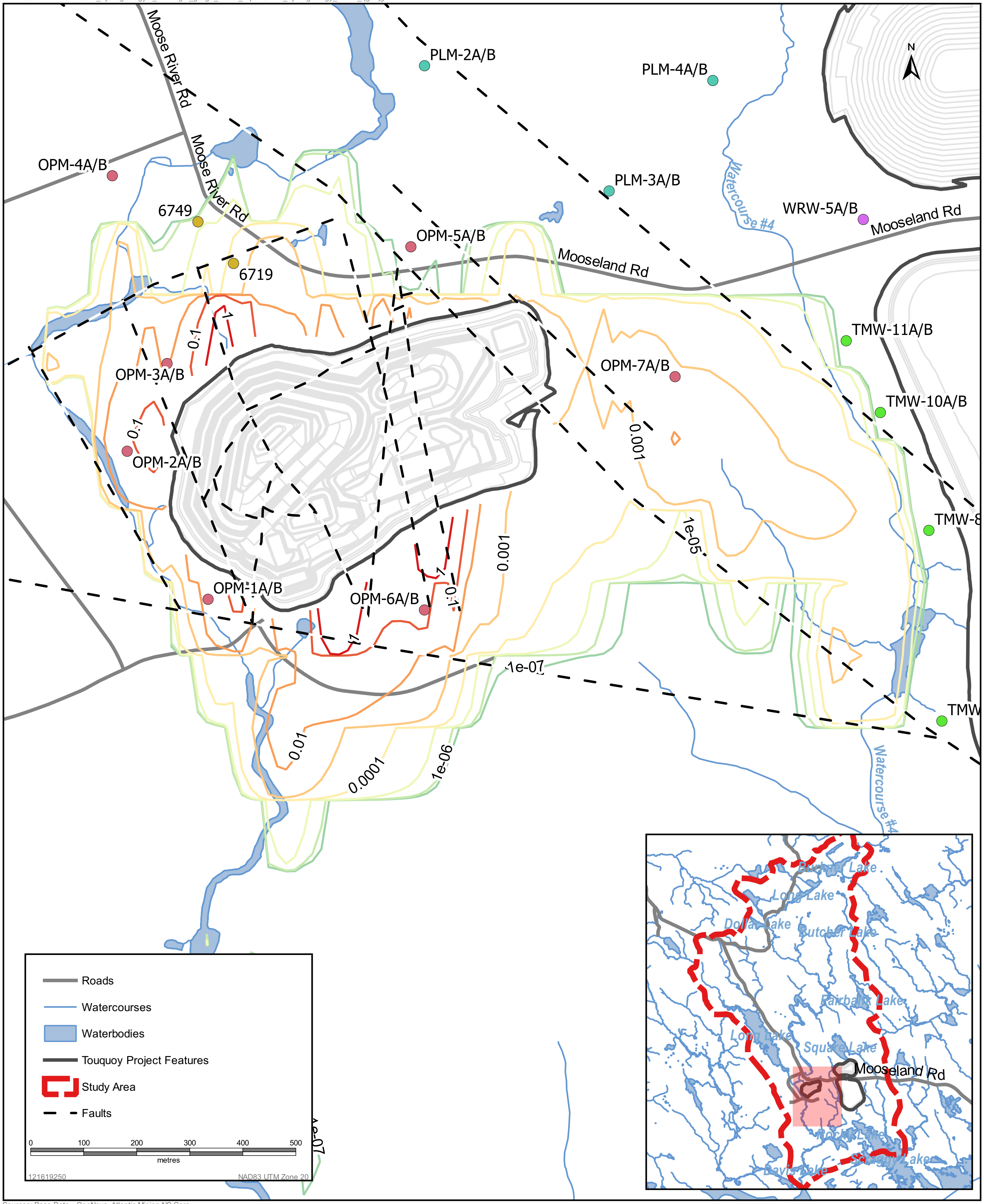
Sources: Base Data - GeoNova, Atlantic Mining NS Corp.

Relative Concentration Contours in Groundwater with High Permeability Faults 5 Years Following Pit Lake at Stage 108 m

Stantec

Beaver Dam Gold Project

Figure 5.9



Sources: Base Data - GeoNova, Atlantic Mining NS Corp.

Relative Concentration Contours in Groundwater with High Permeability Faults 500 Years Following Pit Lake at Stage 108 m

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Figure 5.10

6.0 CONCLUSIONS

A three-dimensional steady-state groundwater flow model and solute transport model was constructed using MODFLOW to simulate current groundwater conditions in the Study Area, baseline conditions (i.e., when Beaver Dam operations begin at the Touquoy mine site), changes to groundwater inflows during operations (i.e., when the Beaver Dam tailings are filling the open pit), and to evaluate potential changes to water quality in the receiving environment due to the subaqueous disposal of tailings in the Touquoy pit post-closure (i.e., when the pit is full). The model was prepared using a conceptual model and hydrostratigraphic framework developed from regional and site-specific data, and assumed homogeneous properties within the units. A good calibration of model parameters was obtained, as evaluated by comparing simulated and observed groundwater levels and estimated baseflow. The parameter values for hydraulic conductivity are similar to those obtained from other analyses of field observations.

At baseline, the open pit will be fully dewatered, and is simulated to intercept groundwater seepage at a rate of 475 m^3/d. The extent of the corresponding drawdown cone, as delineated by the 0.5 m drawdown contour, extends approximately 350 m south of the site and about 50 m west of the site toward Moose River. The inflow to the open pit decreases as it is filled with tailings and water during Beaver Dam operations, until the open pit stage reaches the maximum level of 108 m asl. At this stage, the groundwater seepage decreases to 251 m^3/d, and the corresponding drawdown cone is about the same as the baseline condition. Groundwater baseflow to Moose River is reduced by less than 1% in all cases.

Upon the filling of the open pit to its ultimate lake stage at 108 m asl, groundwater flow is anticipated to flow from the pit to Moose River through the glacial till and weathered fractured bedrock. Solute transport in this case is dominated by advection (movement with the flow of groundwater). Solute transport modelling using the calibrated model simulates a slow migration of solutes to Moose River, with concentrations approaching a steady state after about 150 years of travel. Mass loadings for various parameters of concern are simulated by the model for inclusion in a surface water mixing model of Moose River (Stantec 2019).

The presence of preferential pathways, such as fractures and faults not characterized in previous field assessment, were assessed with sensitivity analyses in the model to predict the potential migration of solutes from pit into the receiving environment. The results of the sensitivity analyses indicated that should the faults have higher hydraulic conductivity, solute transport to Moose River would occur more quickly, and would also be predicted extend to Watercourse #4. Therefore the potential for higher permeability faults should be considered in the development of management, mitigation and contingency plans.

The groundwater flow and solute transport modelling was conducted with the best available information on the hydrogeologic conditions at the Touquoy site. However, it is recommended that the following data gaps be addressed to improve the reliability of the predictions made with the model:

- Confirm the faults in the Study Area have the same hydraulic characteristics as the native bedrock.
- Test Beaver Dam tailings to confirm assumptions on their similarity to the characteristics of the Touquoy tailings.
- Perform geochemical testing of water quality in the Touquoy Pit lake to predict the concentrations of potential compounds of concern in the open pit lake. These data could then be simulated to predict actual concentrations to the receiving environment.

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ATLANTIC GOLD

Appendix G.1

Surface Water Baseline Analytical Results

Table 1: General Chemistry

		CCME FAL	MMER	MDMER	SW-1									
Sampling Date					**9-Oct-14**	**13-Nov-14**	**18-Dec-14**	**22-Jan-15**	**22-Jan-15**	**29-Apr-15**	**28-May-15**	**30-Jun-15**	**29-Jul-15**	**24-Aug-15**
Calculated Parameters	**Units**								SW-1D (DUP)					
Anion Sum	me/L				0.140	0.170	0.100	0.120	0.120	0.060	0.0900	0.0800	0.0800	0.100
Bicarb. Alkalinity (calc. as CaCO3)	mg/L				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Calculated TDS	mg/L				14	16	10	12	13	6	8.0	9.0	10	12
Carb. Alkalinity (calc. as CaCO3)	mg/L				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cation Sum	me/L				0.290	0.290	0.190	0.210	0.210	0.110	0.160	0.170	0.180	0.230
Hardness (CaCO3)	mg/L				5.5	5.0	3.3	3.5	3.5	1.6	2.6	2.9	3.3	4.0
Ion Balance (% Difference)	%				34.9	26.1	31.0	27.3	27.3	29.4	28.0	36.0	38.5	39.4
Langelier Index (@ 20C)	N/A				NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Langelier Index (@ 4C)	N/A				NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Nitrate (N)	mg/L	**2.935**			<0.050	0.061	<0.050	0.087	0.080	0.052	<0.050	0.062	0.051	<0.050
Saturation pH (@ 20C)	N/A				NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Saturation pH (@ 4C)	N/A				NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Inorganics														
Total Alkalinity (Total as CaCO3)	mg/L				<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Dissolved Chloride (Cl)	mg/L				5.1	5.8	3.4	4.0	4.2	1.9	3.1	2.6	2.8	3.7
Colour	TCU				150	160	99	83	100	85	110	170	160	230
Nitrate + Nitrite	mg/L				<0.050	0.061	<0.050	0.087	0.080	0.052	<0.050	0.062	0.051	<0.050
Nitrite (N)	mg/L	**0.06**			<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nitrogen (Ammonia Nitrogen)	mg/L	**Varies(1)**			<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.10	<0.050	<0.050	<0.050
Total Organic Carbon (C)	mg/L				13	18	8.2	7.0	7.5	6.3	7.5	12	12	11 (1)
Orthophosphate (P)	mg/L				<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
pH	pH	**6.5-9**	**6-9.5**	**6-9.5**	5.55	4.59	5.23	4.87	4.91	5.19	5.85	6.00	5.57	5.59
Reactive Silica (SiO2)	mg/L				2.5	3.9	2.7	3.8	4.0	1.9	1.1	2.1	2.6	3.2
Dissolved Sulphate (SO4)	mg/L				<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Turbidity	NTU				1.1	0.64	0.59	0.62	0.69	0.76	1.1	1.2	1.1	1.2
Conductivity	uS/cm				30	33	25	27	27	14	16	17	18	21
Total Suspended Solids					-	-	-	-	-	-	-	-	-	-
Field Parameters														
Temperature	°C				15.57	8	4.2	0.16	-	3.62	19.14	19.69	19.90	-
Conductivity	μS/cm				39	36	26.7	25	-	16	22	24	-	-
Total Dissolved Solids	g/L				0.031	0.035	-	0.029	-	-	-	-	-	-
Dissolved Oxygen	mg/L	**5.5-9.5(2)**			9.99	14.31	13.32	37.9	-	14.97	10.63	9.6	-	-
pH		**6.5-9**	**6-9.5**	**6-9.5**	3.97	2.63	4.1	2.89	-	6.48	5.25	5.49	5.3	-

Notes

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(2) Dissolved oxygen - lowest acceptable concentration ranges from 5.5 mg/L for warm water biota at other life stages to 9.5 mg/L for cold water biota at early life stages (see CCME Summary Table).

- denotes not analyzed

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Table 1: General Chemistry

		CCME FAL	MMER	MDMER	SW-2A										
Sampling Date					**9-Oct-14**	**13-Nov-14**	**18-Dec-14**	**18-Dec-14**	**22-Jan-15**	**29-Apr-15**	**28-May-15**	**28-May-15**	**30-Jun-15**	**29-Jul-15**	**24-Aug-15**
Calculated Parameters	**Units**							SW-2AD (DUP)				SW-2AD (DUP)			
Anion Sum	me/L				0.150	0.180	0.100	0.110	0.130	0.0500	0.0900	0.0900	0.0800	0.0800	0.100
Bicarb. Alkalinity (calc. as CaCO3)	mg/L				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Calculated TDS	mg/L				14	17	10	10	13	6.0	7.0	7.0	8.0	9.0	12
Carb. Alkalinity (calc. as CaCO3)	mg/L				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cation Sum	me/L				0.290	0.300	0.180	0.180	0.210	0.110	0.140	0.140	0.160	0.180	0.220
Hardness (CaCO3)	mg/L				5.1	4.9	2.9	2.8	3.4	1.4	2.1	2.0	2.6	2.9	3.6
Ion Balance (% Difference)	%				31.8	25.0	28.6	24.1	23.5	37.5	21.7	21.7	33.3	38.5	37.5
Langelier Index (@ 20C)	N/A				NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Langelier Index (@ 4C)	N/A				NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Nitrate (N)	mg/L	**2.935**			0.11	0.065	<0.050	<0.050	0.079	<0.050	<0.050	<0.050	0.055	<0.050	<0.050
Saturation pH (@ 20C)	N/A				NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Saturation pH (@ 4C)	N/A				NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Inorganics															
Total Alkalinity (Total as CaCO3)	mg/L				<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Dissolved Chloride (Cl)	mg/L				5.0	6.3	3.6	3.8	4.2	1.6	3.1	3.1	2.8	2.8	3.7
Colour	TCU				160	160	100	100	110	96	120	120	170	180	230
Nitrate + Nitrite	mg/L				0.11	0.065	<0.050	<0.050	0.079	<0.050	<0.050	<0.050	0.055	<0.050	<0.050
Nitrite (N)	mg/L	**0.06**			<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nitrogen (Ammonia Nitrogen)	mg/L	**Varies(1)**			<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.052	<0.050	<0.050	<0.050	0.084
Total Organic Carbon (C)	mg/L				14	19	8.9	9.1	7.4	5.5	7.9	8.1	12	13	14 (1)
Orthophosphate (P)	mg/L				<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
pH	pH	**6.5-9**	**6-9.5**	**6-9.5**	5.06	4.54	4.88	4.75	4.75	5.08	5.59	5.36	5.29	5.26	5.16
Reactive Silica (SiO2)	mg/L				2.7	3.9	2.8	2.7	3.7	1.9	1.1	1.1	1.9	2.6	3.2
Dissolved Sulphate (SO4)	mg/L				<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Turbidity	NTU				1.1	0.50	0.59	0.23	0.70	0.29	1.5	1.4	0.99	0.97	1.9
Conductivity	uS/cm				31	33	25	25	28	13	16	15	17	19	21
Total Suspended Solids					-	-	-	-	-	-	-	-	-	-	-
Field Parameters															
Temperature	°C				13.57	7.89	4.2	-	0.27	3.34	20.64	-	18.81	21.2	-
Conductivity	µS/cm				38	37	27.4	-	25	16	23	-	24	-	-
Total Dissolved Solids	g/L				0.031	0.036	-	-	0.03			-		-	-
Dissolved Oxygen	mg/L	**5.5-9.5(2)**			8.97	13.07	12.88	-	36.14	15.35	9.91	-	9.18	-	-
pH		**6.5-9**	**6-9.5**	**6-9.5**	4.09	3.08	3.75	-	3.56	6.53	4.63	-	4.00	4.94	-

Notes

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Table 1: General Chemistry

		CCME FAL	MMER	MDMER	SW-4A									
Sampling Date					**9-Oct-14**	**13-Nov-14**	**13-Nov-14**	**18-Dec-14**	**22-Jan-15**	**29-Apr-15**	**28-May-15**	**30-Jun-15**	**29-Jul-15**	**24-Aug-15**
Calculated Parameters	**Units**						SW-4AD (DUP)		No Sample					
Anion Sum	me/L				0.150	0.180	0.180	0.110		0.0400	0.110	0.0700	0.0700	0.110
Bicarb. Alkalinity (calc. as CaCO3)	mg/L				<1.0	<1.0	<1.0	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0
Calculated TDS	mg/L				15	16	16	11		6.0	9.0	8.0	9.0	12
Carb. Alkalinity (calc. as CaCO3)	mg/L				<1.0	<1.0	<1.0	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0
Cation Sum	me/L				0.300	0.300	0.300	0.200		0.120	0.180	0.170	0.190	0.230
Hardness (CaCO3)	mg/L				5.9	5.6	5.6	3.5		1.6	3.1	3.0	3.6	3.9
Ion Balance (% Difference)	%				33.3	25.0	25.0	29.0		50.0	24.1	41.7	46.2	35.3
Langelier Index (@ 20C)	N/A				NC	NC	NC	NC		NC	NC	NC	NC	NC
Langelier Index (@ 4C)	N/A				NC	NC	NC	NC		NC	NC	NC	NC	NC
Nitrate (N)	mg/L	**2.935**			0.093	0.062	<0.050	<0.050		<0.050	<0.050	0.064	<0.050	<0.050
Saturation pH (@ 20C)	N/A				NC	NC	NC	NC		NC	NC	NC	NC	NC
Saturation pH (@ 4C)	N/A				NC	NC	NC	NC		NC	NC	NC	NC	NC
Inorganics														
Total Alkalinity (Total as CaCO3)	mg/L				<5.0	<5.0	<5.0	<5.0		<5.0	<5.0	<5.0	<5.0	<5.0
Dissolved Chloride (Cl)	mg/L				5.0	6.2	6.4	3.9		1.3	3.8	2.2	2.6	3.7
Colour	TCU				120	130	130	88		100	130	160	170	260
Nitrate + Nitrite	mg/L				0.093	0.062	<0.050	<0.050		<0.050	<0.050	0.064	<0.050	<0.050
Nitrite (N)	mg/L	**0.06**			<0.010	<0.010	<0.010	<0.010		<0.010	<0.010	<0.010	<0.010	<0.010
Nitrogen (Ammonia Nitrogen)	mg/L	**Varies(1)**			<0.050	<0.050	<0.050	<0.050		0.073	0.092	<0.050	<0.050	<0.050
Total Organic Carbon (C)	mg/L				9.3	16	16	8.2		5.5	9.7	12	18	14 (1)
Orthophosphate (P)	mg/L				<0.010	<0.010	<0.010	<0.010		<0.010	<0.010	<0.010	<0.010	<0.010
pH	pH	**6.5-9**	**6-9.5**	**6-9.5**	5.57	4.76	4.71	4.96		5.14	5.74	5.42	5.09	4.93
Reactive Silica (SiO2)	mg/L				3.4	3.5	3.6	2.9		2.5	1.5	2.0	2.3	3.0
Dissolved Sulphate (SO4)	mg/L				<2.0	<2.0	<2.0	<2.0		<2.0	<2.0	<2.0	<2.0	<2.0
Turbidity	NTU				1.4	0.68	0.65	0.80		0.38	1.4	1.3	0.81	1.0
Conductivity	uS/cm				29	31	31	24		15	18	17	19	21
Total Suspended Solids					-	-	-	-		-	-	-	-	-
Field Parameters														
Temperature	°C				10.85	8.98	-	5.1		5.98	22.45	20.72	22.4	-
Conductivity	μS/cm				34	35	-	24.9		31	27	32	-	-
Total Dissolved Solids	g/L				0.03	0.033	-	-		-	-	-	-	-
Dissolved Oxygen	mg/L	**5.5-9.5(2)**			7.11	10.4	-	7.82		13.48	7.88	6.8	-	-
pH		**6.5-9**	**6-9.5**	**6-9.5**	4.27	3.71	-	3.75		6.56	5.34	5.34	4.92	-

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Table 1: General Chemistry

		CCME FAL	MMER	MDMER	SW-5									
Sampling Date					**9-Oct-14**	**9-Oct-14**	**13-Nov-14**	**18-Dec-14**	**22-Jan-15**	**29-Apr-15**	**28-May-15**	**30-Jun-15**	**29-Jul-15**	**24-Aug-15**
Calculated Parameters	**Units**					SW-5D (DUP)								
Anion Sum	me/L				0.480	0.480	0.520	0.340	0.400	0.100	0.360	0.350	0.360	0.410
Bicarb. Alkalinity (calc. as CaCO3)	mg/L				14	14	11	6.1	8.0	<1.0	7.8	9.3	11	13
Calculated TDS	mg/L				28	28	33	23	27	12	21	21	21	25
Carb. Alkalinity (calc. as CaCO3)	mg/L				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cation Sum	me/L				0.480	0.470	0.510	0.340	0.430	0.240	0.350	0.350	0.340	0.420
Hardness (CaCO3)	mg/L				16	16	17	10	14	7.3	11	12	12	15
Ion Balance (% Difference)	%				0.00	1.05	0.970	0.00	3.61	41.2	1.41	0.00	2.86	1.20
Langelier Index (@ 20C)	N/A				(2.56)	(2.54)	-2.74	-3.79	-3.17	NC	-3.22	-3.00	-2.84	-2.55
Langelier Index (@ 4C)	N/A				(2.81)	(2.80)	-2.99	-4.04	-3.42	NC	-3.48	-3.26	-3.09	-2.80
Nitrate (N)	mg/L	**2.935**			0.10	0.15	0.051	0.094	0.096	0.870	<0.050	0.063	<0.050	0.055
Saturation pH (@ 20C)	N/A				9.43	9.46	9.52	10.0	9.77	NC	9.84	9.76	9.66	9.50
Saturation pH (@ 4C)	N/A				9.69	9.71	9.77	10.3	10.0	NC	10.1	10.0	9.92	9.75
Inorganics														
Total Alkalinity (Total as CaCO3)	mg/L				14	14	11	6.1	8.0	<5.0	7.8	9.3	11	13
Dissolved Chloride (Cl)	mg/L				4.0	4.1	5.2	4.0	5.0	1.5	3.4	1.9	1.7	2.2
Colour	TCU				22	23	26	30	23	28	27	23	24	37
Nitrate + Nitrite	mg/L				0.10	0.15	0.051	0.094	0.096	0.087	<0.050	0.063	<0.050	0.055
Nitrite (N)	mg/L	**0.06**			<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nitrogen (Ammonia Nitrogen)	mg/L	**Varies(1)**			<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.052	<0.050	<0.050
Total Organic Carbon (C)	mg/L				4.1	4.3	3.5	4.0	3.1	3.5	3.6	4.1	5.3	4.3
Orthophosphate (P)	mg/L				<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.011	<0.010	<0.010	0.011
pH	pH	**6.5-9**	**6-9.5**	**6-9.5**	6.88	6.92	6.78	6.23	6.60	6.14	6.62	6.76	6.83	6.95
Reactive Silica (SiO2)	mg/L				1.8	1.8	3.1	3.0	3.1	2.3	<0.50	0.92	0.77	2.5
Dissolved Sulphate (SO4)	mg/L				3.5	3.6	7.0	4.6	4.4	2.5	5.0	5.0	4.5	3.6
Turbidity	NTU				0.44	0.81	1.4	6.2	2.4	0.69	1.2	0.83	0.91	1.2
Conductivity	uS/cm				48	47	49	35	45	28	34	35	32	40
Total Suspended Solids					-	-	-	-	-	-	-	-	-	-
Field Parameters														
Temperature	°C				13.98	-	7.76	4.6	1.75	2.7	20.84	20.51	22.4	-
Conductivity	μS/cm				53	-	49	35.7	36	27	40	40	-	-
Total Dissolved Solids	g/L				0.044	-	0.048	-	0.041	-	-	-	-	-
Dissolved Oxygen	mg/L	**5.5-9.5(2)**			8.26	-	15.04	13.08	39.05	14.95	8.59	9.13	-	-
pH		**6.5-9**	**6-9.5**	**6-9.5**	5.46	-	4.61	5.94	4.8	6.67	6.56	6.34	6.39	-

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Table 1: General Chemistry

		CCME FAL	MMER	MDMER	SW-6A									
Sampling Date					**9-Oct-14**	**13-Nov-14**	**18-Dec-14**	**22-Jan-15**	**29-Apr-15**	**28-May-15**	**30-Jun-15**	**30-Jun-15**	**29-Jul-15**	**24-Aug-15**
Calculated Parameters	**Units**								No Sample			SW-6AD (DUP)		
Anion Sum	me/L				0.130	0.160	0.110	0.120		0.0700	0.0700	0.0700	0.0700	0.100
Bicarb. Alkalinity (calc. as CaCO3)	mg/L				<1.0	<1.0	<1.0	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0
Calculated TDS	mg/L				13	15	11	12		7.0	7.0	7.0	8.0	12
Carb. Alkalinity (calc. as CaCO3)	mg/L				<1.0	<1.0	<1.0	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0
Cation Sum	me/L				0.240	0.270	0.190	0.210		0.140	0.170	0.160	0.170	0.240
Hardness (CaCO3)	mg/L				4.5	5.0	3.5	3.9		2.5	2.8	2.8	3.2	4.4
Ion Balance (% Difference)	%				29.7	25.6	26.7	27.3		33.3	41.7	39.1	41.7	41.2
Langelier Index (@ 20C)	N/A				NC	NC	NC	NC		NC	NC	NC	NC	NC
Langelier Index (@ 4C)	N/A				NC	NC	NC	NC		NC	NC	NC	NC	NC
Nitrate (N)	mg/L	**2.935**			0.080	<0.050	<0.050	<0.050		<0.050	0.053	0.059	<0.050	<0.050
Saturation pH (@ 20C)	N/A				NC	NC	NC	NC		NC	NC	NC	NC	NC
Saturation pH (@ 4C)	N/A				NC	NC	NC	NC		NC	NC	NC	NC	NC
Inorganics														
Total Alkalinity (Total as CaCO3)	mg/L				<5.0	<5.0	<5.0	<5.0		<5.0	<5.0	<5.0	<5.0	<5.0
Dissolved Chloride (Cl)	mg/L				4.3	5.8	3.8	4.2		2.5	2.2	2.2	2.4	3.5
Colour	TCU				80	99	87	82		88	140	130	140	220
Nitrate + Nitrite	mg/L				0.080	<0.050	<0.050	<0.050		<0.050	0.053	0.059	<0.050	<0.050
Nitrite (N)	mg/L	**0.06**			<0.010	<0.010	<0.010	<0.010		<0.010	<0.010	<0.010	<0.010	<0.010
Nitrogen (Ammonia Nitrogen)	mg/L	**Varies(1)**			<0.050	<0.050	<0.050	<0.050		<0.050	0.22	<0.050	<0.050	<0.050
Total Organic Carbon (C)	mg/L				9.1	13	8.1	8.9		7.3	10	11	13	12 (1)
Orthophosphate (P)	mg/L				<0.010	<0.010	<0.010	<0.010		<0.010	<0.010	<0.010	<0.010	<0.010
pH	pH	**6.5-9**	**6-9.5**	**6-9.5**	5.73	5.05	5.13	5.09		5.76	5.79	5.64	5.50	5.37
Reactive Silica (SiO2)	mg/L				3.3	3.5	2.8	3.4		1.1	1.3	1.2	1.6	2.7
Dissolved Sulphate (SO4)	mg/L				<2.0	<2.0	<2.0	<2.0		<2.0	<2.0	<2.0	<2.0	<2.0
Turbidity	NTU				0.30	0.69	0.42	0.44		0.43	0.65	1.1	0.49	0.54
Conductivity	uS/cm				25	28	24	25		16	16	16	16	20
Total Suspended Solids					-	-	-	-		-	-	-	-	-
Field Parameters														
Temperature	°C				10.98	8.04	4.6	1.15		17.4	18.09	-	20.4	-
Conductivity	μS/cm				31	32	25.7	23		34	22	-	-	-
Total Dissolved Solids	g/L				0.028	0.032	-	0.027		-	-	-	-	-
Dissolved Oxygen	mg/L	**5.5-9.5(2)**			8.88	14.49	12.01	42.34		10.89	9.17	-	-	-
pH		**6.5-9**	**6-9.5**	**6-9.5**	3.56	3.43	4.49	3.98		5.72	8.73	-	5.02	-

Notes

CCME FAL - Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Freshwater Aquatic Life (provided for reference)

MMER - Federal Metal Mining Effluent Regulations - guidelines shown represent maximum authorized concentrations in a grab sample (provided for reference)

MDMER - Federal Metal and Diamond Mining Effluent Regulations - guidelines shown represent maximum authorized concentration in a grab sample (provided for reference)

(1) Ammonia guideline dependent on temperature and pH, *e.g.* , if T = 10°C, guideline for total ammonia-N varies from 83.88 mg/L at pH = 6.0 to 0.02 mg/L at pH = 10 (see CCME Fact Sheet).

(2) Dissolved oxygen - lowest acceptable concentration ranges from 5.5 mg/L for warm water biota at other life stages to 9.5 mg/L for cold water biota at early life stages (see CCME Summary Table).

- denotes not analyzed

NC = not calculated

Table 1: General Chemistry

		CCME FAL	MMER	MDMER	SW-9									
Sampling Date					**9-Oct-14**	**13-Nov-14**	**18-Dec-14**	**22-Jan-15**	**29-Apr-15**	**28-May-15**	**30-Jun-15**	**29-Jul-15**	**29-Jul-15**	**24-Aug-15**
Calculated Parameters	**Units**												SW-9 (DUP)	
Anion Sum	me/L				0.310	0.200	0.140	0.180	0.100	0.170	0.130	0.250	0.250	0.150
Bicarb. Alkalinity (calc. as CaCO3)	mg/L				5.8	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.6	5.5	<1.0
Calculated TDS	mg/L				23	17	12	16	9	13	13	18	18	15
Carb. Alkalinity (calc. as CaCO3)	mg/L				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cation Sum	me/L				0.420	0.340	0.230	0.290	0.180	0.260	0.310	0.330	0.340	0.330
Hardness (CaCO3)	mg/L				10	6.4	4.1	5.0	2.8	4.7	7.4	8.0	8.2	7.5
Ion Balance (% Difference)	%				15.1	25.9	24.3	23.4	28.6	20.9	40.9	13.8	15.3	37.5
Langelier Index (@ 20C)	N/A				(4.22)	NC	NC	NC	NC	NC	NC	-3.90	-3.83	NC
Langelier Index (@ 4C)	N/A				(4.47)	NC	NC	NC	NC	NC	NC	-4.16	-4.08	NC
Nitrate (N)	mg/L	**2.935**			0.091	<0.050	<0.050	0.051	<0.050	<0.050	<0.050	0.064	<0.050	<0.050
Saturation pH (@ 20C)	N/A				10.2	NC	NC	NC	NC	NC	NC	10.3	10.3	NC
Saturation pH (@ 4C)	N/A				10.4	NC	NC	NC	NC	NC	NC	10.5	10.5	NC
Inorganics														
Total Alkalinity (Total as CaCO3)	mg/L				5.8	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.6	5.5	<5.0
Dissolved Chloride (Cl)	mg/L				6.7	7.2	4.8	6.2	3.4	6.1	4.8	4.8	4.9	5.4
Colour	TCU				160	140	110	73	82	80	150	130	130	180
Nitrate + Nitrite	mg/L				0.091	<0.050	<0.050	0.051	<0.050	<0.050	<0.050	0.064	<0.050	<0.050
Nitrite (N)	mg/L	**0.06**			<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nitrogen (Ammonia Nitrogen)	mg/L	**Varies(1)**			<0.050	<0.050	<0.050	<0.050	0.082	<0.050	0.14	<0.050	<0.050	<0.050
Total Organic Carbon (C)	mg/L				17	18	8.9	7.0	6.1	6.7	12	12	12	11 (1)
Orthophosphate (P)	mg/L				<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
pH	pH	**6.5-9**	**6-9.5**	**6-9.5**	5.94	4.96	5.06	5.44	5.77	6.17	6.33	6.36	6.43	6.05
Reactive Silica (SiO2)	mg/L				3.2	3.1	2.4	3.5	1.6	1.5	2.2	2.7	2.6	2.3
Dissolved Sulphate (SO4)	mg/L				<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Turbidity	NTU				1.5	0.74	0.49	0.77	1.0	0.72	0.99	1.0	0.93	0.82
Conductivity	uS/cm				39	35	27	32	19	29	29	30	30	29
Total Suspended Solids					-	-	-	-	-	-	-	-	-	-
Field Parameters														
Temperature	°C				16.03	7.84	4	0.07	2.72	20.69	18.96	20.3	-	-
Conductivity	μS/cm				47	36	28.2	26	20	34	34	-	-	-
Total Dissolved Solids	g/L				0.037	0.037	-	0.033		-	-	-	-	-
Dissolved Oxygen	mg/L	**5.5-9.5(2)**			9.82	12.85	12.34	21.9	15.27	10.89	9.9	-	-	-
pH		**6.5-9**	**6-9.5**	**6-9.5**	4.90	3.17	4.66	3.68	6.6	5.72	8.04	6.14	-	-

Notes

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MMER - Federal Metal Mining Effluent Regulations - guidelines shown represent maximum authorized concentrations in a grab sample (provided for reference)

MDMER - Federal Metal and Diamond Mining Effluent Regulations - guidelines shown represent maximum authorized concentration in a grab sample (provided for reference)

(1) Ammonia guideline dependent on temperature and pH, *e.g.* , if T = 10°C, guideline for total ammonia-N varies from 83.88 mg/L at pH = 6.0 to 0.02 mg/L at pH = 10 (see CCME Fact Sheet).

(2) Dissolved oxygen - lowest acceptable concentration ranges from 5.5 mg/L for warm water biota at other life stages to 9.5 mg/L for cold water biota at early life stages (see CCME Summary Table).

- denotes not analyzed

NC = not calculated

Table 1: General Chemistry

		CCME FAL	MMER	MDMER	SW-10				SW-11	SW-12
Sampling Date					**30-Jun-15**	**29-Jul-15**	**24-Aug-15**	**24-Aug-15**	**5-Oct-17**	**Oct-5-2017**
Calculated Parameters	**Units**							SW-10 (DUP)		
Anion Sum	me/L				0.450	0.580	0.770	0.780	0.150	0.130
Bicarb. Alkalinity (calc. as CaCO3)	mg/L				8.0	11	25	25	<1.0	<1.0
Calculated TDS	mg/L				32	39	55	55	15	13
Carb. Alkalinity (calc. as CaCO3)	mg/L				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cation Sum	me/L				0.450	0.510	0.960	0.960	0.250	0.230
Hardness (CaCO3)	mg/L				15	20	30	30	4.9	4.1
Ion Balance (% Difference)	%				0.00	6.42	11.0	10.3	25.0	27.8
Langelier Index (@ 20C)	N/A				-3.05	-3.09	-2.67	-2.60	NC	NC
Langelier Index (@ 4C)	N/A				-3.31	-3.35	-2.92	-2.85	NC	NC
Nitrate (N)	mg/L	**2.935**			0.060	0.070	<0.050	<0.050	<0.050	<0.050
Saturation pH (@ 20C)	N/A				9.70	9.46	8.91	8.91	NC	NC
Saturation pH (@ 4C)	N/A				9.96	9.71	9.16	9.16	NC	NC
Inorganics										
Total Alkalinity (Total as CaCO3)	mg/L				8.0	11	25	25	<5.0	<5.0
Dissolved Chloride (Cl)	mg/L				2.9	2.2	2.9	3.1	5.3	4.6
Colour	TCU				9.4	<5.0	100	110	230 (1)	170 (1)
Nitrate + Nitrite	mg/L				0.060	0.070	<0.050	<0.050	<0.050	<0.050
Nitrite (N)	mg/L	**0.06**			<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nitrogen (Ammonia Nitrogen)	mg/L	**Varies(1)**			<0.050	<0.050	0.10	0.19	<0.050	<0.050
Total Organic Carbon (C)	mg/L				2.1	1.8	7.6	7.4	24 (1)	23.0
Orthophosphate (P)	mg/L				<0.010	0.012	0.064	0.064	<0.010	<0.010
pH	pH	**6.5-9**	**6-9.5**	**6-9.5**	6.65	6.37	6.24	6.31	5.65	5.30
Reactive Silica (SiO2)	mg/L				4.7	6.0	7.0	7.0	3.9	3.5
Dissolved Sulphate (SO4)	mg/L				9.6	14	8.8	8.9	<2.0	<2.0
Turbidity	NTU				1.0	<0.10	10	8.3	1.3	0.67
Conductivity	uS/cm				46	54	75	76	34	35
Total Suspended Solids					-	-	-	-	-	-
Field Parameters										
Temperature	°C				14.14	17.6	-	-	-	-
Conductivity	µS/cm				51	-	-	-	-	-
Total Dissolved Solids	g/L				-	-	-	-	-	-
Dissolved Oxygen	mg/L	**5.5-9.5(2)**			11.8	-	-	-	-	-
pH		**6.5-9**	**6-9.5**	**6-9.5**	6.55	5.88	-	-	-	-

Notes

CCME FAL - Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Freshwater Aquatic Life (provided for reference)

MMER - Federal Metal Mining Effluent Regulations - guidelines shown represent maximum authorized concentrations in a grab sample (provided for reference)

MDMER - Federal Metal and Diamond Mining Effluent Regulations - guidelines shown represent maximum authorized concentration in a grab sample (provided for reference)

(1) Ammonia guideline dependent on temperature and pH, *e.g.* , if T = 10°C, guideline for total ammonia-N varies from 83.88 mg/L at pH = 6.0 to 0.02 mg/L at pH = 10 (see CCME Fact Sheet).

(2) Dissolved oxygen - lowest acceptable concentration ranges from 5.5 mg/L for warm water biota at other life stages to 9.5 mg/L for cold water biota at early life stages (see CCME Summary Table).

- denotes not analyzed

NC = not calculated

Table 2: Metals

		CCME FAL	Tier 1 EQS	MMER	MDMER	SW-1									
Sampling Date						**9-Oct-14**	**13-Nov-14**	**18-Dec-14**	**22-Jan-15**	**22-Jan-15**	**29-Apr-15**	**28-May-15**	**30-Jun-15**	**29-Jul-15**	**24-Aug-15**
Metals	**Units**									SW-1D (DUP)					
Total Aluminum (Al)	ug/L	**5 / 100(1)**	**5**			330	320	220	200	200	140	190	280	280	400
Total Antimony (Sb)	ug/L		**20**			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Arsenic (As)	ug/L	**5.0**	**5.0**	**1000**	**1000**	2.7	1.5	1.3	<1.0	<1.0	<1.0	2.6	2.5	3.7	1.3
Total Barium (Ba)	ug/L		**1000**			5.8	5.6	3.1	3.3	3.4	1.7	2.4	3.0	3.2	4.6
Total Beryllium (Be)	ug/L		**5.3**			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Bismuth (Bi)	ug/L					<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Boron (B)	ug/L	**1500**	**1200**			<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	**0.04 - 0.37(2)**	**0.01**			0.024	0.029	0.023	0.012	0.022	0.012	<0.010	0.028	0.014	0.022
Total Calcium (Ca)	ug/L					1200	1100	780	720	740	350	630	690	790	770
Total Chromium (Cr)	ug/L					<1.0	<1.0	<1.0	1.6	<1.0	<1.0	3.0	<1.0	<1.0	<1.0
Total Cobalt (Co)	ug/L		**10**			0.51	0.52	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	0.53
Total Copper (Cu)	ug/L	**2 - 4(3)**	**2**	**600**	**600**	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Iron (Fe)	ug/L	**300**	**300**			670	630	330	350	340	240	360	580	750	1000
Total Lead (Pb)	ug/L	**1 - 7(4)**	**1**	**400**	**400**	0.51	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.54	<0.50	0.57
Total Magnesium (Mg)	ug/L					590	560	330	400	410	170	240	290	310	420
Total Manganese (Mn)	ug/L		**820**			79	68	41	51	53	27	31	37	43	58
Total Mercury (Hg)	ug/L	**0.026**				<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	0.015	<0.013	<0.013	0.032
Total Molybdenum (Mo)	ug/L	**73**	**73**			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Nickel (Ni)	ug/L	**25 - 150(5)**	**25**	**1000**	**1000**	<2.0	<2.0	<2.0	<2.0	2.6	<2.0	<2.0	<2.0	<2.0	<2.0
Total Phosphorus (P)	ug/L					<100	<100	<100	<100	<100	<100	<100	150	170	140
Total Potassium (K)	ug/L					570	550	380	380	370	330	340	170	210	170
Total Selenium (Se)	ug/L	**1**	**1**			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Silver (Ag)	ug/L	**0.1**	**0.1**			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Sodium (Na)	ug/L					3100	3000	2100	2300	2400	1200	1800	1900	1900	2300
Total Strontium (Sr)	ug/L		**21000**			11.0	10	5.8	6.3	6.6	2.9	4.6	5.9	6.3	7.4
Total Thallium (Tl)	ug/L	**0.8**	**0.8**			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Tin (Sn)	ug/L					<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Titanium (Ti)	ug/L					3.8	3.2	3.3	2.4	2.2	3.2	2.7	3.7	3.7	5.0
Total Uranium (U)	ug/L	**15**	**300**			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Vanadium (V)	ug/L		**6**			<2.0	2.3	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Zinc (Zn)	ug/L	**30**	**30**	**1000**	**1000**	5.0	5.1	7.8	<5.0	<5.0	<5.0	6.8	<5.0	<5.0	<5.0

Notes

CCME FAL - Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Freshwater Aquatic Life (provided for reference)

Tier 1 EQS - Nova Scotia Environment Tier 1 Environmental Quality Standards for Freshwater Surface Water (provided for reference)

MMER - Federal Metal Mining Effluent Regulations - guidelines shown represent maximum authorized concentrations in a grab sample (provided for reference)

MDMER - Federal Metal and Diamond Mining Effluent Regulations - guidelines shown represent maximum authorized concentration in a grab sample (provided for reference)

(1) Aluminum guideline dependent on pH. Guideline is 5 ug/L if pH <6.5 and 100 ug/L if pH ≥ 6.5 (see CCME Summary Table).

(2) Cadmium guideline (updated for 2014) (µg/L) = $10^{(0.83(\log[\text{hardness}])-2.46)}$ for hardness between 17-280 mg/L $CaCO_3$ or a lower limit of 0.04 ug/L for hardness < 17mg/L or an upper limit of 0.37 ug/L for hardness >280 mg/L (see CCME Fact Sheet).

(3) Copper guideline based on sample hardness: copper guideline (µg/L) = $e^{0.8545[\ln(\text{hardness})]-1.465} * 0.2$ for hardness ≥82 to ≤180 mg/L, or a lower limit of 2 µg/L for hardness <82 mg/L and an upper limit of 4 µg/L for hardness >180 mg/L (see CCME Summary Table).

(4) Lead guideline based on sample hardness: lead guideline (µg/L) = $e^{1.273[\ln(\text{hardness})]-4.705}$ for hardness >60 to ≤180 mg/L, or a lower limit of 1 µg/L for hardness <60 mg/L and an upper limit of 7 µg/L for hardness >180 mg/L (see CCME Summary Table).

(5) Nickel guideline based on sample hardness: nickel guideline (µg/L) = $e^{0.76[\ln(\text{hardness})]+1.06}$ for hardness >60 to ≤180 mg/L, or a lower limit of 25 µg/L for hardness <60 mg/L and an upper limit of 150 µg/L for hardness >180 mg/L (see CCME Summary Table).

- denotes not analyzed

Table 2: Metals

		CCME FAL	Tier 1 EQS	MMER	MDMER	SW-2A										
Sampling Date						9-Oct-14	13-Nov-14	18-Dec-14	18-Dec-14	22-Jan-15	29-Apr-15	28-May-15	28-May-15	30-Jun-15	29-Jul-15	24-Aug-15
Metals	Units								SW-2AD (DUP)	.			SW-2AD (DUP)			
Total Aluminum (Al)	ug/L	5 / 100(1)	5			330	340	210	210	210	140	190	190	280	300	400
Total Antimony (Sb)	ug/L		20			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Arsenic (As)	ug/L	5.0	5.0	1000	1000	1.1	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	1.1	<1.0	1.5	1.3
Total Barium (Ba)	ug/L		1000			5.6	5.8	3.2	3.0	3.3	1.6	2.2	2.2	3.0	3.5	4.6
Total Beryllium (Be)	ug/L		5.3			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Bismuth (Bi)	ug/L					<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Boron (B)	ug/L	1500	1200			<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	0.04 - 0.37(2)	0.01			0.026	0.028	0.017	0.017	0.013	<0.010	0.013	0.013	0.012	0.017	0.022
Total Calcium (Ca)	ug/L					1100	1000	640	590	680	290	470	460	580	620	770
Total Chromium (Cr)	ug/L					1.4	1.6	<1.0	<1.0	<1.0	1.2	<1.0	<1.0	<1.0	<1.0	<1.0
Total Cobalt (Co)	ug/L		10			0.49	0.58	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	0.53
Total Copper (Cu)	ug/L	2 - 4(3)	2	600	600	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Iron (Fe)	ug/L	300	300			740	700	360	350	340	260	410	400	590	820	1000
Total Lead (Pb)	ug/L	1 - 7(4)	1	400	400	0.78	0.55	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.55	0.62	0.57
Total Magnesium (Mg)	ug/L					570	570	320	310	410	160	220	210	280	330	420
Total Manganese (Mn)	ug/L		820			77	71	43	42	51	25	27	27	35	40	58
Total Mercury (Hg)	ug/L	0.026				<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	0.013	0.013	<0.013	<0.013	0.035
Total Molybdenum (Mo)	ug/L	73	73			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Nickel (Ni)	ug/L	25 - 150(5)	25	1000	1000	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Phosphorus (P)	ug/L					<100	110	<100	<100	<100	<100	<100	<100	150	170	140
Total Potassium (K)	ug/L					600	600	370	340	380	330	290	290	160	200	170
Total Selenium (Se)	ug/L	1	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Silver (Ag)	ug/L	0.1	0.1			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Sodium (Na)	ug/L					3100	3100	2100	2000	2400	1200	1600	1600	1900	1900	2300
Total Strontium (Sr)	ug/L		21000			11.0	9.5	5.6	5.2	6.6	3.0	4.1	3.9	5.0	6.3	7.4
Total Thallium (Tl)	ug/L	0.8	0.8			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Tin (Sn)	ug/L					<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Titanium (Ti)	ug/L					4.2	3.8	2.6	2.6	2.2	3.2	2.0	2.4	3.6	4.6	5.0
Total Uranium (U)	ug/L	15	300			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Vanadium (V)	ug/L		6			<2.0	2.5	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Zinc (Zn)	ug/L	30	30	1000	1000	6.9	6.2	5.5	5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Notes

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(3) Copper guideline based on sample hardness: copper guideline (µg/L) = $e^{0.8545[\ln(\text{hardness})]-1.465}$ * 0.2 for hardness ≥82 to ≤180 mg/L, or a lower limit of 2 µg/L for hardness <82 mg/L and an upper limit of 4 µg/L for hardness >180 mg/L (see CCME Summary Table).

(4) Lead guideline based on sample hardness: lead guideline (µg/L) = $e^{1.273[\ln(\text{hardness})]-4.705}$ for hardness >60 to ≤180 mg/L, or a lower limit of 1 µg/L for hardness <60 mg/L and an upper limit of 7 µg/L for hardness >180 mg/L (see CCME Summary Table).

(5) Nickel guideline based on sample hardness: nickel guideline (µg/L) = $e^{0.76[\ln(\text{hardness})]+1.06}$ for hardness >60 to ≤180 mg/L, or a lower limit of 25 µg/L for hardness <60 mg/L and an upper limit of 150 µg/L for hardness >180 mg/L (see CCME Summary Table).

- denotes not analyzed

Table 2: Metals

		CCME FAL	Tier 1 EQS	MMER	MDMER	SW-4A									
Sampling Date						**9-Oct-14**	**13-Nov-14**	**13-Nov-14**	**18-Dec-14**	**22-Jan-15**	**29-Apr-15**	**28-May-15**	**30-Jun-15**	**29-Jul-15**	**24-Aug-15**
Metals	**Units**							SW-4AD (DUP)		No Sample					
Total Aluminum (Al)	ug/L	**5 / 100(1)**	**5**			250	300	310	220		130	240	300	350	390
Total Antimony (Sb)	ug/L		**20**			<1.0	<1.0	<1.0	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0
Total Arsenic (As)	ug/L	**5.0**	**5.0**	**1000**	**1000**	5.8	2.9	2.8	2.0		1.1	7.3	5.4	5.6	5.6
Total Barium (Ba)	ug/L		**1000**			3.4	4.6	4.4	3.2		1.7	2.8	2.8	3.7	3.4
Total Beryllium (Be)	ug/L		**5.3**			<1.0	<1.0	<1.0	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0
Total Bismuth (Bi)	ug/L					<2.0	<2.0	<2.0	<2.0		<2.0	<2.0	<2.0	<2.0	<2.0
Total Boron (B)	ug/L	**1500**	**1200**			<50	<50	<50	<50		<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	**0.04 - 0.37(2)**	**0.01**			0.015	0.024	0.025	0.044		0.012	0.013	0.016	0.014	0.021
Total Calcium (Ca)	ug/L					1500	1300	1300	810		350	780	710	860	930
Total Chromium (Cr)	ug/L					<1.0	<1.0	<1.0	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0
Total Cobalt (Co)	ug/L		**10**			0.43	0.53	0.59	<0.40		<0.40	0.42	<0.40	0.63	0.48
Total Copper (Cu)	ug/L	**2 - 4(3)**	**2**	**600**	**600**	<2.0	<2.0	<2.0	<2.0		<2.0	<2.0	<2.0	<2.0	<2.0
Total Iron (Fe)	ug/L	**300**	**300**			690	540	540	320		160	580	650	840	1100
Total Lead (Pb)	ug/L	**1 - 7(4)**	**1**	**400**	**400**	0.54	<0.50	<0.50	<0.50		<0.50	<0.50	0.52	0.56	0.55
Total Magnesium (Mg)	ug/L					540	590	590	350		170	280	290	360	370
Total Manganese (Mn)	ug/L		**820**			53	58	58	41		20	37	32	42	51
Total Mercury (Hg)	ug/L	**0.026**				<0.013	<0.013	<0.013	<0.013		<0.013	0.015	<0.013	<0.013	0.028
Total Molybdenum (Mo)	ug/L	**73**	**73**			<2.0	<2.0	<2.0	<2.0		<2.0	<2.0	<2.0	<2.0	<2.0
Total Nickel (Ni)	ug/L	**25 - 150(5)**	**25**	**1000**	**1000**	<2.0	<2.0	<2.0	<2.0		<2.0	<2.0	<2.0	<2.0	<2.0
Total Phosphorus (P)	ug/L					<100	100	100	<100		<100	<100	140	150	150
Total Potassium (K)	ug/L					450	500	520	480		290	280	140	180	200
Total Selenium (Se)	ug/L	**1**	**1**			<1.0	<1.0	<1.0	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0
Total Silver (Ag)	ug/L	**0.1**	**0.1**			<0.10	<0.10	<0.10	<0.10		<0.10	<0.10	<0.10	<0.10	<0.10
Total Sodium (Na)	ug/L					3200	3100	3200	2300		1300	1900	1900	1700	2200
Total Strontium (Sr)	ug/L		**21000**			10	9.1	9.2	5.7		2.8	5.1	5.0	6.4	7.2
Total Thallium (Tl)	ug/L	**0.8**	**0.8**			<0.10	<0.10	<0.10	<0.10		<0.10	<0.10	<0.10	<0.10	<0.10
Total Tin (Sn)	ug/L					<2.0	<2.0	<2.0	<2.0		<2.0	<2.0	<2.0	<2.0	<2.0
Total Titanium (Ti)	ug/L					5	3.7	3.9	2.3		2.4	4.7	3.8	3.8	4.9
Total Uranium (U)	ug/L	**15**	**300**			<0.10	<0.10	<0.10	<0.10		<0.10	<0.10	<0.10	<0.10	<0.10
Total Vanadium (V)	ug/L		**6**			<2.0	2.9	2.8	<2.0		<2.0	<2.0	<2.0	<2.0	<2.0
Total Zinc (Zn)	ug/L	**30**	**30**	**1000**	**1000**	19	7.8	6.9	12		<5.0	7.5	<5.0	<5.0	6.0

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Table 2: Metals

		CCME FAL	Tier 1 EQS	MMER	MDMER	SW-5									
Sampling Date						**9-Oct-14**	**9-Oct-14**	**13-Nov-14**	**18-Dec-14**	**22-Jan-15**	**29-Apr-15**	**28-May-15**	**30-Jun-15**	**29-Jul-15**	**24-Aug-15**
Metals	**Units**						SW-5D (DUP)								
Total Aluminum (Al)	ug/L	**5 / 100(1)**	**5**			28	29	100	460	210	98	61	45	43	52
Total Antimony (Sb)	ug/L		**20**			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Arsenic (As)	ug/L	**5.0**	**5.0**	**1000**	**1000**	29	30	15	17	22	15	41	32	20	47
Total Barium (Ba)	ug/L		**1000**			4.5	4.6	5.5	6.1	6.1	4.6	4.4	3.6	4.1	4.5
Total Beryllium (Be)	ug/L		**5.3**			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Bismuth (Bi)	ug/L					<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Boron (B)	ug/L	**1500**	**1200**			<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	**0.04 - 0.37(2)**	**0.01**			<0.010	0.016	<0.010	0.010	0.011	0.018	<0.010	<0.010	<0.010	<0.010
Total Calcium (Ca)	ug/L					5000	4900	5300	3000	4100	2200	3500	3600	3800	4500
Total Chromium (Cr)	ug/L					<1.0	<1.0	<1.0	1.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Cobalt (Co)	ug/L		**10**			<0.40	<0.40	<0.40	<0.40	0.44	0.61	<0.40	<0.40	<0.40	<0.40
Total Copper (Cu)	ug/L	**2 - 4(3)**	**2**	**600**	**600**	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Iron (Fe)	ug/L	**300**	**300**			400	400	470	730	680	560	880	530	610	750
Total Lead (Pb)	ug/L	**1 - 7(4)**	**1**	**400**	**400**	<0.50	<0.50	<0.50	0.57	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Total Magnesium (Mg)	ug/L					940	920	970	640	780	430	600	640	720	870
Total Manganese (Mn)	ug/L		**820**			60	59	28	25	150	200	65	50	45	97
Total Mercury (Hg)	ug/L	**0.026**				<0.013	<0.013	<0.013	<0.013	<0.013	<0.013	0.015	<0.013	<0.013	0.027
Total Molybdenum (Mo)	ug/L	**73**	**73**			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Nickel (Ni)	ug/L	**25 - 150(5)**	**25**	**1000**	**1000**	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Phosphorus (P)	ug/L					<100	<100	<100	<100	<100	<100	<100	140	170	150
Total Potassium (K)	ug/L					730	710	1000	720	740	480	670	580	350	450
Total Selenium (Se)	ug/L	**1**	**1**			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Silver (Ag)	ug/L	**0.1**	**0.1**			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Sodium (Na)	ug/L					2700	2700	2900	2200	2700	1400	1700	1800	1500	2000
Total Strontium (Sr)	ug/L		**21000**			28.0	27	26	15	21	11	18	20	25	27
Total Thallium (Tl)	ug/L	**0.8**	**0.8**			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Tin (Sn)	ug/L					<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Titanium (Ti)	ug/L					<2.0	<2.0	3.2	14	4.2	<2.0	<2.0	<2.0	<2.0	<2.0
Total Uranium (U)	ug/L	**15**	**300**			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Vanadium (V)	ug/L		**6**			<2.0	<2.0	3.1	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Zinc (Zn)	ug/L	**30**	**30**	**1000**	**1000**	<5.0	<5.0	<5.0	<5.0	<5.0	5.4	<5.0	<5.0	<5.0	<5.0

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Table 2: Metals

		CCME FAL	Tier 1 EQS	MMER	MDMER	SW-6A								
Sampling Date						9-Oct-14	13-Nov-14	18-Dec-14	22-Jan-15	28-May-15	30-Jun-15	30-Jun-15	29-Jul-15	24-Aug-15
Metals	Units											SW-6AD (DUP)		
Total Aluminum (Al)	ug/L	**5 / 100(1)**	**5**			220	290	240	250	220	290	39	320	470
Total Antimony (Sb)	ug/L		**20**			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Arsenic (As)	ug/L	**5.0**	**5.0**	**1000**	**1000**	4.0	1.9	1.1	1.0	3.2	3.0	130	2.8	7.6
Total Barium (Ba)	ug/L		**1000**			3.2	4.1	3.1	3.0	2.3	2.6	5.4	3.1	3.8
Total Beryllium (Be)	ug/L		**5.3**			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Bismuth (Bi)	ug/L					<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Boron (B)	ug/L	**1500**	**1200**			<50	<50	<50	<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	**0.04 - 0.37(2)**	**0.01**			0.024	0.021	0.014	0.011	<0.010	0.016	0.061	0.012	0.031
Total Calcium (Ca)	ug/L					1000	1200	790	880	620	670	4900	770	1000
Total Chromium (Cr)	ug/L					<1.0	<1.0	1.3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Cobalt (Co)	ug/L		**10**			<0.40	0.44	<0.40	<0.40	<0.40	<0.40	1.8	<0.40	1.0
Total Copper (Cu)	ug/L	**2 - 4(3)**	**2**	**600**	**600**	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	3.0	<2.0	<2.0
Total Iron (Fe)	ug/L	**300**	**300**			500	480	330	380	370	550	1400	750	1500
Total Lead (Pb)	ug/L	**1 - 7(4)**	**1**	**400**	**400**	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Total Magnesium (Mg)	ug/L					470	510	360	410	230	270	660	310	430
Total Manganese (Mn)	ug/L		**820**			50	51	39	46	29	33	110	38	100
Total Mercury (Hg)	ug/L	**0.026**				<0.013	<0.013	<0.013	<0.013	0.017	<0.013	0.013	<0.013	0.035
Total Molybdenum (Mo)	ug/L	**73**	**73**			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Nickel (Ni)	ug/L	**25 - 150(5)**	**25**	**1000**	**1000**	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	7.2	<2.0	<2.0
Total Phosphorus (P)	ug/L					<100	<100	<100	<100	<100	140	140	160	150
Total Potassium (K)	ug/L					340	470	300	300	280	190	640	200	240
Total Selenium (Se)	ug/L	**1**	**1**			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Silver (Ag)	ug/L	**0.1**	**0.1**			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Sodium (Na)	ug/L					2800	3000	2200	2300	1700	1800	1900	1700	2200
Total Strontium (Sr)	ug/L		**21000**			7.1	7.7	5.9	6.1	4.4	4.8	19	5.5	7.6
Total Thallium (Tl)	ug/L	**0.8**	**0.8**			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Tin (Sn)	ug/L					<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Titanium (Ti)	ug/L					2.7	3.1	2.8	2.6	2.8	3.4	<2.0	3.5	4.3
Total Uranium (U)	ug/L	**15**	**300**			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Vanadium (V)	ug/L		**6**			<2.0	2.2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Zinc (Zn)	ug/L	**30**	**30**	**1000**	**1000**	<5.0	5.5	<5.0	<5.0	5.7	<5.0	13	<5.0	<5.0

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(3) Copper guideline based on sample hardness: copper guideline (µg/L) = $e^{0.8545[\ln(hardness)]-1.465}$ * 0.2 for hardness ≥82 to ≤180 mg/L, or a lower limit of 2 µg/L for hardness <82 mg/L and an upper limit of 4 µg/L for hardness >180 mg/L (see CCME Summary Table).

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(5) Nickel guideline based on sample hardness: nickel guideline (µg/L) = $e^{0.76[\ln(hardness)]+1.06}$ for hardness >60 to ≤180 mg/L, or a lower limit of 25 µg/L for hardness <60 mg/L and an upper limit of 150 µg/L for hardness >180 mg/L (see CCME Summary Table).

- denotes not analyzed

Table 2: Metals

		CCME FAL	Tier 1 EQS	MMER	MDMER	SW-9									
Sampling Date						9-Oct-14	13-Nov-14	18-Dec-14	22-Jan-15	29-Apr-15	28-May-15	30-Jun-15	29-Jul-15	29-Jul-15	24-Aug-15
Metals	Units													SW-1 (DUP)	
Total Aluminum (Al)	ug/L	5 / 100(1)	5			410	330	310	210	160	170	280	260	270	320
Total Antimony (Sb)	ug/L		20			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Arsenic (As)	ug/L	5.0	5.0	1000	1000	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Barium (Ba)	ug/L		1000			6.6	5.7	3.5	3.4	2.1	2.4	3.3	3.4	3.3	4.2
Total Beryllium (Be)	ug/L		5.3			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Bismuth (Bi)	ug/L					<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Boron (B)	ug/L	1500	1200			<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	0.04 - 0.37(2)	0.01			0.024	0.025	0.019	0.010	0.014	<0.010	0.014	<0.010	<0.010	0.015
Total Calcium (Ca)	ug/L					2300	1400	890	1100	640	1100	1700	1800	1900	1700
Total Chromium (Cr)	ug/L					<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.3	<1.0
Total Cobalt (Co)	ug/L		10			<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
Total Copper (Cu)	ug/L	2 - 4(3)	2	600	600	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Iron (Fe)	ug/L	300	300			620	500	280	290	220	210	440	490	510	580
Total Lead (Pb)	ug/L	1 - 7(4)	1	400	400	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Total Magnesium (Mg)	ug/L					1100	700	450	530	300	480	740	830	840	810
Total Manganese (Mn)	ug/L		820			140	75	51	51	36	34	57	56	60	76
Total Mercury (Hg)	ug/L	0.026				<0.013	<0.013	<0.013	<0.013	<0.013	0.013	<0.013	<0.013	0.013	0.032
Total Molybdenum (Mo)	ug/L	73	73			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Nickel (Ni)	ug/L	25 - 150(5)	25	1000	1000	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Phosphorus (P)	ug/L					<100	<100	<100	<100	<100	<100	150	160	170	160
Total Potassium (K)	ug/L					640	530	340	350	300	270	200	210	240	180
Total Selenium (Se)	ug/L	1	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Silver (Ag)	ug/L	0.1	0.1			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Sodium (Na)	ug/L					4000	3900	2900	3900	2400	3500	3100	3300	3500	3500
Total Strontium (Sr)	ug/L		21000			10	7.7	5.0	5.6	2.8	4.2	5.9	6.5	5.9	6.6
Total Thallium (Tl)	ug/L	0.8	0.8			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Tin (Sn)	ug/L					<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Titanium (Ti)	ug/L					4.8	4.1	3.5	2.8	3.1	3.0	3.1	3.6	4.9	4.3
Total Uranium (U)	ug/L	15	300			0.11	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.12	0.13	0.11
Total Vanadium (V)	ug/L		6			<2.0	2.3	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Zinc (Zn)	ug/L	30	30	1000	1000	5.2	7.5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Notes

CCME FAL - Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Freshwater Aquatic Life (provided for reference)

Tier 1 EQS - Nova Scotia Environment Tier 1 Environmental Quality Standards for Freshwater Surface Water (provided for reference)

MMER - Federal Metal Mining Effluent Regulations - guidelines shown represent maximum authorized concentrations in a grab sample (provided for reference)

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(2) Cadmium guideline (updated for 2014) (µg/L) = $10^{(0.83(\log[\text{hardness}])-2.46)}$ for hardness between 17-280 mg/L $CaCO_3$ or a lower limit of 0.04 ug/L for hardness < 17mg/L or an upper limit of 0.37 ug/L for hardness >280 mg/L (see CCME Fact Sheet).

(3) Copper guideline based on sample hardness: copper guideline (µg/L) = $e^{0.8545[\ln(\text{hardness})]-1.465}$ * 0.2 for hardness ≥82 to ≤180 mg/L, or a lower limit of 2 µg/L for hardness <82 mg/L and an upper limit of 4 µg/L for hardness >180 mg/L (see CCME Summary Table).

(4) Lead guideline based on sample hardness: lead guideline (µg/L) = $e^{1.273[\ln(\text{hardness})]-4.705}$ for hardness >60 to ≤180 mg/L, or a lower limit of 1 µg/L for hardness <60 mg/L and an upper limit of 7 µg/L for hardness >180 mg/L (see CCME Summary Table).

(5) Nickel guideline based on sample hardness: nickel guideline (µg/L) = $e^{0.76[\ln(\text{hardness})]+1.06}$ for hardness >60 to ≤180 mg/L, or a lower limit of 25 µg/L for hardness <60 mg/L and an upper limit of 150 µg/L for hardness >180 mg/L (see CCME Summary Table).

- denotes not analyzed

Table 2: Metals

		CCME FAL	Tier 1 EQS	MMER	MDMER	SW-10				SW-11	SW-12
Sampling Date						30-Jun-15	29-Jul-16	24-Aug-15	24-Aug-15	Oct-5-2017	5-Oct-17
Metals	Units								SW-10 (DUP)		
Total Aluminum (Al)	ug/L	**5 / 100(1)**	**5**			39	28	220	210	420	430
Total Antimony (Sb)	ug/L		**20**			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Arsenic (As)	ug/L	**5.0**	**5.0**	**1000**	**1000**	130	36	380	370	1.4	1.9
Total Barium (Ba)	ug/L		**1000**			5.4	7.3	7.1	6.9	3.9	3.5
Total Beryllium (Be)	ug/L		**5.3**			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Bismuth (Bi)	ug/L					<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Boron (B)	ug/L	**1500**	**1200**			<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	**0.04 - 0.37(2)**	**0.01**			0.061	0.10	0.011	<0.010	0.022	0.021
Total Calcium (Ca)	ug/L					4900	6400	10000	10000	1100	830
Total Chromium (Cr)	ug/L					<1.0	<1.0	<1.0	<1.0	1.1	<1.0
Total Cobalt (Co)	ug/L		**10**			1.8	1.4	2.2	2.3	<0.40	0.73
Total Copper (Cu)	ug/L	**2 - 4(3)**	**2**	**600**	**600**	3.0	3.6	<2.0	<2.0	<2.0	<2.0
Total Iron (Fe)	ug/L	**300**	**300**			1400	78	6000	5900	1200	1000
Total Lead (Pb)	ug/L	**1 - 7(4)**	**1**	**400**	**400**	<0.50	<0.50	1.1	1.2	0.75	0.60
Total Magnesium (Mg)	ug/L					660	900	1200	1200	530	500
Total Manganese (Mn)	ug/L		**820**			110	78	290	280	41	54
Total Mercury (Hg)	ug/L	**0.026**				<0.013	<0.013	0.025	0.028	-	-
Total Molybdenum (Mo)	ug/L	**73**	**73**			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Nickel (Ni)	ug/L	**25 - 150(5)**	**25**	**1000**	**1000**	7.2	8.7	6.2	6.1	<2.0	<2.0
Total Phosphorus (P)	ug/L					140	170	140	140	<100	<100
Total Potassium (K)	ug/L					640	790	1000	1000	180	160
Total Selenium (Se)	ug/L	**1**	**1**			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Silver (Ag)	ug/L	**0.1**	**0.1**			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Sodium (Na)	ug/L					1900	2100	2500	2400	2300	2400
Total Strontium (Sr)	ug/L		**21000**			19	26	33	33	9.0	7.1
Total Thallium (Tl)	ug/L	**0.8**	**0.8**			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Tin (Sn)	ug/L					<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Titanium (Ti)	ug/L					<2.0	<2.0	2.8	2.9	4.5	3.3
Total Uranium (U)	ug/L	**15**	**300**			<0.10	<0.10	0.21	0.20	<0.10	<0.10
Total Vanadium (V)	ug/L		**6**			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Zinc (Zn)	ug/L	**30**	**30**	**1000**	**1000**	13	19	<5.0	<5.0	5.0	<5.0

Notes

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- denotes not analyzed

ATLANTIC GOLD

Appendix G.2

Touquoy Integrated Water and Tailings Management Plan

TOUQUOY INTEGRATED WATER AND TAILINGS MANAGEMENT PLAN - BEAVER DAM GOLD PROJECT

HALIFAX COUNTY, NS

January 17, 2019

Prepared for:

Atlantic Gold Mining NS Corp

Prepared by:

Stantec Consulting Ltd.

Job No.: 121619250

Sign-off Sheet

This document entitled TOUQUOY INTEGRATED WATER AND TAILINGS MANAGEMENT PLAN - BEAVER DAM GOLD PROJECT was prepared by Stantec Consulting Ltd. (“Stantec”) for the account of Atlantic Gold Mining NS Corp. (the “Client”). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec’s professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

This report was prepared by Rachel Jones, Water Resources Engineer and reviewed by Sitotaw Yirdaw-Zeleke, Water Resources Engineer, Jonathan Keizer, Water Resources Engineer, and Sheldon Smith, senior hydrologist. If you required additional information, please do not hesitate to contact us.

Prepared by ____
(signature)
Rachel Jones

Reviewed by ____
(signature)
Sheldon Smith

Reviewed by ____
(signature)
Jon Keizer

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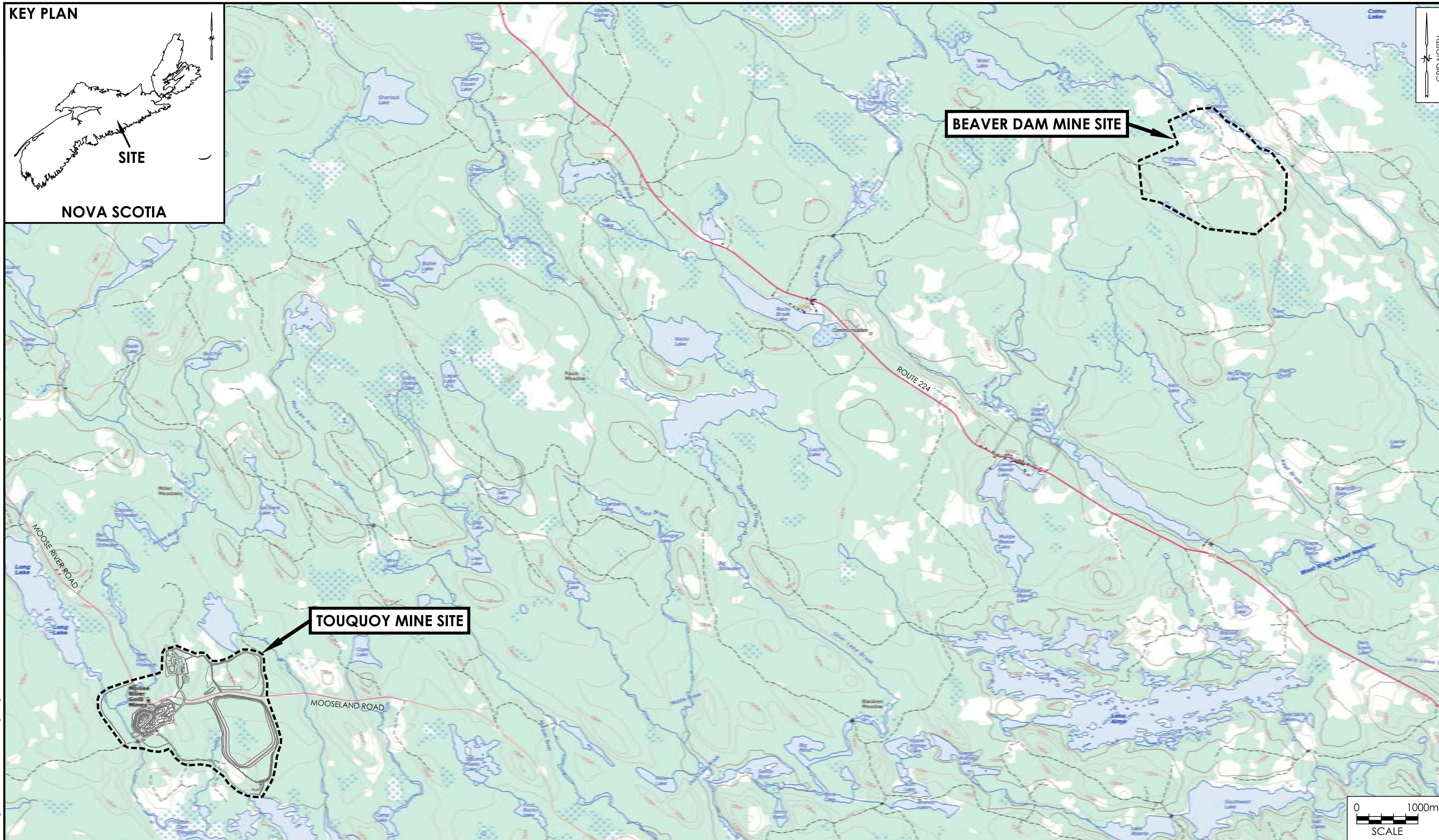
1.0 INTRODUCTION

The Beaver Dam Gold Project is part of the Moose River consolidated project, which comprises the Beaver Dam, 15 Mile, Cochrane Hill and Touquoy gold deposits. Beaver Dam is being developed as a satellite deposit to the Touquoy operation with haulage of ore 37 km by road to the Touquoy Mill for processing following completion of mining at Touquoy. Beaver Dam ore processing will extend production at Touquoy by an additional 3.1 years. This report covers the Beaver Dam ore processing at Touquoy and does not cover the open pit mine at Beaver Dam or haulage. The location of the Beaver Dam mine site in relation to the existing Touquoy mining site is depicted in Figure 1.1. Beaver Dam ore is proposed to be processed at the existing Touquoy mill site. Beaver Dam ore processing will commence once the Touquoy open pit ore reserve is depleted corresponding to the commencement of the Touquoy reclamation phase. Tailings generated by processing the Beaver Dam ore will be deposited in the exhausted Touquoy open pit. This memo summarizes the water and tailings management plan, including Beaver Dam tailings deposition and the integrated mine site water balance, in support of the environmental impact statement screening document for the Beaver Dam Gold Project.

This memo is divided into four sections:

- **Section 2.0 Operational Water Management Plan** – outlines the sources of reclaim and make up water during the processing of Beaver Dam ore at the Touquoy mill site, manage site runoff, seepage and other flow components.
- **Section 3.0 Conceptual Tailings Deposition Plan** – outlines the tailings deposition methods based on subaqueous deposition, considering seasonality.
- **Section 4.0 Water Quantity Balance** – outlines the predictions of water volume discharged to the open pit, water volume available for reclaim in the Touquoy Tailings Management Facility (TMF), required freshwater make-up from Scraggy Lake, and the timing of when water could be reclaimed from the Touquoy open pit rather the Touquoy TMF.
- **Section 5.0 Water Quality Balance -** outlines the predictions of water quality in the pit lake and effluent discharge to Moose River.



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Reference:

DATA SOURCE: SNSMR (REPRODUCED AND DISTRIBUTED WITH THE PERMISSION OF SERVICE NOVA SCOTIA & MUNICIPAL RELATIONS).

SITE LOCATION PLAN

TOUQUOY INTEGRATED WATER & TAILINGS MANAGEMENT PLAN

HALIFAX COUNTY, NOVA SCOTIA

Client: ATLANTIC MINING NOVA SCOTIA CORPORATION

Job No.:	121619250
Scale:	1 : 60 000
Date:	17-JAN-2019
Dwn. By:	JL
App'd By:	RJ

Fig. No.: 1.1

Stantec

2.0 OPERATIONAL WATER MANAGEMENT PLAN

Figure 2.1. depicts components of the operational water management plan at the Touquoy complex including the existing mill site, Touquoy TMF, effluent treatment plant, the ultimate extent of the exhausted Touquoy open pit and the Beaver Dam open pit. Water management at Touquoy is described in more detail in the water management plan (Stantec 2017a) and the Water Balance Report (Stantec 2016), excluding integration of the Beaver Dam open pit. Figure 2.1 also illustrates the direction of flow between components, effluent discharge locations, mine component drainage areas, and locations of MDMER final discharge point(s). The MDMER final discharge point for Touquoy operations is located at the outlet of the Touquoy TMF polishing pond. When the Touquoy open pit fills and is allowed to spill, the Final Discharge point will be located approximately 70 m downstream from the SW-2 monitoring station on Moose River for Touquoy open pit closure (Figure 2.2).

When the Touquoy pit is exhausted of ore and the Touquoy TMF has reached its tailings storage capacity, reclamation activities will commence for the Touquoy TMF including the associated polishing pond and constructed wetland. The polishing pond and wetland dams are planned to be breached, the ponds drained, and the entire area, contoured and revegetated in closure of the Touquoy TMF, retiring the final discharge point. When Beaver dam ore processing comes on-line, tailings will be deposited into the existing Touquoy Open pit. Initially, water will be reclaimed from the Touquoy TMF until water storage is not adequate to meet process water demand. After which water will be reclaimed from the open pit as a closed loop. The open pit will not be allowed to spill until water in the pit lake meets MDMER discharge limits, until such time water will be treated in the pit or pumped and treated in the existing Touquoy effluent treatment plant. The water management plan is based on operation and reclamation/ closure.

An overview of key features of the Touquoy water management plan for the Beaver Dam Gold project are provided in the sections below. Water management is presented by project phase (Operation, Reclamation, and Closure) as it pertains to Beaver Dam Gold Mine Project. The operational phase of the Beaver Dam Gold project corresponds to the period when Beaver dam gold ore is being processed at the Touquoy mill. Following ore processing, water will be treated during the reclamation phase. Once water quality meets regulatory reclamation criteria the water level in the pit lake will be allowed to spill from the open pit and discharge to Moose River during the closure phase. As per the MDMER, water quality monitoring will be conducted to inform water management at Touquoy.

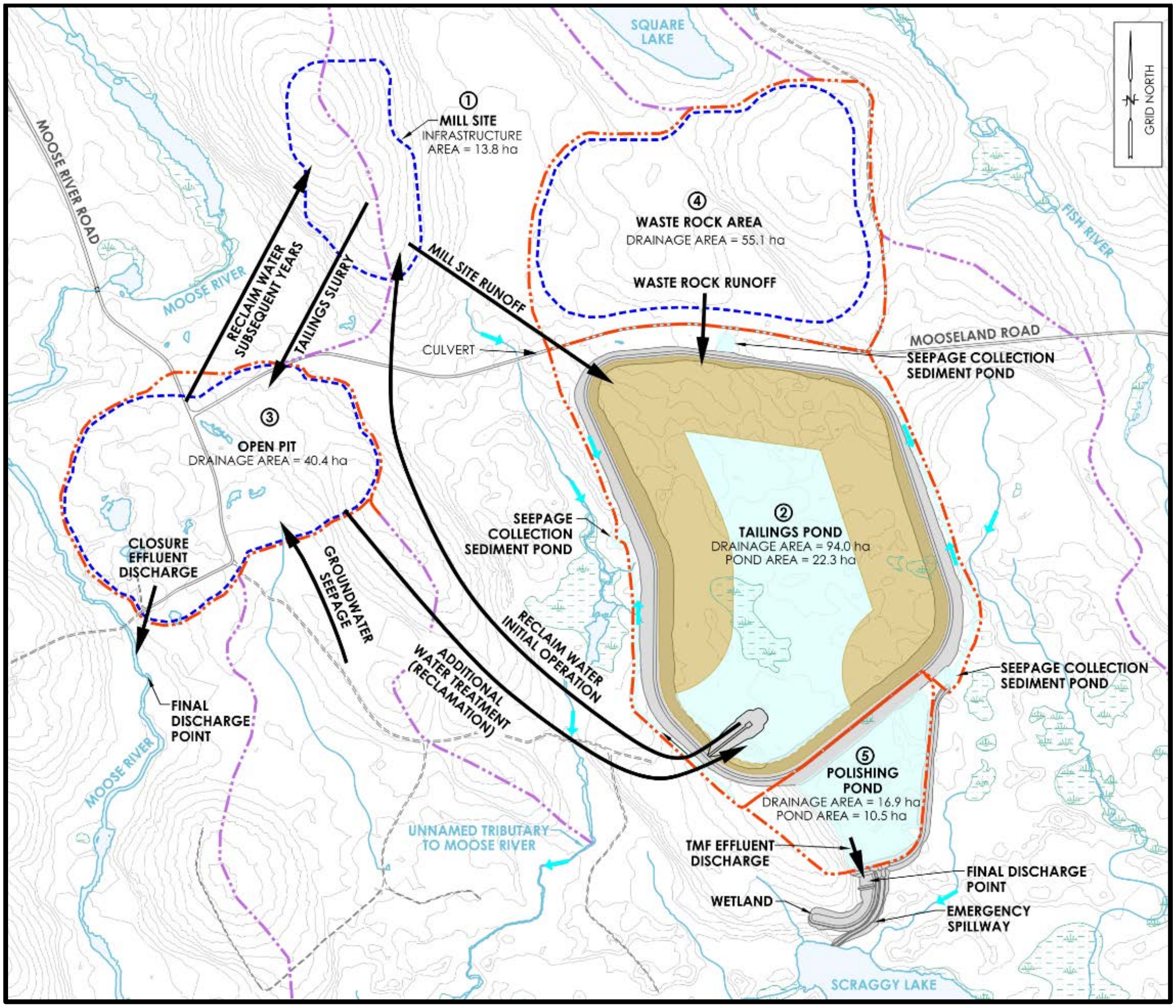
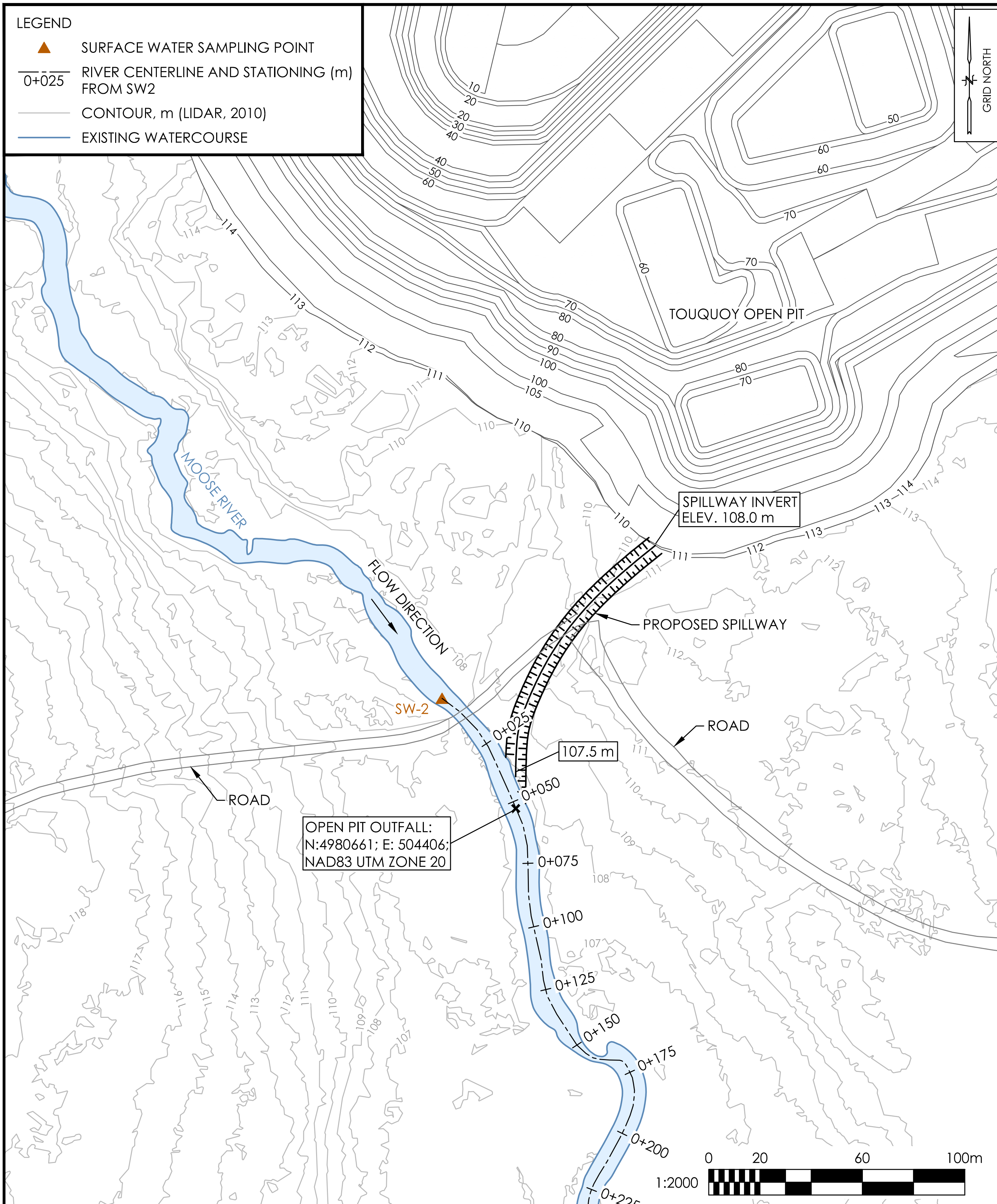


Figure 2.1 Major Mine Site Components



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LOCATION OF OPEN PIT OUTFALL

TOUQUOY INTEGRATED WATER & TAILINGS MANAGEMENT PLAN
HALIFAX COUNTY, NOVA SCOTIA

Client: ATLANTIC MINING NOVA SCOTIA CORPORATION

Job No.:	121619250
Scale:	1 : 2000
Date:	17-JAN-2019
Dwn. By:	JL
App'd By:	RJ
Fig. No.:	2.2

Stantec

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2.1 WATER MANAGEMENT TO ACCOMMODATE BEAVER DAM ORE PROCESSING

A total of 7.250 Mt Beaver Dam ore will be processed at the existing Touquoy mill facility, extending operation at the Touquoy mill. Mill operation for Beaver Dam ore processing is planned to be consistent with Touquoy ore processing with respect to mill throughput, mill process flows, and tailings slurry density. Water Management at Touquoy to accommodate Beaver Dam ore processing during operation is described below.

Beaver Dam Project Phase – Operation

- Processing of Beaver Dam ore at Touquoy involves the continued use of Touquoy water management facilities, including:
  - The TMF will continue to receive surface runoff from the waste rock pile, seepage collection ditches, and direct precipitation.
  - Seepage collection ditches will continue to collect tailings seepage around the perimeter of the Touquoy TMF and will continue to be pumped back into the TMF pond.
  - Perimeter ditches around the waste rock area will flow into three sedimentation ponds with the option to by-pass the TMF if water quality objectives are achieved.
  - Runoff from the mill site pond and run-of-mine (ROM) stockpile will continue to be included in the tailings slurry flow.
  - The TMF water surplus, that is water that is not reclaimed as process water, or lost to evaporation or seepage, will continue to discharge to the effluent treatment plant. Effluent from the treatment plant will continue to discharge to the polishing pond through geobags and subsequently to the constructed wetland and finally to the receiving environment - Scraggy Lake.
  - The effluent treatment plant and downstream discharge facilities will continue to be in operation at the TMF until surplus water meets reclamation regulatory water quality requirements as described in the reclamation plan for Touquoy (Stantec 2017b).
- Dewatering of the open pit to the TMF will cease at the end of Touquoy open pit mine life. This will result in reduced water surplus from the TMF.
- At initial stages of Beaver Dam ore processing, reclaim water will be directed to the mill from the TMF through the existing decant tower or floating barge infrastructure for treatment and/or reuse for various mill processes. Water will continue to be reclaimed from the TMF until a water deficit is reached. Delay of water reclaim from the open pit will allow time for water inflows to collect in the pit as a start-up process water supply.
- When water is to be reclaimed from the open pit, the existing floating barge and associated infrastructure will be relocated from the TMF to the exhausted open pit. The barge will raise with the water and tailings elevation in the pit, decreasing pump head and associated pumping costs over time.
- Additional Beaver Dam ore processing start-up water supply will be sourced from Scraggy Lake, subject to NSE water withdrawal approval.
- Freshwater make-up for the process will continue to be sourced from Scraggy Lake. Additional make-up process water required in a dry year or to build a reservoir incase of a dry year will be sourced from effluent from the TMF treatment plant or Scraggy Lake, subject to NSE approval.
- Beaver dam tailings will be deposited in the open pit. The existing tailings slurry pipeline from the mill will be redirected from the TMF to the Touquoy open pit.

The objective of Water Management at Touquoy to accommodate Beaver Dam ore processing during reclamation is for water in the pit lake to meet the reclamation regulatory water quality requirements or site specific criteria. Key water management features are described below.

Beaver Dam Project Phase – Reclamation

- The existing TMF effluent treatment plant and downstream discharge facilities will continue to be in operation to treat TMF water surplus
- Throughout reclamation as the Touquoy open pit fills with water, the pit lake will be treated as a batch reactor with the objective of adjusting the pH to precipitate metals thus improving discharge quality.
- Surplus water in the open pit will be pumped to the TMF for treatment, until such time as water quality monitoring indicates that water quality is suitable for direct discharge to the environment.
- Until water quality meets discharge criteria, the water level in the pit lake will be maintained at or below elevation 104 m (i.e. corresponding to the shallow permeable zone) thus reducing seepage to Moose River and normalizing treatment rates to the extent feasible.
  - A minimum of 1 m water cover will be maintained above the deposited tailings to facilitate pumping. The water cover depth will vary over the tailings depositional period.
  - The effluent treatment plant will operate intermittently during non-frozen periods (April – November, inclusive) to low the pit lake to 103 m by the end of November thus providing storage over the period when the effluent treatment plan is shut down.
  - Assuming the existing effluent treatment rate of 400 m^3/hr, the effluent treatment plant would be in operation for an additional 4.4 months to pump and treat the annual climate normal surplus of the open pit watershed of 436,000 m^3.
- Operation of the existing effluent treatment plant will be modified to accommodate Beaver Dam water surplus or additional capacity will be added to effluent treatment plant to treat water over a shorter period simultaneously.

As described below, once water quality meets regulatory reclamation criteria the open pit can be prepared for closure, in accordance with the mine site closure plan.

Beaver Dam Project Phase – Closure

- The effluent treatment plant and downstream discharge facilities are not required for Beaver Dam Gold Mine Project during closure because effluent discharge will meet regulatory discharge criteria and will not require treatment.
- Surplus water in the open pit will be discharged via a constructed spillway/conveyance channel to Moose River, subject to meeting regulatory discharge criteria.
- The spillway and conveyance channel will be sized to accommodate the inflow design flood in accordance with the Canadian Dam Association (CDA) guidelines. The spillway invert is set at elevation 108 m, approximately 2 m below the lowest open pit elevation to prevent overtopping.

3.0 CONCEPTUAL TAILINGS DEPOSITION PLAN

This section presents a conceptual plan for subaqueous deposition of conventional tailings slurry into the exhausted Touquoy open pit from Beaver Dam ore processing. The total capacity of the Touquoy open pit at the proposed spillway elevation of 108.0 m is of 9.420 Mm^3 is sufficient to store tailings from processing of the Beaver Dam ore reserve using subaqueous (i.e. in water) deposition. Based on the feasibility study (Ausenco 2015), 7.25 Million tonnes (Mt) of tailings are predicted to be produced from processing of Beaver Dam ore. Considering subaqueous deposition, the open pit can accommodate the estimated deposited volume of 5.577 Mm^3 from Beaver Dam ore processing. At the direction of AMNS, no tailings is planned to be deposited in the existing TMF as part of the Beaver Dam gold project.

Subaqueous deposition is the most pragmatic way to deposit tailings in the confined open pit. Subaerial deposition (i.e., tailings beach) like in the Touquoy TMF was not considered for the Touquoy open pit. Subaerial deposition would introduce complexities in design and operation due to the conical geometry of the open pit – reducing in area over the 25 meter depth, use of the pit as a process water supply, and maintaining access to the water surface. As the capacity of the open pit is adequate for tailings depositions, tailings slurry alternatives, such as high-density tailings and paste were not considered.

Quality of reclaim water will need to meet criteria for total suspended solids, residual reagents and other parameters to limit fouling or reduced recoveries in the mill. These criteria will need to be refined in subsequent phases of study to determine if additional treatment of reclaim water will be required.

In general, spring, summer and fall operation is more flexible than winter (frozen) operations, and appropriate planning and mitigation is required to prevent potential issues with respect to maintaining minimum capacities during frozen conditions.

3.1 NORMAL OPERATION (SPRING, SUMMER AND FALL)

Tailings will be transported to the TMF as thickened slurry via a tailings pipeline that runs from the mill to the open pit. The existing tailings pipeline will be relocated to accommodate Beaver dam ore processing. Secondary containment is achieved by running the main tailings pipeline in a lined ditch. The tailings will be deposited into the open pit by end-of-pipe discharge, beginning in the lower areas and moving radially around the open pit. The tailings discharge pipe will be suspended in the pond by floats or a floating barge. Initially, the pipe will likely discharge from surface at a lower bench as the bottom of the open pit has a deeper basin. Detailed procedures will be developed for tailings line moves and plant shut downs to prevent plugging of the tailings pipeline.

Summer deposition will be carried out in shallower portions of the pit in preparation for the winter. Bathymetric surveys will be conducted at least once a year during the ice free period to identify areas where tailings deposition should be concentrated and to create a tailings surface. From the tailings surface, design assumptions of tailings volume and average tailings deposited density can be checked. The tailings deposition plan should be updated routinely to check capacity is available in deeper parts of the open pit to prepare for winter operation.

The existing TMF reclaim barge will be relocated from the tailings pond to the open pit for reclaim in Beaver Dam ore processing. The reclaim barge will be placed in an area with the highest water depth. A floating baffle curtain will be installed around the barge should high suspended solids become an issue in processing.

Pertinent considerations and design criteria have been collated in Table 2.1. The assumptions presented in this water management plan should be updated with reported values when the final deposition plan is prepared. An average settled tailings density of 1.3 t/m³ was assumed considering subaqueous tailing deposition, thus a lower average deposited tailings density than that of the Touquoy tailings pond of 1.44 t/m³ practicing sub-aerial deposition.

Table 3.1 Tailings Deposition Assumptions

Criteria	Value	Unit	Source
Production Criteria/Characteristics			
Life of Mine (LOM)	3.1	years	
Total tailings production (LOM)	7.25	Mt	Ausenco 2015, GHD 2017
Mill throughput, accounting for mill availability	6400	tpd	AMNSC 2018
Deposited tailings volume	4,923	m³/d	
Tailings Characteristics			
Average settled tailings density	1.3	t/m³	
Slurry density (w/w) (% of tailings production (t))	41	%	
Specific gravity	2.83	---	Stantec 2018a
Saturated water content (% of tailings production (t))	36.1	%	Calculated parameter
Open Pit Characteristics			
Open pit volume at spillway elev. (108.0 m)	8.962	Mm³	Ultimate Pit Design April 2017 (AMNS 2018)
Pit lake freezes over	December	month	
Pit lake ice melts	April	month	
Closure spillway elevation	108	m	
Minimum water depth - pump operation	1	m	
Minimum water cover - to reduce metal leaching	1	---	
Adjustment to mean tailings elev. (underwater cones)	8	m	
Average maximum tailings elevation	90.5	m	
Storage capacity of pond at 90.5 m elev.	5.577	m³	Calculated: LOM tailings production Mt /density t/m³

Criteria	Value	Unit	Source
Assumed Freeboard Requirements of open pit	1	m	
Inflow Design Flood	143,000	m^3	

Note: Blank fields indicate an estimate or assumption as part of this study

3.2 WINTER (FROZEN) OPERATION

Based on a review of climate normal temperatures, frozen conditions typically occur between January and April, although solid ice cover of the pond may occur as early as December. Subaqueous deposition employed in cold climates require mitigation strategies to continue deposition when the water surface is frozen. Bubbler systems can be installed around the discharge/reclaim barge and its pontoons to reduce ice formation. The discharge/reclaim barge will be placed over a deep portion of the pond to provide storage of tailings deposited throughout the ice-covered portion of the winter. Another option is to submerge the tailings slurry discharge line below the ice depth to discharge tailings to a single point, or over a linear array of discharge points within the pond during the winter period. It is not practical to access submerged tailings lines while the pond is frozen over.

4.0 WATER BALANCE MODEL

A preliminary water balance model was developed to simulate the overall operational water management of Beaver Dam ore processing in operation and reclamation. The water balance model was developed through multiple iteration and revisions simulating construction, commissioning, and operation of ore processing and tailings deposition at the Touquoy mine site to improve accuracy. Using the existing conditions water balance model at Touquoy, the model was extended to simulate the integrated water management of Beaver Dam ore processing at Touquoy, as part of a water and tailings management plan. Model inputs and outputs to the open pit accounted for groundwater inflows and seepage losses, surface runoff, direct precipitation, evaporation, process water, porewater lock up and reclaim to the TMF and open pit. The objectives of the water balance model were to:

- Assess the continued use of Touquoy Water Management Facilities to process and deposit Beaver Dam ore
- Understand water management adjustments needed to accommodate Beaver Dam Ore processing and deposition
- Simulate the water and tailings volume in the exhausted open pit over the life of the project
- Predict when it would be necessary to withdraw reclaim water from the Touquoy open pit, as opposed to the TMF, under climate normal conditions

The model was run for the climate normal conditions in addition to the 1:100 Annual Exceedance Probability (AEP) wet conditions, and 1:100 AEP dry climate conditions (assuming groundwater inflow and storage in the open pit) for the during of operation, reclamation to closure. Only water elevation in the open is reported, as water management of the tailings pond is not changing from Beaver Dam ore processing. Considerations of flows in the TMF downstream facilities, such as the polishing pond and constructed wetland, were not incorporated into the model.

4.1 EXISTING CONDITIONS AND ASSUMPTIONS

Water balance assumptions for the Beaver Dam processing and tailings deposition are listed below.

Mill Process Flows

- Start-up process water supply in open pit will be sourced from the following sources:
  - Reclaiming water from the TMF for the first 5 months of operation, assuming start-up in spring.
  - To offset anticipated start up reclaim deficit and build deposited tailings water cover, increase freshwater make-up from Scraggy Lake of 15,862 m³/month to the maximum monthly permitted rate of 21,900 m³/month for the first 7 months of reclaim in the open pit.
  - Stop pit dewatering 5 months prior to start-up of Beaver Dam ore processing commensurate with the remaining 5 months of storage available in the TMF allocated to tailings deposition for other projects. This will result in water collected in the pit for use as process supply in start-up. During this 5 month pre-processing period, the Mill will drawdown ROM ore stockpiles and retool, refine metallurgical processes and commission Beaver Dam ore processing.
  - Withdraw additional start-up volume from Scraggy Lake based on climate normal conditions (subject to a permitted water withdrawal approval from NSE).
- Freshwater make-up from Scraggy Lake of 534 m³/d (5.8% of production) is consistent with the Touquoy operations, following the initial start-up volume.

- Tailings water discharged with tailings slurry of 9,022 m³/d.
- Reclaim water to mill of 8,379 m³/d.
- Moisture going into mill of 2.5% of tailings production (t).
- Water lost to evaporation and spillage of 3.0% of tailings production (t).

TMF (Drainage area of 94 ha)

- TMF at high normal operating water level at commencement of Beaver Dam ore processing (approximately 1 Mm^3) to store water available for reclaim.
- TMF at ultimate spillway design elevation 128.5 m with a dam crest elevation of 130.0 m CGVD 2013 assuming 7.36 million cubic meters (Mm³) of tailings storage volume and 1.30 Mm³ of water storage below the spillway invert elevation of 128.5 m.
- Minimum inactive storage of in the tailings pond is 635,500 m³ in non-frozen months, and 825,500 m³ in frozen months.
- Surplus water discharge to the effluent treatment plant at a maximum rate of 400 m³/hr
- Seepage from the TMF at 1336 m³/d, of that 200 m³/d is captured in polishing pond and 736 m³/d re-circulated to the TMF in non-frozen months and the remainder bypasses to groundwater.
- Accepts inputs from undiverted catchments (waste rock pile, mill pond runoff, and open pit dewatering).
- The elevation storage relationship for the TMF is illustrated in Figure 4.1

Waste Rock Area (Drainage area of 55.1 ha)

- The waste rock area is not expanding over the life of Beaver Dam.
- The runoff coefficient at the commencement of Beaver Dam is estimated at 28%. However, the runoff coefficient of the waste rock pile is expected to increase to 70% over 15 years as the waste rock pile starts to wet and the transmission of infiltration and recharge through the pile improves overtime.
- Runoff coefficient increases from 5 to 27% by the end of the Touquoy operation (e.g. from existing conditions in Touquoy operation to a model result from a reference waste rock site (Stantec 2018e)).

Touquoy Open Pit (Drainage area of 40.4 ha)

- Open pit receives 5 months of runoff (associated to remaining volume n TMF) upon commencement of beaver dam ore processing amounting to a water volume of 273,000 m³ with a bottom elevation from -25.0 m to 11.2 m CGVD 2013.
- Open pit geometry as per the ultimate pit design of April 2017 at ultimate Touquoy
- Model represents climate normal, 1:100 AEP and 1:100 AEP climate conditions, characterized by Environment Canada’s Middle Musquodoboit climate station (Station ID 8203535).
- Total storage capacity at the overflow elevation 108 m CDGV 2013 of 8.962 $Mm^{3.}$
- Beaver Dam wet tailings storage volume of approximately 5.579 Mm3 reaching an average elevation of 108 m.
- Natural filling of the open pit over time to create a pit lake water cover over of the deposited tailings
- The pit lake amounts to approximately 17.5 m of water cover above the tailings (3.38 Mm^3 of water), assuming the spillway invert elevation of 108 m.
- Net groundwater inflow to the pit consistent at 450 m³/day but decreasing to 250 m³/d when water elevation is at the more permeable zone at 104 m or higher (Stantec 2018b).
- An emergency spillway in the open pit with invert of 104 m, an open pit crest elevation of 108 m to prevent overtopping and a conveyance channel to Moose River.
- The elevation storage relationship for the exhausted open pit is illustrated in Figure 4.2

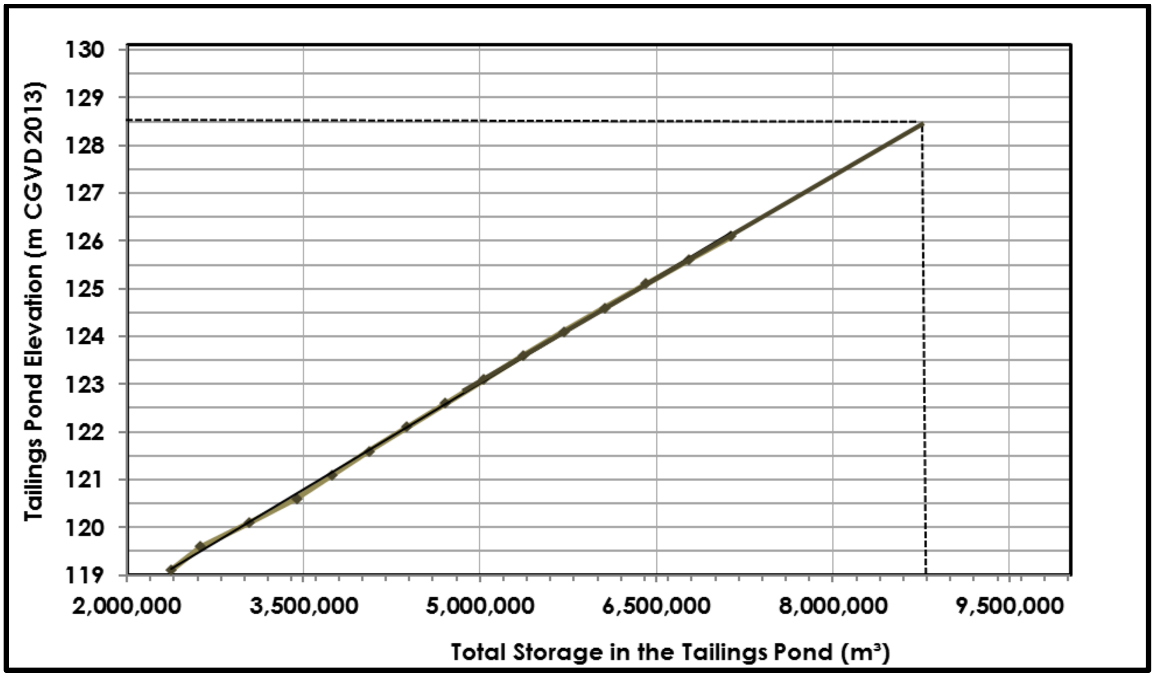

Figure 4.1 TMF Elevation Storage Relationship

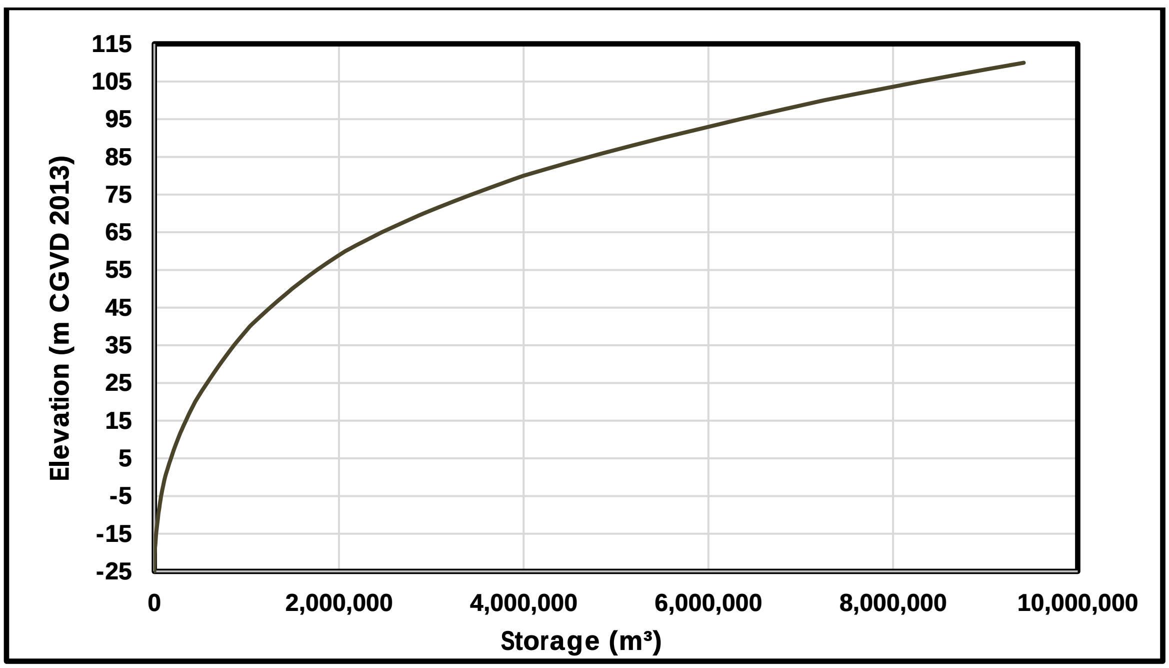

Figure 4.2 Elevation Storage Relationship in the Exhausted Touquoy Open Pit

4.2 MODEL RESULTS

The water balance model predicted the amount of water and tailings stored in the pit over the simulation period. Based on results of the water balance model and the derived elevation storage relationship, tailings will be deposited in the open pit for a total of 37 months reaching an elevation in the pit of 90.5 m CGVD 2013. As originally planned in the approved Touquoy Gold Mine Project Reclamation Plan (Stantec 2017b), the inflow of groundwater, surface runoff and precipitation into the pit will naturally create a lake upon closure of the site. The water balance model simulated that it would take an additional 69 months or a total of 106 months from commencement of Beaver Dam operation to fill the pit to the spillway invert elevation. Figures 4.3 and 4.4 illustrate the predicted water and tailings elevation and storage volume in the exhausted Touquoy open pit over a 10-year simulation period, respectively. Model results are summarized in Table 4.1 for the TMF and open pit. The model simulated the predicted month of operation when the source of reclaim is relocated from the TMF to the open pit, the end of Beaver Dam ore processing, and the monthly volume of water spilled and conveyed to Moose River during closure. During closure, the flow volume to Moose River is simulated to be similar to pre-development conditions of the mine site. Table 4.1 shows the water and tailings volume and elevation in the open pit and also the water volume in the TMF for the first 5 months of start-up.

Based on results of the water balance model, process water can be reclaimed from the TMF for approximately 3-5 months depending on the climatic conditions and with no water discharged to the effluent treatment plant during this time to maintain the reservoir supply. When the TMF pond volume is no longer adequate for process water supply, process water will be reclaimed from the open pit as a closed loop,with the exception of freshwater make-up from Scraggy Lake. Figure 4.5 shows the water volume in the TMF decrease as process water is reclaimed from the pond and then begin to recover when the process water reclaim barge is relocated to the open pit. In the open pit, the figure shows the pond volume increase as tailings slurry is discharged to the pit and starts to decrease when the process water reclaim barge is relocated to the open pit. Water supply in the open pit is adequate for operation of Beaver Dam under normal and wet climate conditions, considering the 5.8% fresh water make-up from Scraggy Lake. Should operation commence under dry climate conditions, there will be little water available in the TMF for reclaim and insufficient time to store water in the open pit prior to start-up. The water balance simulated a water deficit under dry climate conditions that would require takings exceeding the permitted water volume from Scraggy Lake for Touquoy operation. Therefore, under dry climate conditions or based on the operational requirements of pumping infrastructure, start-up water in the open pit may be supplied from Scraggy lake (subject to provincial permitting) and/or effluent from the effluent treatment plant.

As mill production rates at Beaver Dam remain consistent to Touquoy, existing Touquoy reclaim water lines and tailings slurry lines are anticipated to be adequate both in capacity and length for Beaver Dam ore processing. Additional lift booster pumps may be required to reclaim water from the open pit. Methods for Tailings Deposition in the open pit will differ during cold and mild climatic conditions and the tailings deposition progress should be monitored and updated as more information becomes available.

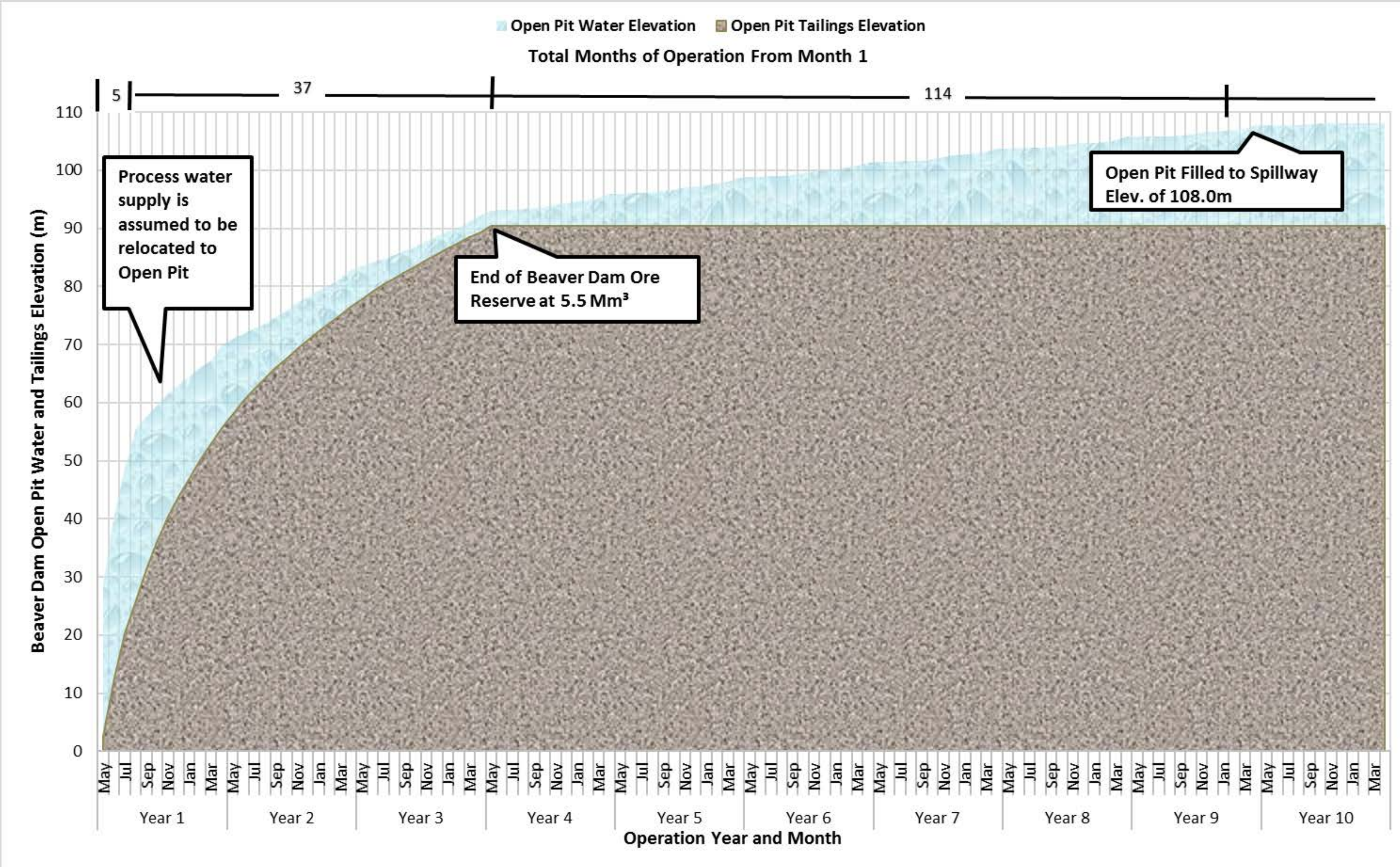

Figure 4.3 Tailings and Water Elevation in the Exhausted Touquoy Open Pit

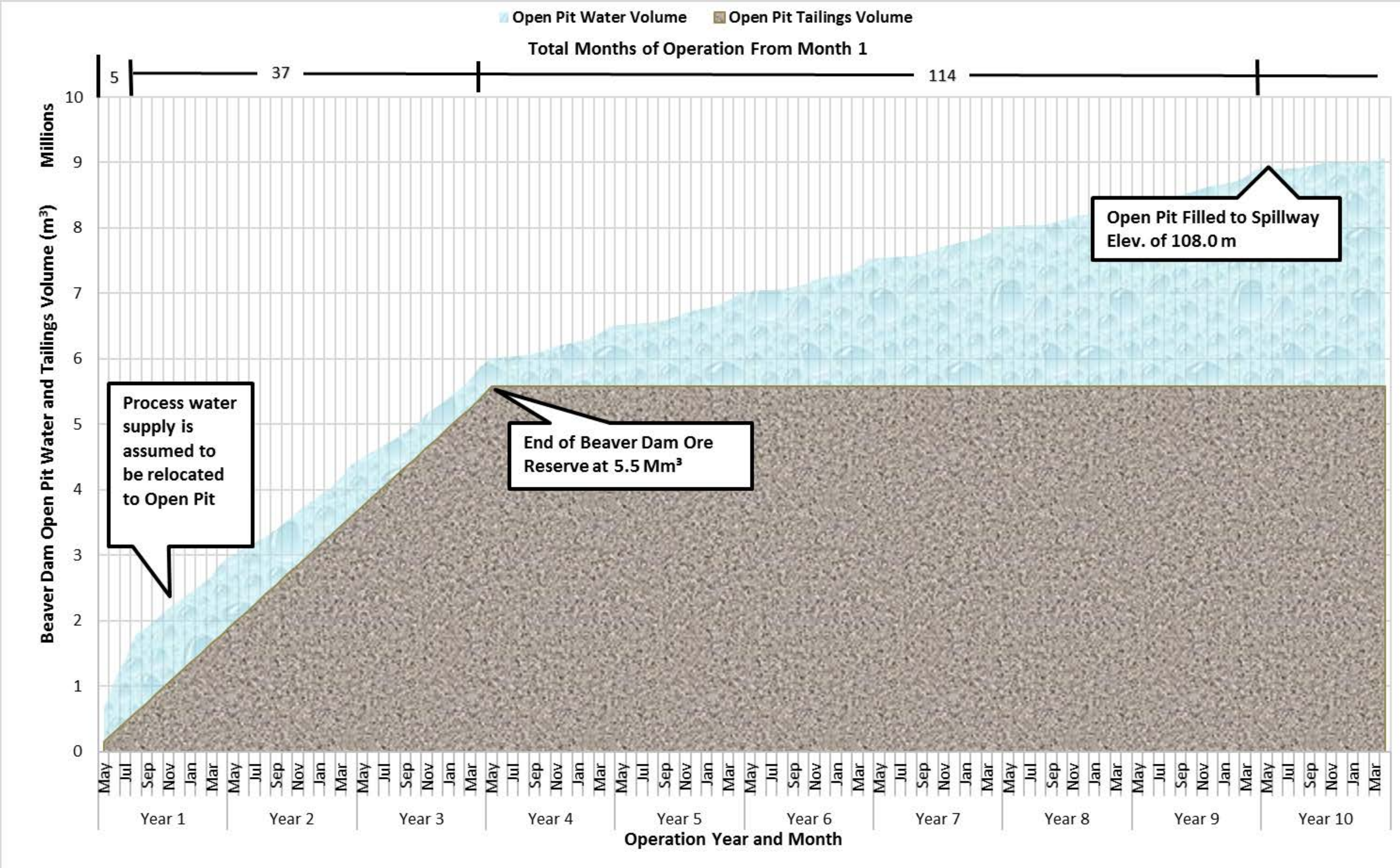

Figure 4.4 Tailings and Water Storage in the Exhausted Touquoy Open Pit

Table 4.1 TMF and Open Pit Storage (Elevation and Volume)

Year	Month of Year	Open Pit Tailings Volume (m³)	Open Pit Tailings Elevation (m)	Open Pit Water Volume (m³)	Open Pit Water and Tailings Elevation (m)	TMF Water Available for Reclaim (m³)
	Initial	0	-25.0	273,339	11.2	1,054,546
Year 1	May	149,744	2.7	526,523	28.8	829,022
	June	299,487	12.7	770,733	40.9	603,351
	July	449,231	20.3	982,362	48.7	366,222
	Aug	598,974	26.0	1,197,905	55.6	126,813
	Sep	748,718	31.3	1,161,263	57.5	
	Oct	898,462	36.1	1,136,838	59.5	
	Nov	1,048,205	40.4	1,138,627	61.5	
	Dec	1,197,949	43.8	1,109,257	63.1	
	Jan	1,347,692	47.0	1,073,399	64.5	
	Feb	1,497,436	50.1	1,047,749	65.9	
	Mar	1,647,179	52.9	1,023,530	67.3	
	Apr	1,796,923	55.6	1,108,181	69.9	
Year 2	May	1,946,667	58.1	1,059,162	70.9	
	June	2,096,410	60.4	1,004,783	71.8	
	July	2,246,154	62.3	943,864	72.7	
	Aug	2,395,897	64.2	886,858	73.6	
	Sep	2,545,641	65.9	850,216	74.7	
	Oct	2,695,385	67.6	825,791	75.8	
	Nov	2,845,128	69.3	827,580	77.2	
	Dec	2,994,872	70.8	798,210	78.2	
	Jan	3,144,615	72.3	762,352	79.2	
	Feb	3,294,359	73.7	736,702	80.2	
	Mar	3,444,103	75.1	743,870	81.4	
	Apr	3,593,846	76.5	797,134	82.8	
Year 3	May	3,743,590	77.8	748,115	83.5	
	June	3,893,333	79.1	693,736	84.2	
	July	4,043,077	80.3	632,817	84.8	
	Aug	4,192,821	81.4	575,812	85.4	
	Sep	4,342,564	82.5	539,169	86.1	
	Oct	4,492,308	83.5	514,744	86.9	
	Nov	4,642,051	84.5	516,533	87.9	
	Dec	4,791,795	85.5	487,163	88.6	
	Jan	4,941,538	86.5	451,305	89.4	
	Feb	5,091,282	87.5	425,655	90.1	
	Mar	5,241,026	88.4	432,823	91.1	
	Apr	5,390,769	89.3	486,087	92.3	
Year 4	May	5,576,923	90.5	437,069	93.1	
	June	5,576,923	90.5	450,000	93.1	
	July	5,576,923	90.5	458,637	93.2	
	Aug	5,576,923	90.5	471,187	93.3	
	Sep	5,576,923	90.5	501,856	93.4	
	Oct	5,576,923	90.5	546,986	93.7	
	Nov	5,576,923	90.5	616,087	94.1	
	Dec	5,576,923	90.5	656,272	94.3	
	Jan	5,576,923	90.5	689,970	94.5	
	Feb	5,576,923	90.5	727,705	94.8	
	Mar	5,576,923	90.5	804,428	95.2	
	Apr	5,576,923	90.5	925,003	95.9	

Year	Month of Year	Open Pit Tailings Volume (m³)	Open Pit Tailings Elev (m)	Open Pit Water Volume (m³)	Open Pit Water and Tailings Elevation (m)
Year 5	May	5,576,923	90.5	945,540	96.0
	June	5,576,923	90.5	958,472	96.1
	July	5,576,923	90.5	967,109	96.1
	Aug	5,576,923	90.5	979,659	96.2
	Sep	5,576,923	90.5	1,010,328	96.4
	Oct	5,576,923	90.5	1,055,458	96.6
	Nov	5,576,923	90.5	1,124,558	97.0
	Dec	5,576,923	90.5	1,164,744	97.2
	Jan	5,576,923	90.5	1,198,442	97.4
	Feb	5,576,923	90.5	1,236,177	97.6
	Mar	5,576,923	90.5	1,312,900	98.0
	Apr	5,576,923	90.5	1,433,475	98.7
Year 6	May	5,576,923	90.5	1,454,012	98.8
	June	5,576,923	90.5	1,466,944	98.9
	July	5,576,923	90.5	1,475,580	98.9
	Aug	5,576,923	90.5	1,488,130	99.0
	Sep	5,576,923	90.5	1,518,799	99.2
	Oct	5,576,923	90.5	1,563,930	99.4
	Nov	5,576,923	90.5	1,633,030	99.8
	Dec	5,576,923	90.5	1,673,216	100.0
	Jan	5,576,923	90.5	1,706,913	100.2
	Feb	5,576,923	90.5	1,744,648	100.4
	Mar	5,576,923	90.5	1,821,372	100.7
	Apr	5,576,923	90.5	1,941,947	101.3
Year 7	May	5,576,923	90.5	1,962,484	101.4
	June	5,576,923	90.5	1,975,416	101.5
	July	5,576,923	90.5	1,984,052	101.5
	Aug	5,576,923	90.5	1,996,602	101.6
	Sep	5,576,923	90.5	2,027,271	101.7
	Oct	5,576,923	90.5	2,072,402	102.0
	Nov	5,576,923	90.5	2,141,502	102.3
	Dec	5,576,923	90.5	2,181,687	102.5
	Jan	5,576,923	90.5	2,215,385	102.6
	Feb	5,576,923	90.5	2,253,120	102.8
	Mar	5,576,923	90.5	2,323,674	103.1
	Apr	5,576,923	90.5	2,438,279	103.7
Year 8	May	5,576,923	90.5	2,452,648	103.8
	June	5,576,923	90.5	2,459,609	103.8
	July	5,576,923	90.5	2,462,077	103.8
	Aug	5,576,923	90.5	2,468,458	103.8
	Sep	5,576,923	90.5	2,493,157	103.9
	Oct	5,576,923	90.5	2,532,118	104.1
	Nov	5,576,923	90.5	2,595,249	104.4
	Dec	5,576,923	90.5	2,629,265	104.6
	Jan	5,576,923	90.5	2,656,794	104.7
	Feb	5,576,923	90.5	2,688,907	104.9
	Mar	5,576,923	90.5	2,759,461	105.2
	Apr	5,576,923	90.5	2,874,066	105.7

Year	Month of Year	Open Pit Tailings Volume (m³)	Open Pit Tailings Elev (m)	Open Pit Water Volume (m³)	Open Pit Water and Tailings Elevation (m)
Year 9	May	5,576,923	90	2,888,434	106
	June	5,576,923	90	2,895,396	106
	July	5,576,923	90	2,897,864	106
	Aug	5,576,923	90	2,904,245	106
	Sep	5,576,923	90	2,928,944	106
	Oct	5,576,923	90	2,967,905	106
	Nov	5,576,923	90	3,031,036	106
	Dec	5,576,923	90	3,065,052	107
	Jan	5,576,923	90	3,092,581	107
	Feb	5,576,923	90	3,124,694	107
	Mar	5,576,923	90	3,195,248	107
	Apr	5,576,923	90	3,309,853	108
Year 10	May	5,576,923	90	(14,368)	108
	June	5,576,923	90	(21,330)	108
	July	5,576,923	90	(23,797)	108
	Aug	5,576,923	90	(30,178)	108
	Sep	5,576,923	90	(54,877)	108
	Oct	5,576,923	90	(93,839)	108
	Nov	5,576,923	90	(138,657)	108
	Dec	5,576,923	90	(109,543)	108
	Jan	5,576,923	90	(103,055)	108
	Feb	5,576,923	90	(107,639)	108
	Mar	5,576,923	90	(146,081)	108
	Apr	5,576,923	90	(190,131)	108
Year 11	May				
	June				
	July				
	Aug				
	Sep				
	Oct				
	Nov				
	Dec				
	Jan				
	Feb				
	Mar				
	Apr				
Year 12	May				
	June				
	July				
	Aug				
	Sep				
	Oct				
	Nov				
	Dec				
	Jan				
	Feb				
	Mar				
	Apr				

Legend: Time When Reclaim is Relocated to Open Pit (yellow); End of Beaver Dam Ore Processing (green); Water Volume Spilled (blue)

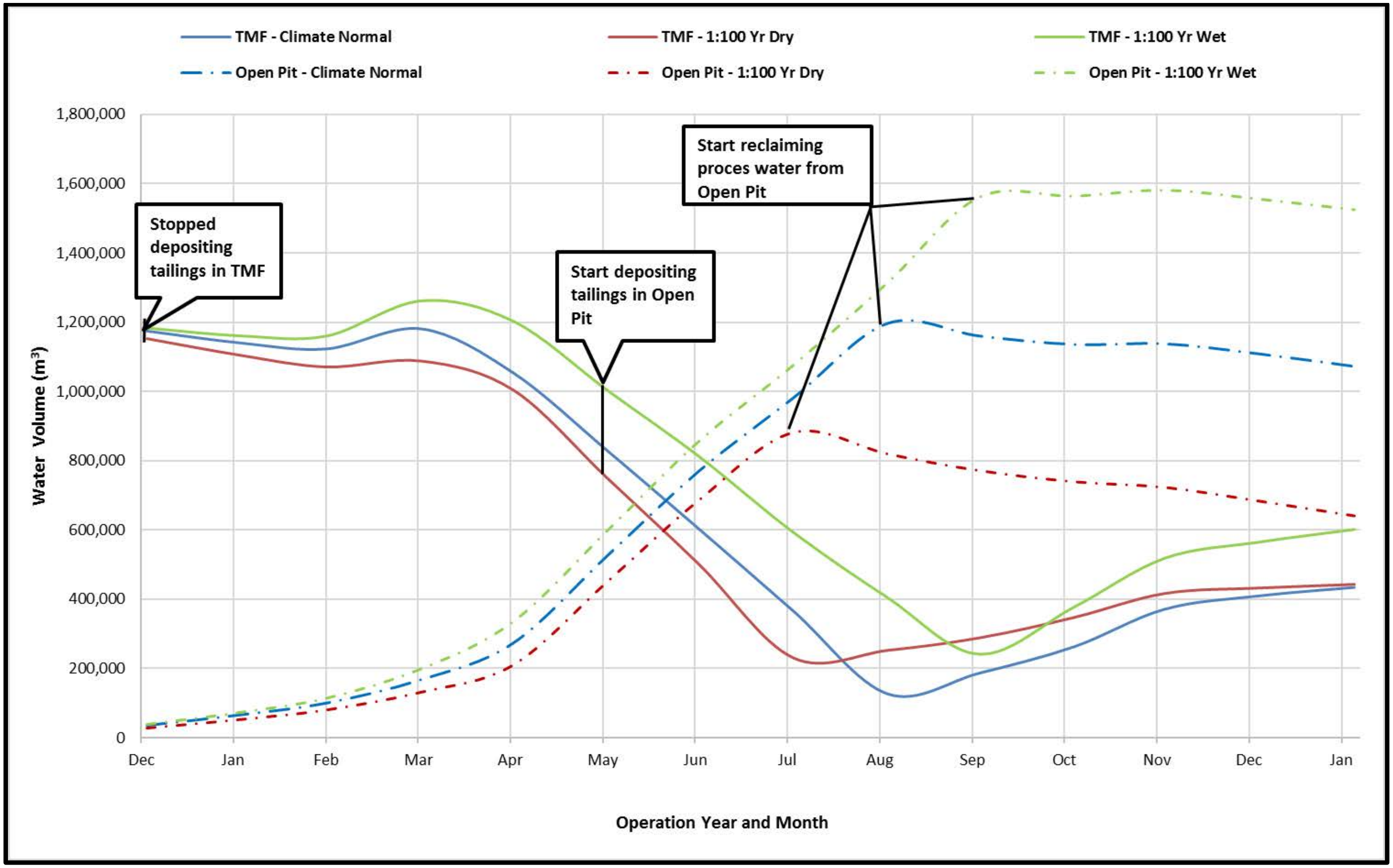

Figure 4.5 Water Volume Simulated at Start-up of Beaver Dam Ore Processing

5.0 WATER QUALITY MODEL

Beaver Dam ore processing amounts to approximately 5.577 Mm^3 of tailings deposited sub-aqueously in the exhausted open pit. Deposition of tailings in the exhausted open pit will alter water quality in the pit compared to filling of the pit as per the Touquoy reclamation plan (Stantec 2017b). The monthly water quality model (Stantec 2018d) for the exhausted Touquoy open pit was developed to simulate the overall water quality of metal parameters, cyanide, and nitrogen species (including ammonia, nitrate, and nitrite) during operation, reclamation, and closure of the Beaver Dam project. The objectives of the Touquoy water quality model are to predict future water quality and inform water treatment required prior to the pit lake effluent discharge to Moose River, and the water quality of effluent discharge to Moose River at aquatic monitoring stations. The environmental effects of predicted discharge water quality in the Moose River are assessed.

5.1 MODEL INPUTS AND ASSUMPTIONS

5.1.1 Geochemical Source Terms

Water quality modelling considered the pore water quality in the tailings, the groundwater inflow quality in the pit floor/ walls, surface runoff, direct precipitation, process water surplus, and the geochemistry of the individual water quality parameters. As discussed in the source terms memo (Lorax 2018), the pore water quality in the tailings and pit walls/floor was based on geochemical source term model predictions derived from upscaling of kinetic tests and Touquoy monitoring data. The geochemical model simulated the oxidation and reduction reactions to understand the water quality of the mixed pit lake quality based on the geochemistry of the individual water quality parameters during operation and reclamation. The kinetic testing and Touquoy monitoring data were considered representative for Beaver Dam ore processing as the Beaver Dam and Touquoy pits mine ore from the same geologic formation with similar marker parameter content and Beaver Dam ore processing and cyanide detoxification in the Touquoy mill will follow the same general approach as the Touquoy ore processing (Lorax 2018).

Using the Touquoy TMF as a site analogue for saturation indices (Lorax 2018), solubility caps were predicted for iron (0.10 mg/L at end of mine and 0.039 mg/L at closure) and aluminum (0.178 mg/L at end of mine and 0.057 mg/L at closure). As recommended by Lorax (2018), a degradation rate for ammonia of $y = -0.0134x^2 + 0.4915x + 0.0676$ was applied, where x is the ammonia concentration in a given year. The degradation rate for ammonia was capped at 4.57 mg/L/yr for ammonia concentrations of 18.35 mg/L or above. Degraded ammonia was converted to nitrate and nitrite in operation and reclamation, at ratios provided by Lorax. During operation, a higher proportion of nitrite was predicted due to competing oxygen-consuming mechanisms where 25% as NO_3 and 75% as NO_2 (Lorax 2018). Within approximately 3 years following completion of tailings deposition, most of the nitrite was estimated to oxidize to nitrate with 98% as NO_3 and 2% as NO_2.

The water quality of the source terms are combined with the water balance model flows to predict monthly discharge water quality over 50 years beginning at the start of operation of Beaver Dam, simulating steady state conditions for all source terms provided by Lorax.

Process freshwater make-up water requirements of approximately 5.8% of production or 544 m^3/d will be sourced from Scraggy Lake as per the existing NSE approval for Touquoy ore processing or other sources as directed in the NSE approval for Beaver Dam. Should additional process make-up water be required in a water reclaim deficit scenario, the Scraggy Lake supply will be supplemented with treated effluent from the existing Touquoy mine polishing pond.

Based on results of the groundwater flow model (Stantec 2018b), the open pit acts solely as a sink (i.e., gaining groundwater to the Touquoy open pit) at pit lake stages lower than 104 m in elevation. The interaction between the Touquoy open pit lake and Moose River is limited to groundwater flow from Moose River to the pit during this period. Therefore, no water quality effects to Moose River are predicted during this period. When the pit lake level rises into and above the more permeable geological units at elevations above 104 m, the groundwater flow gradients will begin to reverse, and seepage from the open pit will migrate towards the Moose River as baseflow at a rate of approximately 310 m^3/d. The flow rate in Moose River in April is 125 times this rate, and therefore represents a dilution ratio of approximately 125.

The water quality model predicts the effluent discharge quality from the open pit during reclamation and closure. Effluent discharge water quality from the pit lake to Moose River is required to meet MDMER discharge limits. Therefore, it was assumed that any effluent quality for any parameter that exceeds the MDMER limits will be treated to meet the MDMER limits. Discharge from the open pit is not anticipated until after 2021, therefore the MDMER discharge limits for an existing mine after June 1, 2021 were used as minimum treatment criteria for effluent discharges to Moose River. An assimilative capacity study of Moose River (Stantec 2018f) was completed to simulate the mixed water quality at the future MDMER biological monitoring stations located at 100 m, 200 m, and 1000 m downstream of the effluent discharge point.

5.1.2 Water Treatment

Similar to Touquoy ore processing, the tailings slurry from the processed Beaver Dam ore will be subject to cyanide destruction at the process plant before flowing to the exhausted open pit. Based on water quality monitoring results at Touquoy for existing operation, cyanide destruction to cyanate is 99.5% effective (Lorax 2018). Cyanate readily complexes with metals and can precipitate under increased pH conditions. The majority of the residual cyanide reagent introduced to the tailings during ore processing will be degraded and hydrolyzed to carbon dioxide and ammonium during storage in the tailings pond. Similarly, this will be expected to occur for the Beaver Dam tailings being stored in the Touquoy open pit. Potential failures related to cyanide recovery and proposed open pit disposal will be addressed in updates to the existing Touquoy groundwater contingency plan (Stantec 2018c), as required in the Industrial Approval for the Touquoy mine site.

Continued use of the existing effluent treatment plant located downstream of the tailings pond is planned to treat the pit lake until MDMER discharge limits are met. The water quality of the pit lake will be monitored during the pit filling and as the pit level approaches the spillway elevation. The water quality will be compared to the MDMER discharge limits and will be treated as required to meet these limits and any additional regulatory closure criteria or site-specific guidelines. The MDMER discharge limits will decrease from the existing limits to those presented in Table 5.1 effective June 1, 2021. The discharge from the Touquoy mine site is anticipated to occur after this period, and therefore the lower MDMER limits will apply.

Table 5.1 Schedule 4 Limits of the Metal and Diamond Mining Effluent Regulations

Deleterious Substance	Maximum Authorized Monthly Mean Concentration	Maximum Authorized Concentration in a Composite Sample	Maximum Authorized Concentration in a Grab Sample
Arsenic	0.30 mg/L	0.45 mg/L	0.6 mg/L
Copper	0.30 mg/L	0.45 mg/L	0.60 mg/L
Cyanide	0.5 mg/L	0.75 mg/L	1.00 mg/L
Lead	0.10 mg/L	0.15 mg/L	0.20 mg/L
Nickel	0.50 mg/L	0.75 mg/L	1.00 mg/L
Zinc	0.50 mg/L	0.75 mg/L	1.00 mg/L
Total Suspended Solids	15.00 mg/L	22.50 mg/L	30.00 mg/L
Radium 226	0.37 Bq/L	0.74 Bq/L	1.11 Bq/L
Un-Ionized Ammonia	0.50 mg/L (as nitrogen)	Not applicable	1.00 mg/L (as nitrogen)

5.2 MODEL RESULTS

Water quality modelling considered the pore water quality in the tailings and the pit floor/ walls, the dilution from surface runoff, direct precipitation in the pit and the water quality of the mixture based on the geochemistry of the individual water quality parameters. As presented by Lorax (2018), geochemical source term predictions of pore water quality of pit walls/floor had elevated metal (e.g., arsenic, cobalt, copper), ammonia, nitrate and cyanide concentrations thus reducing pit lake water quality at the time of discharge. In February of Beaver Dam mine year 10 when the pit lake is simulated to reach the spillway elevation, the water quality model predicted elevated concentrations of arsenic, cobalt, copper, nitrate, nitrite as summarized in Table 5.2 not considering planned water treatment. Results of the water quality model in the exhausted open pit over time for metals, ammonia, and cyanide parameters are presented in Appendix A, not considering planned water treatment. These figures show the water quality trend over time and the outflow to Moose River.

Table 5.2 Predicted Water Quality Concentrations to Moose River, Not Considering Water Treatment

Parameter	Effluent Discharge Concentration (mg/) in Year 10	Groundwater Seepage Concentration (mg/L) in Year 50	Schedule 4 Limits MDMER Monthly Mean Concentration (mg/L)
(SO_4) Sulphate	206	0.626	
(Al) Aluminum	0.038	3.27E-05	

(Ag) Gold	0.0000311	6.98E-09	
(As) Arsenic	**0.802**	0.00214	0.30
(Ca) Calcium	57.6	0.0606	
(Cd) Cadmium	0.00000907	1.39E-08	
(Co) Cobalt	0.0597	1.83E-05	
(Cr) Chromium	0.000358	1.39E-07	
(Cu) Copper	0.0332	6.54E-06	0.30
(Fe) Iron	0.0307	2.27E-05	
(Hg) Mercury	0.0000167	3.49E-09	
(Mg) Magnesium	5.29	0.0103	
(Mn) Manganese	0.116	0.000258	
(Mo) Molybdenum	0.00805	4.21E-05	
(Ni) Nickel	0.0151	4.78E-06	0.50
(Pb) Leak	0.000239	1.73E-08	0.10
(Sb) Antimony	0.0037	4.21E-06	
(Se) Selenium	0.000688	1.35E-07	
(Tl) Silver	0.0000338	1.075E-08	
(U) Uranium	0.00341	1.42E-06	
(Zn) Zinc	0.00225	6.70E-06	0.5
(WAD CN) Weak Acid Dissociable Cyanide	0.114	3.49E-06	0.5
(Total CN) Total Cyanide	0.324	6.072E-05	
(NO_3) Nitrate (as N)	4.77	3.70E-05	
(NO_2) Nitrite (as N)	1.62	7.68E-05	
(NH_3) Ammonia	**0.595**	0.0237	0.50 (Unionized)

Note: Bold indicates an exceedance of MDMER discharge limit

Water quality that is predicted to exceed the MDMER discharge limits will be treated prior to discharge. The pit lake will be treated to meet MDMER discharge limits for an existing mine prior to discharge to Moose River, as presented on Table 5.2. As the pit lake is simulated to take approximately 10 years to fill from commencement of Beaver Dam ore processing, the final water treatment design will be fully developed during operation and pit filling. Proposed water treatment strategies include:

- Initial treatment of the pit as a batch reactor with the objective of adjusting the pH to precipitate metals to improve water quality in the pit lake as the pit is filling. As an additional benefit of the slow filling of the pit over time, the residence time and exposure to sunlight will increase, thus enhancing the natural UV degradation of cyanide and improving water quality in the pit lake.
- Should water treatment still be necessary, effluent from the pit will be pumped for treatment to the existing effluent treatment plant and discharged to the downstream polishing pond facilities and Scraggy lake receiving environment. Once water quality meets discharge criteria (i.e., representing closure conditions), surplus water in the pit will spill to a channel and discharge to Moose River. Discharge water quality will continue to be monitored against discharge criteria to identify if the pit should continue to be pumped and treated at the Touquoy effluent treatment plant.
- Pump and treat water in the open pit opportunistically, as the pit is filling and capacity is available in the existing effluent treatment plant.

As presented in the assimilative capacity study of Moose River by Stantec (2018d), the effluent concentrations under normal discharge from the filled Touquoy open pit, combined with the groundwater seepage contributions in Moose River under the same climate conditions are predicted. Moose River will primarily be driven by climatic conditions, with April flows representing a worst-case dilution ratio between the effluent discharge from the Touquoy open pit and Moose River. Based on results of the assimilative capacity model (Stantec 2018d), once mixed with the background water quality in Moose River, the concentration 100 m downstream of SW-2 is predicted to be 0.023 mg/L for arsenic and 0.184 for aluminum. Although the simulated arsenic concentration is above the NSE Tier 1 and CCME guidelines of 0.005 mg/L, the background levels at SW-2 also exceed the guidelines at 0.018 mg/L. The aluminum concentration is predicted below the 75th percentile receiver quality in Moose River. The potential environmental effects in Moose River from this predicted water quality are presented in the study by Intrinsic (2018).

Concentrations of cobalt, copper and nitrite in groundwater seepage discharging as baseflow to Moose River are predicted to be higher than the CCME FAL or NSE EQS guidelines (2018b). The groundwater seepage quality is simulated based on the source terms pore water quality of the tailings, with an estimated average concentration of 0.002 mg/L of arsenic to Moose River. However, based on the assimilative capacity model results, the mass loading from groundwater to Moose River is very small, and these parameters will meet CCME FAL/NSE EQS after mixing with Moose River within 100 m of the discharge point.

6.0 MODEL SENSITIVITY AND LIMITATIONS

Results of the water balance and quality model are based on information available at the time of the study, as sections above. It is recommended that the existing conditions and assumptions be updated as information becomes available, such as further developed reclamation plan, updates of the water balance/water management plan, updates to the mine plan, testing to predict settled tailings density, and the results of operational monitoring.

The 1:100 AEP wet and the 1:100 AEP dry climate statistics are used to provide an upper and lower bound of predicted climate normal conditions. Assuming the model assumptions reflect future conditions, water levels in the TMF and open pit during the 37 months of processing of Beaver Dam ore, should fall within these bounds. Stochastic combinations of wet and dry years were not modelled.

Model sensitivity to predicted open pit groundwater inflows were conducted by adjusting the groundwater contribution of 450 m^3/d associated to a pit water elevation of -25.0 m (CGVD 2013) to the groundwater contribution filled with water to elevation 104.0 m (CGVD 2013) of 251 m^3/d. This change would delay the timing of when the process water reclaim is relocated from the TMF to the open pit by 1 day.

The variation in the initial pond water volume between low and high operating levels in the TMF on the available water reclaim at time of start-up of Beaver Dam was modelled. Should the pond at the time of start-up be at a low operating level opposed to a high operating level, than the relocation of process water reclaim from the TMF to the open pit would be initiated 3 months after start-up, approximately 2 months earlier than if the pond is at a high operating level at start-up. Under this scenario, additional start-up water supplied by Scraggy lake would be required.

Sensitivity on the deposited tailings density in the open pit was simulated. The average deposited tailings density of 1.3 t/m^3 is expected, with a lower tailings density at start-up and a higher density as tailings are deposited in the open pit due to the consolidation of the tailings from the tailings and water mass. Should we consider the lower tailings density in the first year from 1.3 t/m^3 to 1.2 t/m^3, this will result in approximately 13,000 m^3/month of additional pore water lock-up, reducing the water available for reclaim during start-up.

7.0 SUMMARY & RECOMMENDATIONS

7.1 WATER MANAGEMENT

Water management at Touquoy for the Beaver dam ore processing was developed considering the existing process water requirements, existing water management infrastructure, the water inventory at the mine site, the available freshwater sources, and effluent water quality. Consistent with existing water management at the site, the TMF will receive runoff from the waste rock piles, and seepage collection ditches. Initially in Beaver Dam ore processing, process water will be reclaimed from the TMF until pond volumes are inadequate to meet process water requirements and reclaim will be taken from the open pit. Tailings slurry will be discharged to the exhausted Touquoy open pit upon commencement of processing of the Beaver Dam ore. Additional freshwater may be required from Scraggy lake for start-up under dry conditions. Surplus water in the TMF will be managed through the existing downstream discharge facilities and to the receiving environment at Scraggy Lake. Surplus water in the open pit will be managed through a spillway/channel to Moose River.

The water management plan should be updated to reflect the next stage of design. The Touquoy Closure plan should be updated to reflect the Beaver dam tailings deposition and the resultant accelerated filling of the Touquoy open pit and the changes to water quality. A water withdrawal approval from Scraggy Lake will be required from NSE for start-up process water supply.

7.2 TAILINGS DEPOSITION

It is assumed that tailings deposition will be performed using subaqueous deposition of a conventical tailings slurry through a barge. Deposition strategies will require routine modification based on the season. An approximate volume of deposited tailings, including porewater lock-up of 5.58 Mm^3 is required for processing of Beaver Dam ore. The capacity of the open pit can manage both the tailings and water volume, accommodating flood storage and freeboard.

The tailings management plan should be updated to reflect the next stage of design. A tailings deposition plan should be developed to support operation to define the monthly deposition areas.

7.3 WATER BALANCE MODEL

The water balance model provides an understanding of the water and tailings management for processing of the Beaver Dam ore.

The open pit in combination with the TMF is predicted to have sufficient process water for the Beaver Dam mine life. However, additional process water may be required from Scraggy Lake for start-up under dry climate conditions. The source of process water reclaim is triggered by the water elevation in the open pit, as a water management strategy. For example, initially process water will be reclaimed to the mill from the TMF through the existing reclaim barge and related water piping infrastructure until pond volumes are no longer adequate for process water reclaim. In approximately 5 months, process water will be reclaimed from the open pit as a closed loop between the pit and mill. Reclaiming process water initially from the TMF will reduce the required capacity of booster pumps in the open pit, as a greater capacity is required with depth. The existing reclaim water lines and decant pump could be retrofitted to accommodate the change to the source of the process water reclaim supply.

The water balance should be updated to reflect the next stage of design.

7.4 WATER QUALITY MODEL

Water quality modelling considered the pore water quality in the tailings and the pit floor and walls, dilution from surface runoff, direct precipitation in the pit, and the water quality of the mixture based on the geochemistry of the individual water quality parameters. Water quality is simulated to include elevated metals (e.g., arsenic, cobalt, copper), ammonia, nitrate and cyanide concentrations thus reducing pit lake water quality at the time of pit overflow discharge. The pit lake will be treated to meet applicable MDMER discharge limits for an existing mine prior to discharge to Moose River. As the pit lake was simulated to take approximately 10 years to fill from commencement of Beaver Dam ore processing, the water treatment design will be fully developed during operation and pit filling.

Water quality predictions and assimilative capacity in Moose River should be updated following an update of Beaver dam tailings source terms as a result of the on-going Beaver dam geochemistry assessment. Following this study, a water treatment plan should be further developed for implementation in operation and reclamation of Beaver Dam.

8.0 REFERENCES

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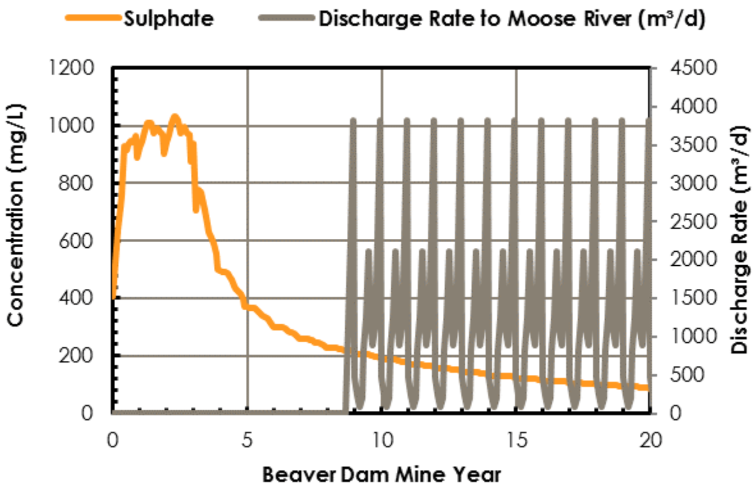
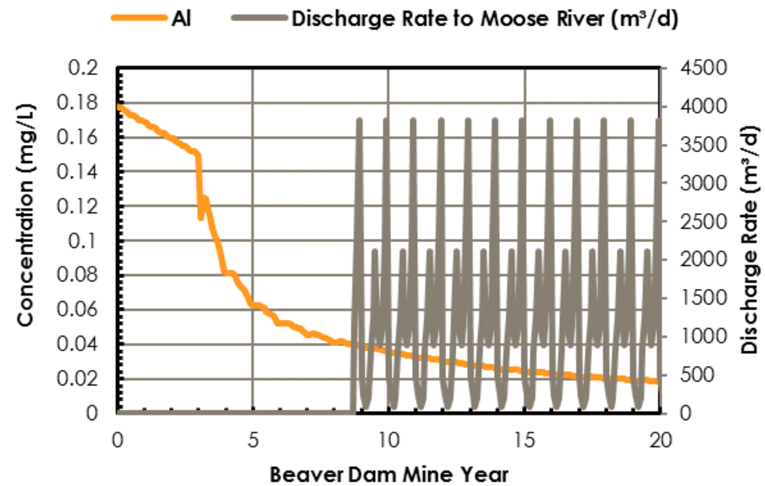
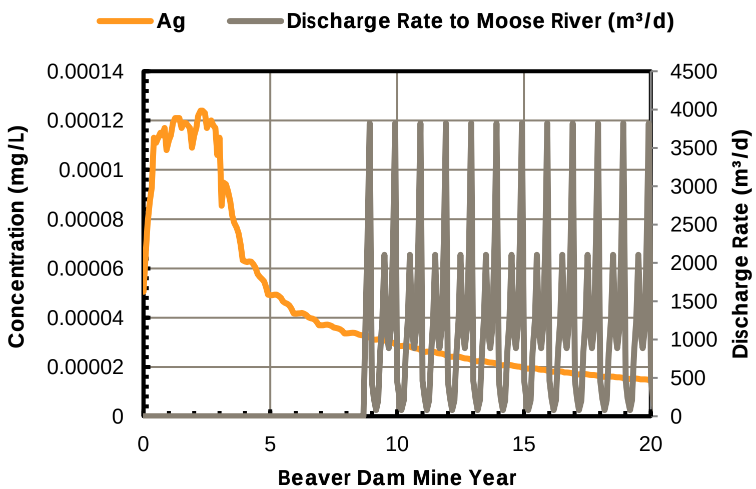
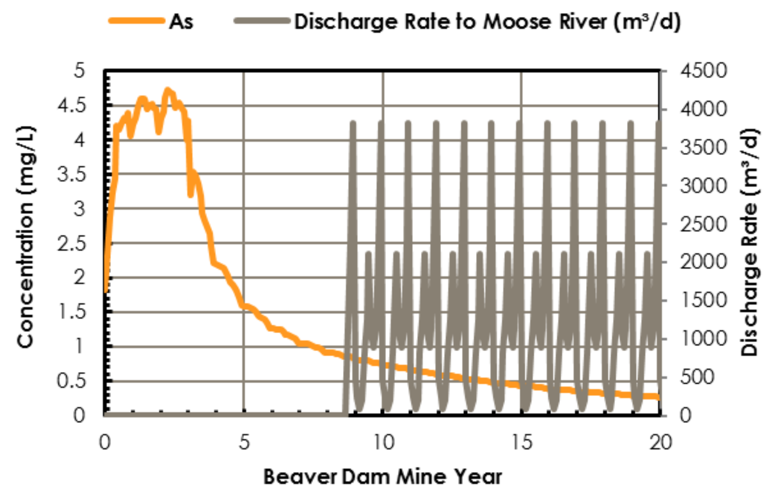
Appendix A WATER QUALITY PREDICTIONS

Open Pit Lake Quality


Sulphate
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year


Al
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year


Ag
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year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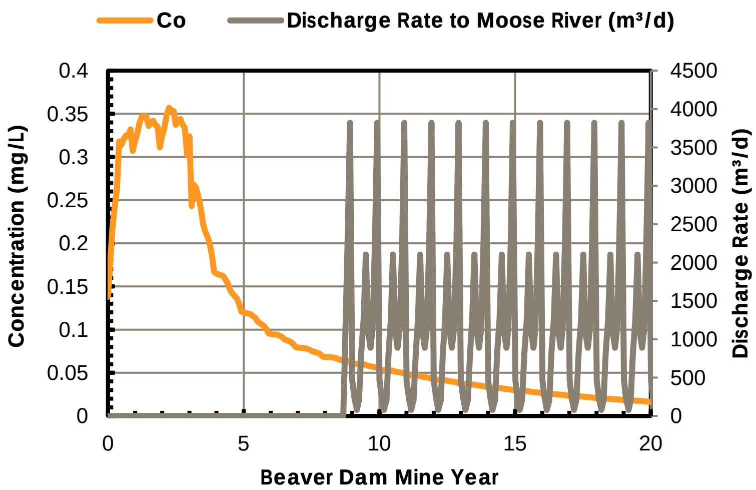
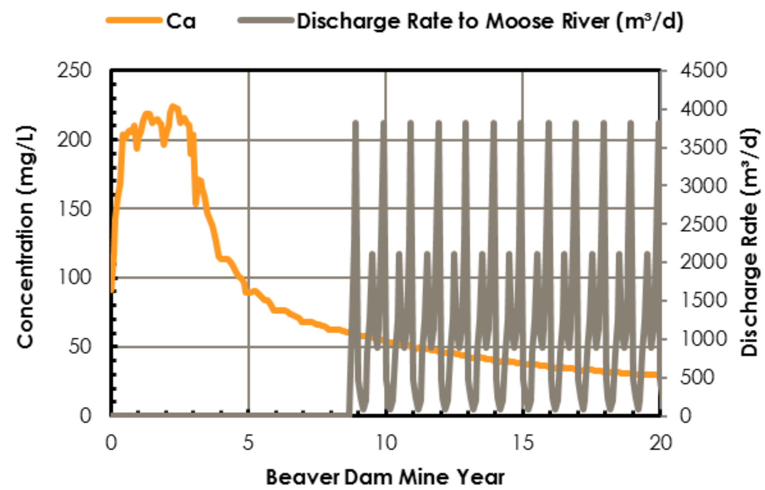
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year


Co
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20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Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
250
200
150
100
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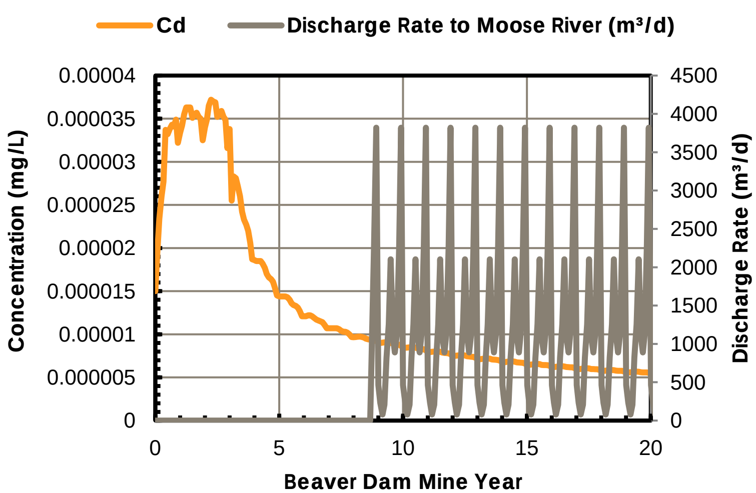
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20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Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
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0.00003
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0.00002
0.000015
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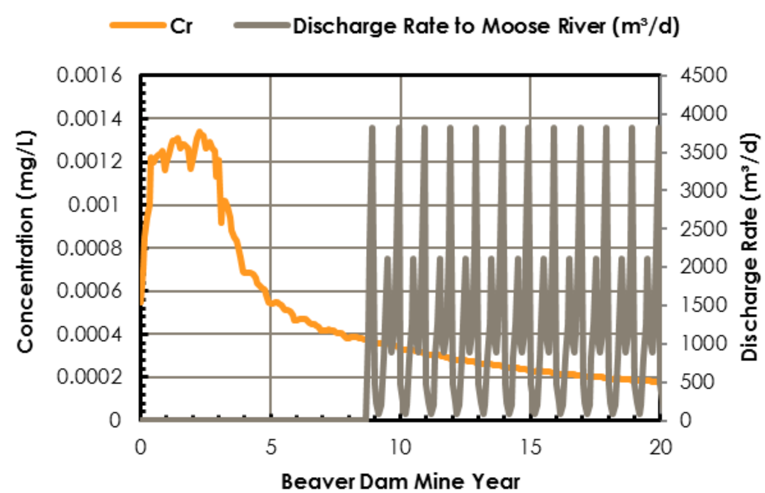
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Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
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0.0012
0.001
0.0008
0.0006
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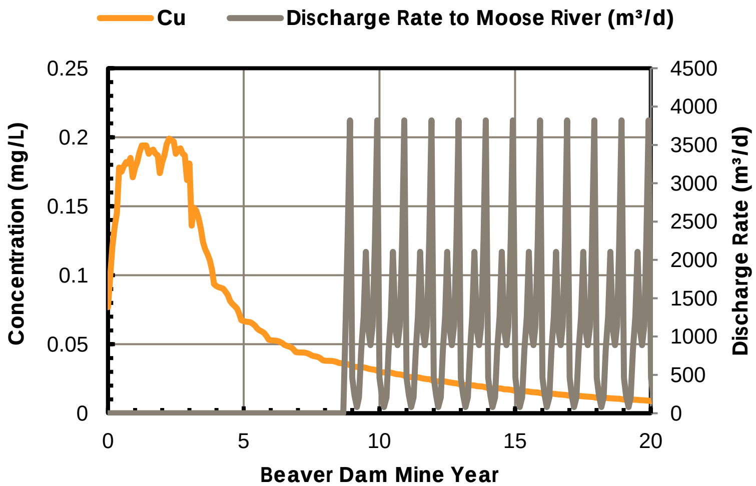
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Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
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3500
3000
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1000
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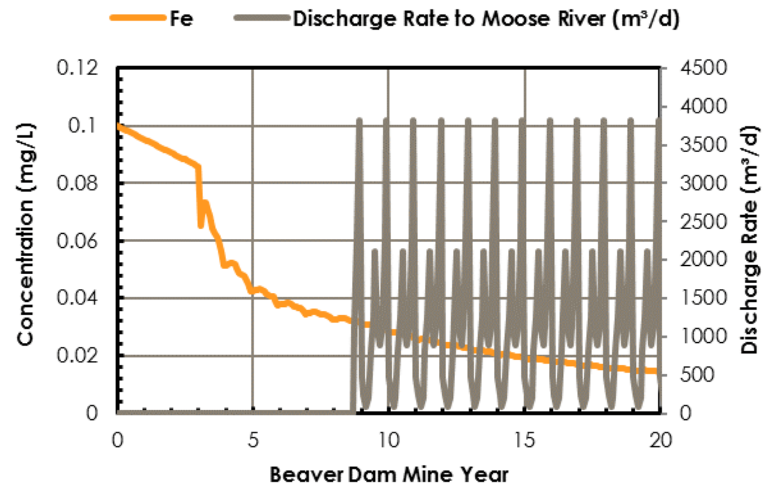
5
10
15
20


Fe
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
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0.08
0.06
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0.02
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4500
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3500
3000
2500
2000
1500
1000
500
5
10
15
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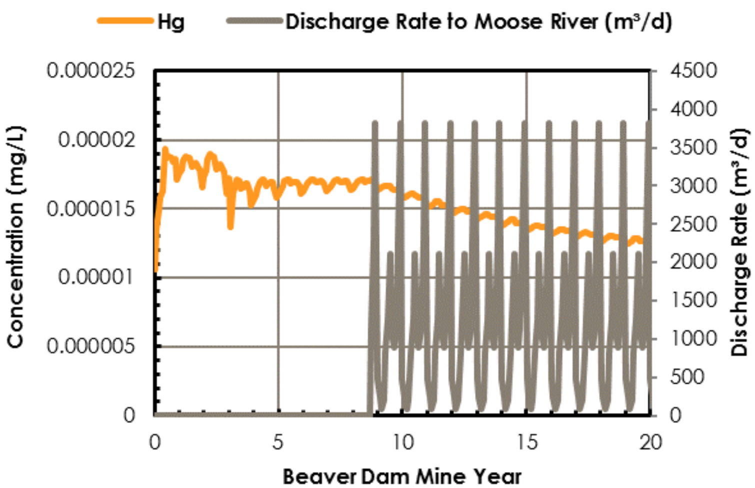
Hg
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
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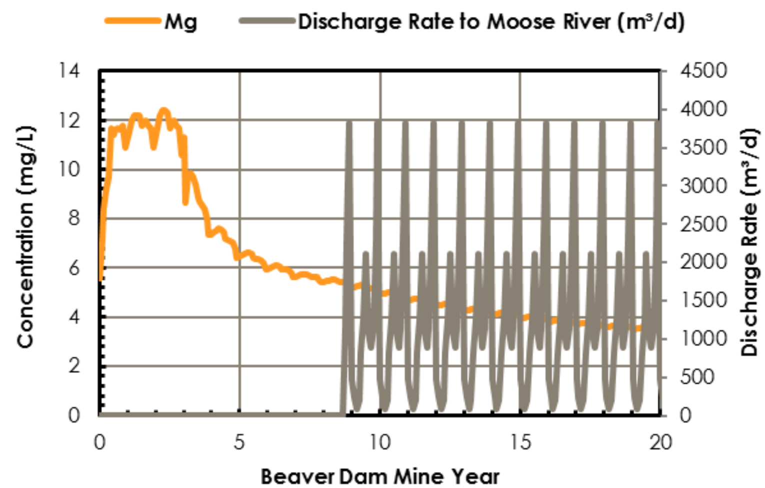
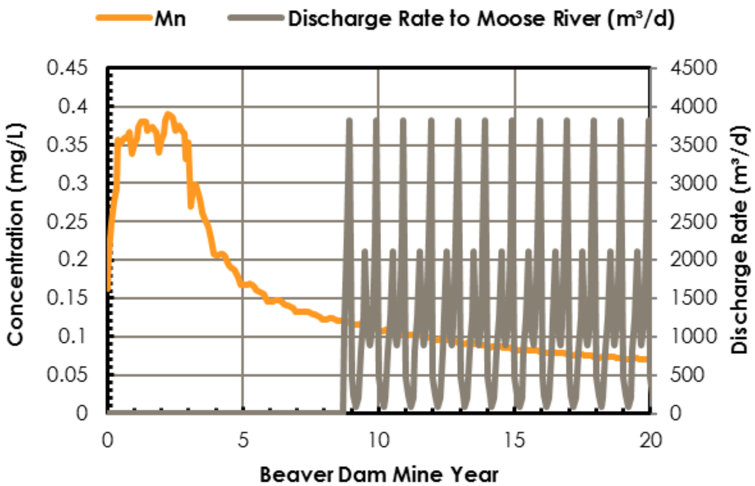
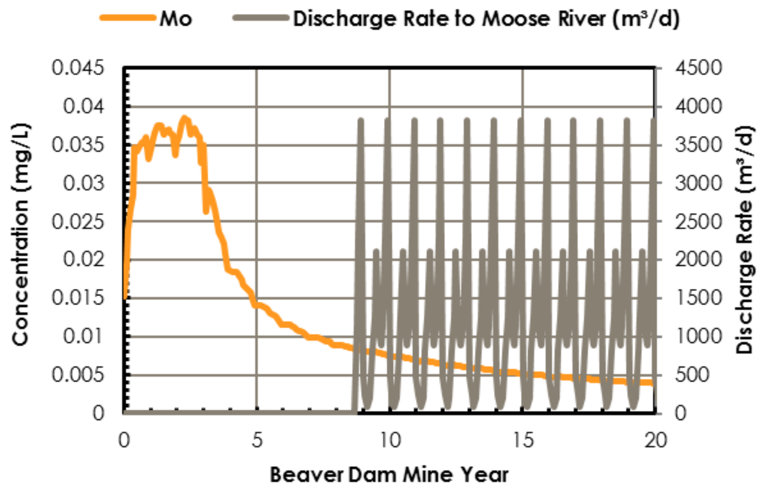
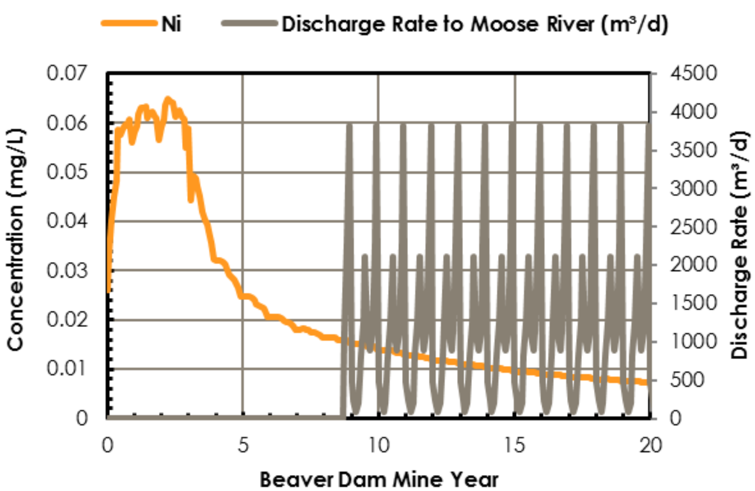
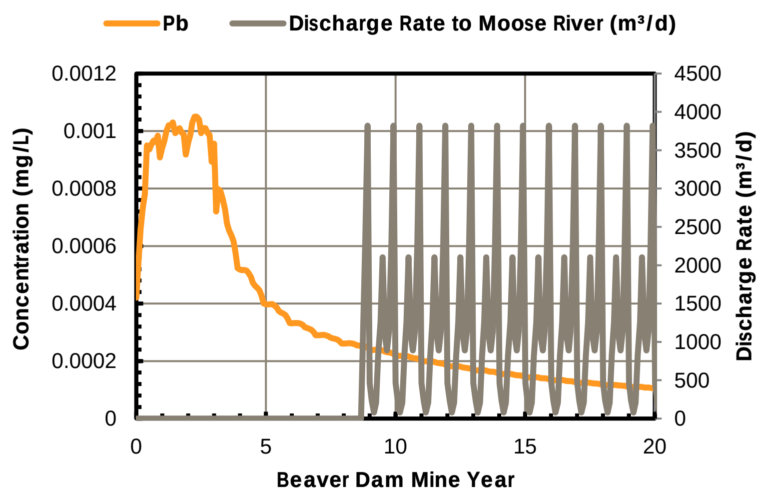
0.000015
0.00001
0.000005
0
4500
4000
3500
3000
2500
2000
1500
1000
500
5
10
15
20

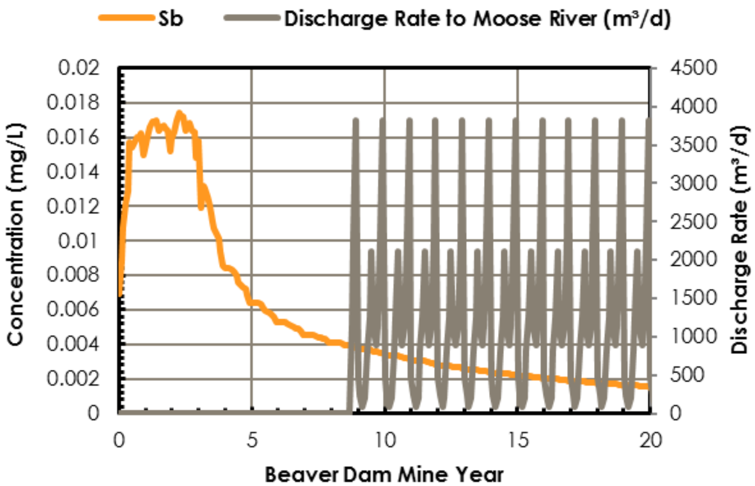

Mg
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
14
12
10
8
6
4
2
0
4500
4000
3500
3000
2500
2000
1500
1000
500
5
10
15
20

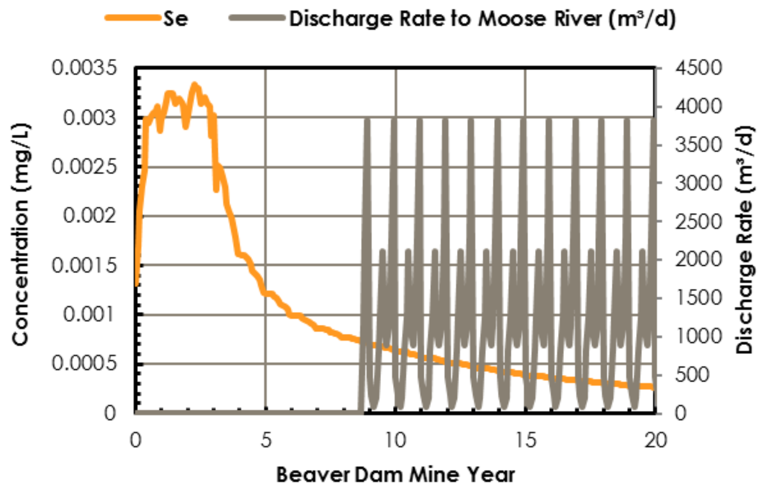

Mn
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
4500
4000
3500
3000
2500
2000
1500
1000
500
0
5
10
15
20

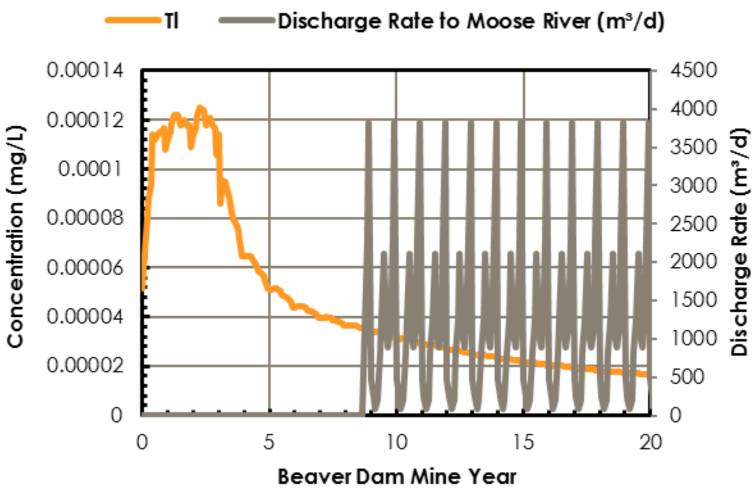

Mo
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
4500
4000
3500
3000
2500
2000
1500
1000
500
0
5
10
15
20

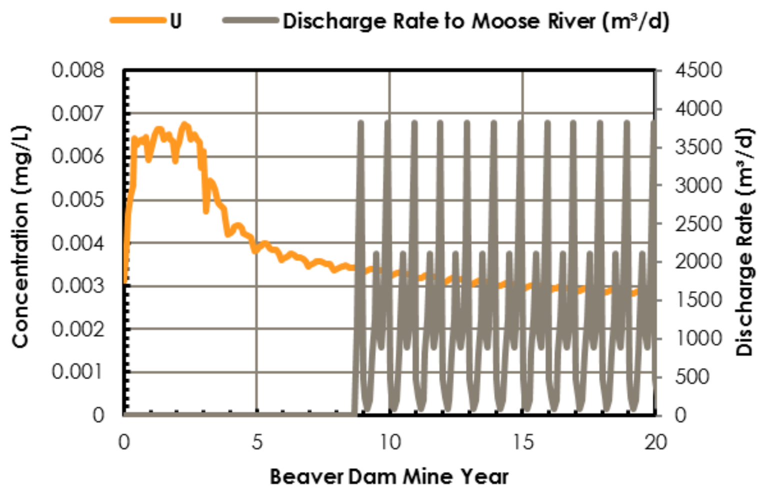

Ni
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
4500
4000
3500
3000
2500
2000
1500
1000
500
0
5
10
15
20

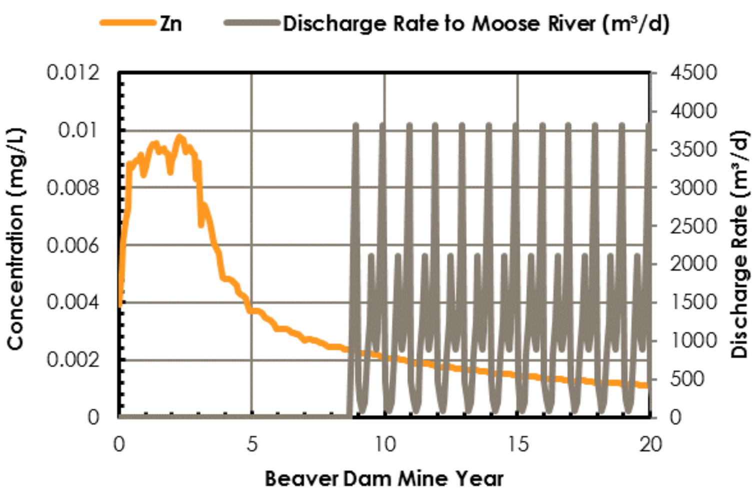

Pb
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
4500
4000
3500
3000
2500
2000
1500
1000
500
0
5
10
15
20

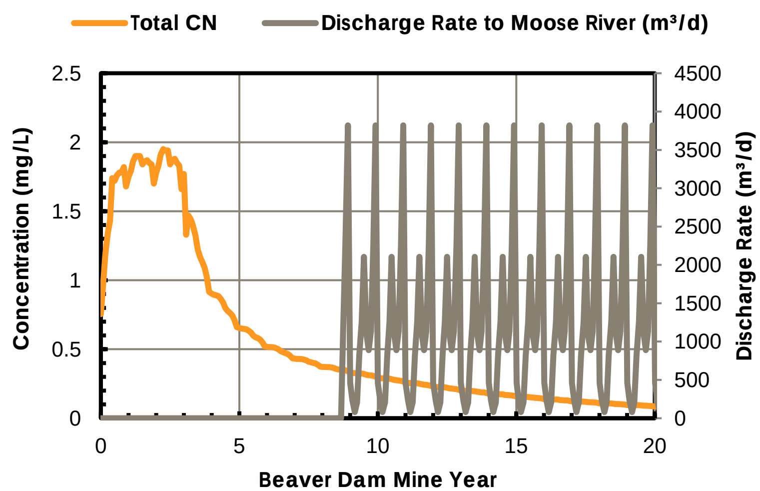

Sb
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year

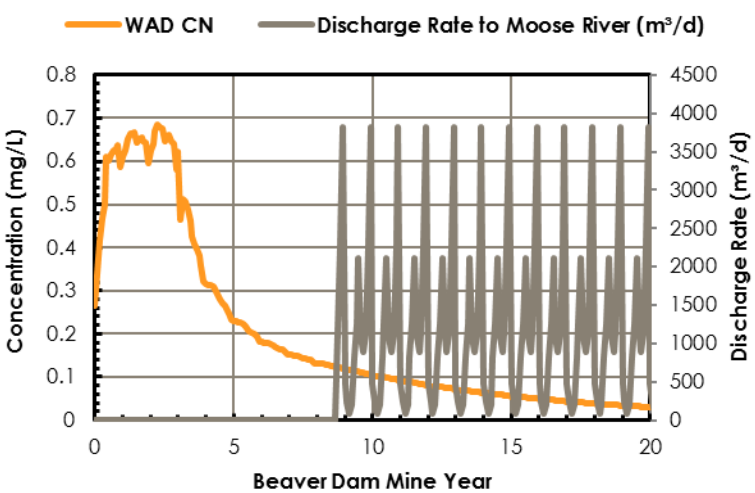

Se
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year

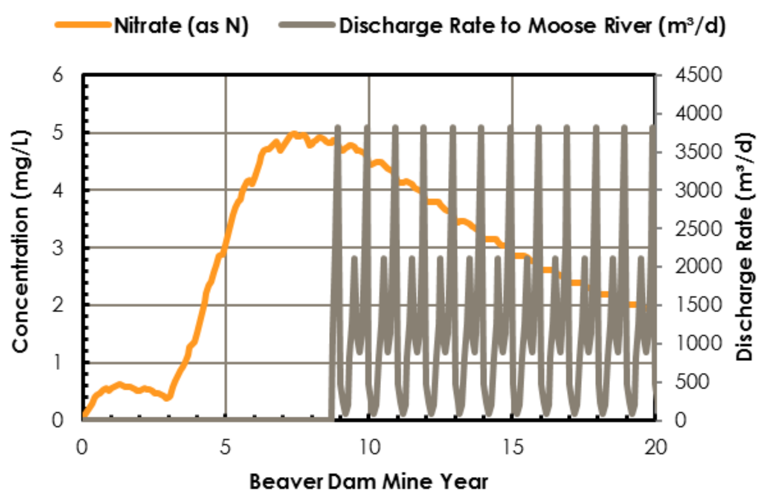

Tl
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year

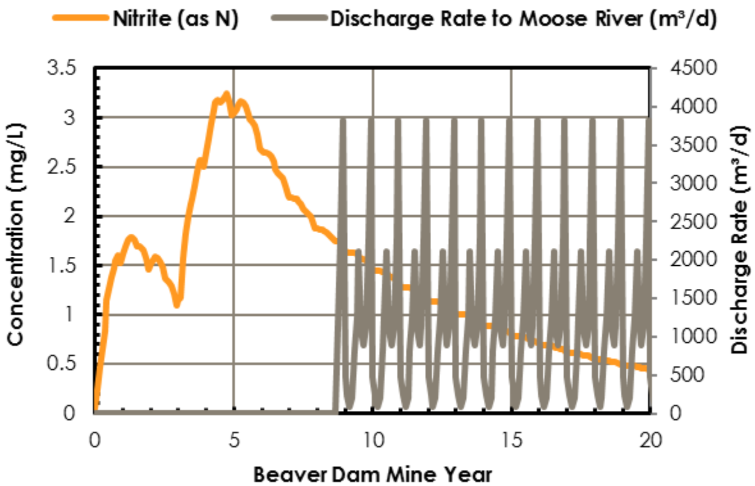

U
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year

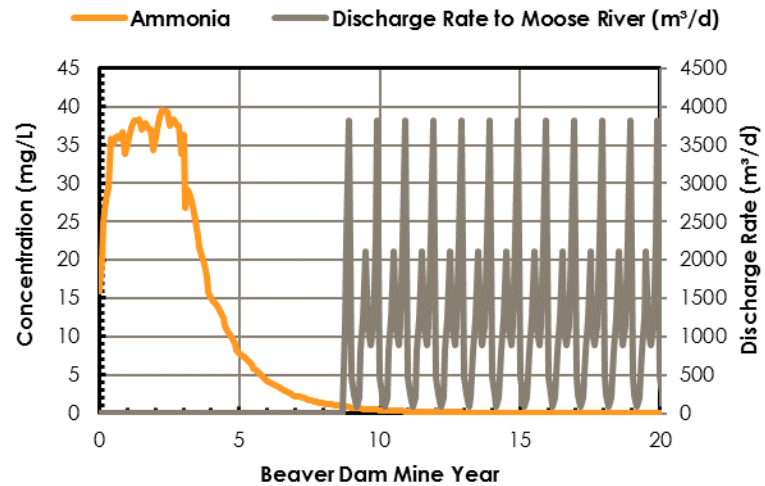

Zn
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year


Total CN
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year


WAD CN
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year


Nitrate (as N)
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year


Nitrite (as N)
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
0
0.5
1
1.5
2
2.5
3
3.5
0
500
1000
1500
2000
2500
3000
3500
4000
4500
0
5
10
15
20


Ammonia
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Beaver Dam Mine Year
0
5
10
15
20
25
30
35
40
45
0
500
1000
1500
2000
2500
3000
3500
4000
4500
0
5
10
15
20

Appendix G.3

Predictive Water Quality Assessment Beaver Dam Gold Mine

Predictive Water Quality Assessment

Beaver Dam Mine Site

Atlantic Gold Corporation

Table of Contents

Figure Index

Table Index

Table Index

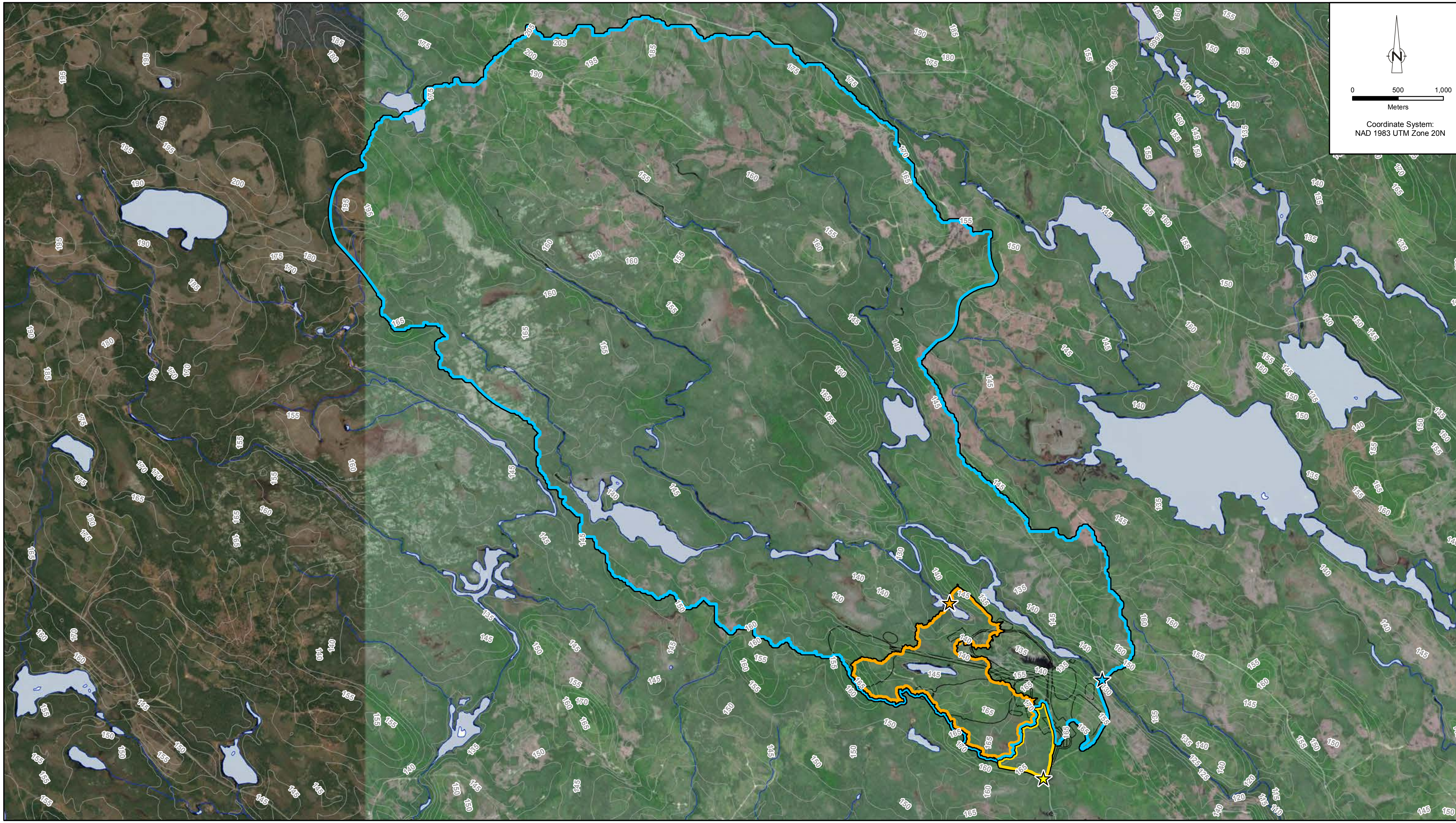
1. Introduction

GHD Limited (GHD) was retained by Atlantic Gold Corporation (AGC) to develop a Mine Water Management Plan (MWMP) for the Beaver Dam Gold Mine (Project) in Marinette, Halifax County (Site), Nova Scotia. The MWMP is in support of the Environmental Impact Statement (EIS). As part of the MWMP, GHD has completed a predictive water quality assessment for two life cycle stages of the mine development, including End-Of-Mine (EOM) and Post-Closure (PC) stages. For each life cycle stage the potential effects of mine contact water to the water quality in the Killag River was assessed under base case (median) and upper case (90th percentile) concentration scenarios. The methodology and results for the predictive water quality assessment are presented in this report.

2. Background Information

The proposed Project Site has a footprint of approximately 145 hectares (ha) and is surrounded by wetlands, streams, lakes and forested land that is in varying degrees of re-growth due to historical logging. The Project is part of the Moose River Consolidated (MRC) Project, which includes the existing and fully permitted Touquoy Gold Project, located in Moose River Gold Mines, Nova Scotia. The Project will operate as a satellite surface mine to the MRC Project, and the ore that is mined from the Project Site will be processed at the existing Touquoy plant. The Project is expected to begin construction in 2021, come into production in 2022, cease operations in 2026 and then be reclaimed.

The objective of the MWMP is to reduce the operational risks and environmental impacts on the surrounding environment including the receiving watercourse and ultimately, the Killag River. As a part of the MWMP, GHD has completed a predictive water quality assessment to determine the effect of developing the Beaver Dam mine on the downstream water body, the Killag River. The total contributing drainage area to the Killag River downstream of the site, which includes the Project Site and Mud Lake, is approximately 3,870 ha. The contributing drainage areas and mine footprint can be seen on Figure 2-1 and Figure 2-2. To note, the Tent Lake drainage area drains away from the Beaver Dam mine site discharge points.



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Imagery: Image ©2019 DigitalGlobe, ©2019 Google, Imagery date: 18/6/2012

Drainage Areas

- Contributing Area to Killag River (~3871.7 ha)
- Contributing Area to Mud Lake(~166.3 ha)
- Contributing Area to Tent Lake (~28.4 ha)

Outlets

- Killag River
- Mud Lake
- Tent Lake

Proposed Mine Footprint

Contours (5m)

NOTES:
1. Mud Lake and Tent Lake Contributing Areas derived from LiDAR measurements supplied by Leading Edge Geomatics, 2015.
2. Killag River Contributing Area derived from a combination of LiDAR measurements, Nova Scotia Department of Natural Resources (Forestry Division) hydrologically-corrected 20m DEM, and interpretations from satellite imagery and topographic maps.

GHD

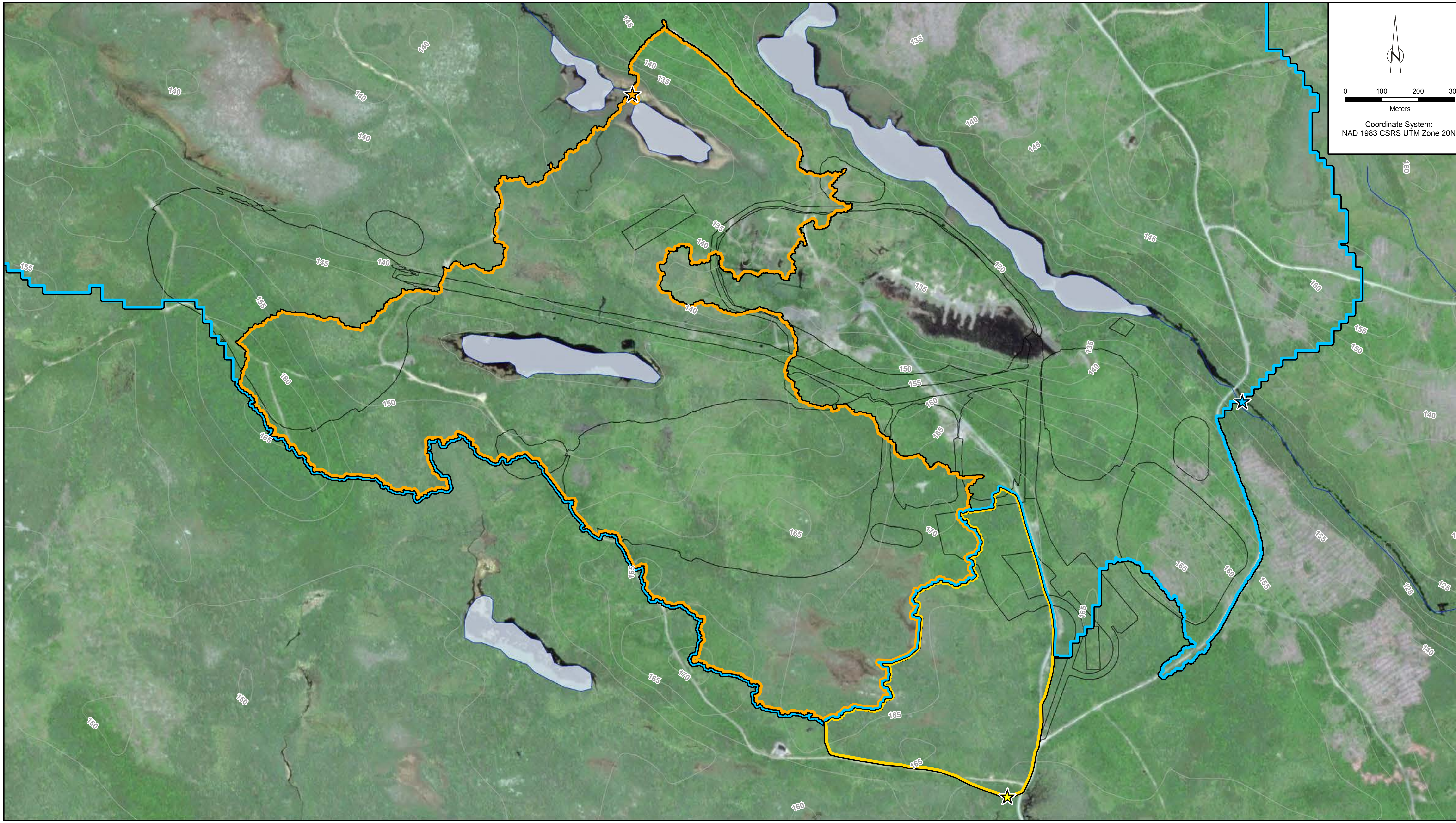
ATLANTIC MINING NS CORP
BEAVER DAM MINE
SURFACE WATER MANAGEMENT PLAN
PREDICTIVE WATER QUALITY ASSESSMENT

CONTRIBUTING DRAINAGE AREAS - BASELINE CONDITION

088664-27
Jan 17, 2019

FIGURE 2-1

GIS File: Q:\GIS\PROJECTS\88000s\88664\Layouts\011\088664-27(011)GIS-WA001.mxd



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Imagery: Image ©2019 DigitalGlobe, ©2019 Google, Imagery date: 18/6/2012

Drainage Areas

- Contributing Area to Killag River (~3871.7 ha)
- Contributing Area to Mud Lake(~166.3 ha)
- Contributing Area to Tent Lake (~28.4 ha)

Outlets

- Killag River
- Mud Lake
- Tent Lake

Proposed Mine Footprint

Contours (5m)

NOTES:
1. Mud Lake and Tent Lake Contributing Areas derived from LiDAR measurements supplied by Leading Edge Geomatics, 2015.
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ATLANTIC MINING NS CORP
BEAVER DAM MINE
SURFACE WATER MANAGEMENT PLAN
PREDICTIVE WATER QUALITY ASSESSMENT
CONTRIBUTING DRAINAGE AREAS - BASELINE CONDITION (DETAILED VIEW)

088664-27
Jan 17, 2019

FIGURE 2-2

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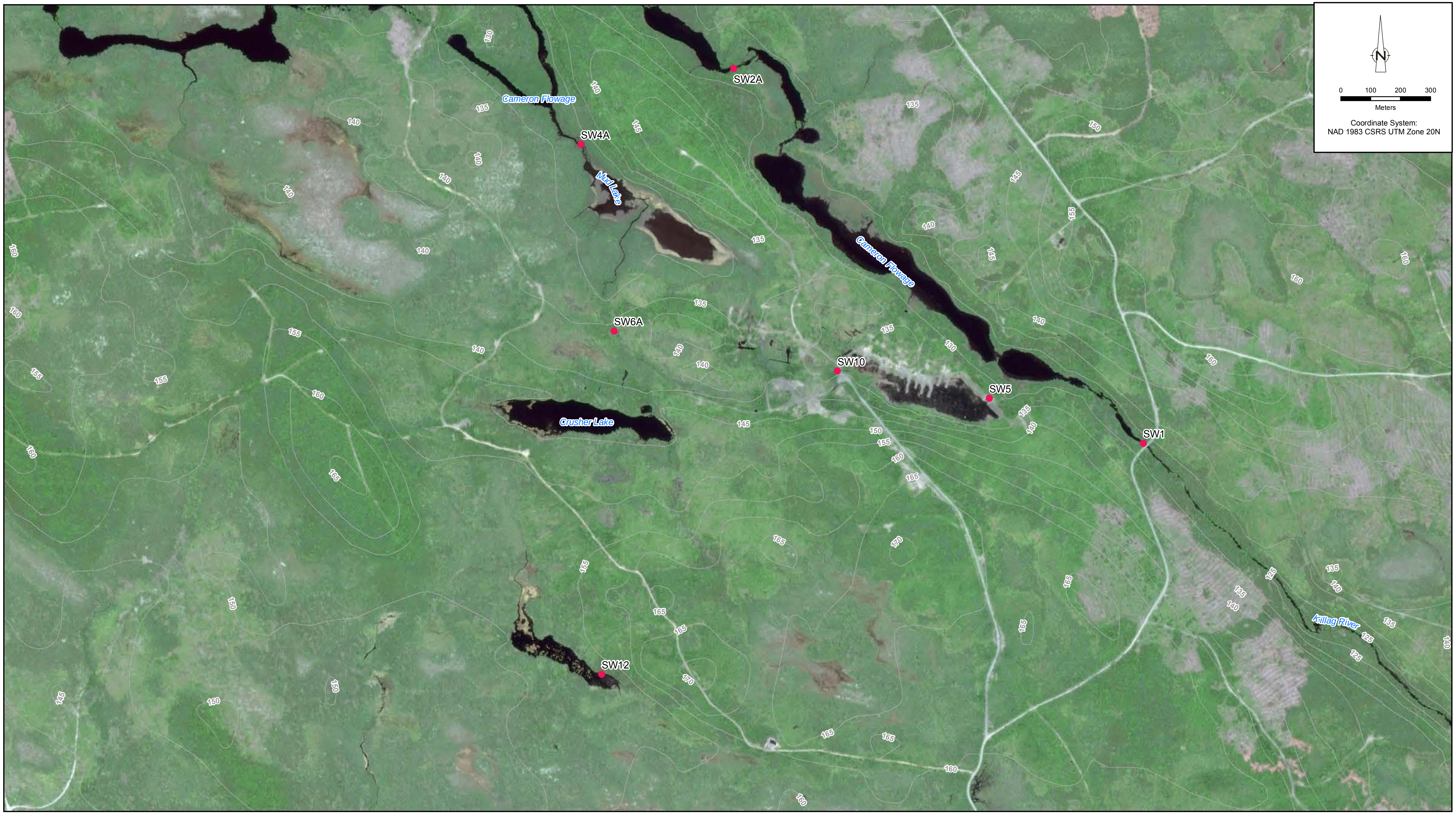
2.1 Surface Water Sampling Results

In preparation for development of the Beaver Dam mine, GHD undertook the monitoring of background concentration levels of surface water in the Killag River and several nearby tributaries from October 2014 to August 2015. In total, 10 surface water samples were taken at seven (7) locations to accurately reflect background conditions. The sampling locations with respect to the mine footprint are shown on Figure 2-3. The background concentrations of constituents of concern are shown in Table 2-1.

Table 2-1 Background Concentrations in Killag River

Constituent	Concentration in Killag River
	µg/L
Ag	0.05
Al	256.00
As	1.71
Cd	0.02
Co	0.30
Cu	1.00
Fe	525.00
Hg	0.01
Mn	48.80
Mo	1.00
Ni	1.00
Pb	0.34
Sb	0.50
Se	0.50
Tl	0.05
U	0.05
Zn	3.97



- Surface Water Sample Location
- Contours (5m)

GHD

ATLANTIC MINING NS CORP
BEAVER DAM MINE
SURFACE WATER MANAGEMENT PLAN
PREDICTIVE WATER QUALITY ASSESSMENT

088664-27
Jan 15, 2019

BASELINE SURFACE WATER MONITORING LOCATIONS

FIGURE 2-3

GIS File: Q:\GIS\PROJECTS\88000s\88664\Layouts\011\088664-27(011)GIS-WA003.mxd

These background concentrations will be used in combination with the background flow volume in the mixing calculations with the mine effluent concentrations and volumes to determine the resulting constituent concentration within the Killag River downstream of Beaver Dam mine. Cyanide has not been included in the background constituents of concern because it is typically a by-product of the refining process of the ore. The refining process is to take place off-site at the Touquoy mine and therefore Cyanide will not be a concern regarding water quality entering Killag River from the Beaver Dam mine.

2.2 Water Quality Effluent Regulations

Several governing bodies regulate the water quality discharged from a project site into a natural water body. Specifically this water quality assessment will focus on Metal and Diamond Mining Environmental Regulation (MDMER) Objectives and Canadian Council of Ministers of the Environment (CCME) Guidelines for the Protection of Aquatic Life to determine potential constituents of concern. MDMER and CCME are federal regulations. To note, since operations are set to begin in 2022 the MDMER objectives referenced in this report relate to "New Mines" and therefore follow Table 1 of Schedule 4 from the MDMER. In addition, Site-Specific Water Quality Guidelines have been established for the Project Site. These Site-Specific Guidelines are based on background concentrations which exceed CCME Guidelines or a risk hazard assessment performed for the receiving water body. MDMER, CCME and Site-Specific regulations are shown in Table 2-2. MDMER regulations are used to assess End-Of-Pipe discharge concentrations while CCME and Site-Specific guidelines were used to assess concentrations within the Killag River after mixing.

Table 2-2 MDMER, CCME and Site Specific Water Quality Regulations

Constituent	MDMER	CCME	Site Specific
	µg/L	µg/L	µg/L
	a	b	c
Ag	-	0.25	-
Al	-	5.00	256
As	100	5.00	30.0
Cd	-	0.09	-
Co	-	-	-
Cu	100	2.00	-
Fe	-	300	525
Hg	-	0.026	-
Mn	-	-	-
Mo	-	73.0	-
Ni	250	25.0	-
Pb	80.0	1.00	-

Table 2-2 MDMER, CCME and Site Specific Water Quality Regulations

Constituent	MDMER	CCME	Site Specific
	µg/L	µg/L	µg/L
	a	b	c
Sb	-	-	-
Se	-	1.00	-
Tl	-	0.80	-
U	-	15.0	-
Zn	400	7.00	-

3. Predictive Water Quality Assessment

The predictive water quality assessment was calculated on a monthly basis for the average year climatic conditions. Performing the water quality assessment on a monthly basis allows for the prediction of the seasonality characteristics of water quality in the Killag River. This allows for the assessment of the wet and dry months to determine the month with the highest effect on the water quality in the Killag River and will assist with the design of water quality treatment options at the Project Site.

The following section presents the environmental data inputs and predictive water quality results.

3.1 Environmental Data

3.1.1 Climatic Data

Historical rainfall data was obtained from the Environment Canada climate station Middle Musquodoboit (ID: 8203535) with continuous historical daily precipitation data from 1968 to 2005. The GHD water balance model (WBM) (GHD, 2019a) created in GoldSim was used to generate precipitation probabilities using a stochastic distribution of the precipitation data. Monthly precipitation totals were calculated from the Middle Musquodoboit Climate Station daily precipitation record for 41-years including 1968 – 2005, 2009, 2014 and 2016. The years that have a significant amount of missing data were excluded from the analysis. Monthly precipitation totals are represented by lognormal distributions for each month of the year. The Kolmogorov-Smirnov test was performed to assess the fit of the lognormal distribution to the monthly precipitation totals. The null hypothesis is that the observed and simulated precipitation datasets have the same underlying distribution. The results show that the null hypothesis is accepted at the 5% level of significance for all twelve months/distributions; therefore, the lognormal distribution can be used to accurately represent monthly precipitation totals in the WBM. Rainfall occurrence is modelled using a second order Markov Chain. The rainfall plus snowmelt values were taken from this analysis for use in the predictive water quality assessment. Rainfall plus snowmelt depths peaked in April due to the rising temperature depleting the snow pack, creating a greater volume of available water for discharge. The lowest rainfall plus snowmelt occurred in January as the only source of water was due to abnormally high temperatures temporarily melting part of the snow pack.

3.1.2 Predictive Source Term Model

To determine the concentration of each constituent leaving the site, the geochemistry of each stockpile (till, waste rock, low grade ore) and the pit wall rock were assessed individually by Lorax Environmental (Lorax Environmental, 2018). This assessment included both the base case and the upper case scenarios of constituent concentrations for EOM and PC mine life cycle conditions. Base case conditions represent the most likely concentration scenario (median) while upper case conditions represent the likely worst-case (90^{th} percentile) concentration scenario.

For the EOM conditions, the source term model assumed the following:

- The waste rock piles have reached their maximum height but remain uncovered and unrestored
- The low grade ore stockpiles have an area of 25,000 m^2 and remain uncovered and unrestored
- The pit is constantly being dewatered and discharged into the North Settling Pond
- Standard erosion and sediment control measures have been implemented on the soil and till piles

For the PC conditions, the source term model assumed the following:

- Waste rock stockpiles have been covered with soil and seeded
- The low grade ore stockpile has been removed from the Project Site and processed at the Touquoy site
- The pit has been allowed to naturally fill with water to an elevation of 127 m
- All site water will drain to the pit prior to discharge into the river
- Other than what is mentioned above no other reclamation activities have been implemented at the Project Site

3.1.3 Project Site Water Balance

Stockpiles Water Balance

Runoff, infiltration and evaporation from each stockpile material were determined as a percentage of total rainfall based on estimated runoff-infiltration values from Touquoy mine for EOM and PC conditions and were provided by Stantec (pers., comm., 2018a). Waste rock and low grade ore stockpiles will have high infiltration rates (90%) and low runoff rates (5%) during EOM conditions due to the high porosity of the stockpile. This infiltration rate will decrease during PC conditions (42.5%) while runoff rates will increase (22.5%) due to covering of the stockpile with soil and seed. Till is less permeable and is only expected to infiltrate approximately 16% of rainfall with 49% leaving as runoff during both EOM and PC conditions.

Runoff volumes for the stockpiles were calculated based on the runoff coefficient provided by Stantec and the area of each stockpile while runoff volumes from catchments with no stockpiles were determined through GHD's WBM (GHD, 2019a). The WBM took into account field capacity of the soil, saturation points and calculated both infiltration and runoff as a result. Infiltration volumes for the stockpile catchments were calculated based on the stockpile area. Infiltration into each stockpile was then split into absorbed infiltration (water remaining within the stockpile or recharging groundwater baseflow) and seepage (water leaching out of the stockpile).

The volume of water that was absorbed by the stockpile was determined based on estimated recharge into the groundwater, an estimated 20-year time-to-saturation of the stockpiles (provided by Stantec) and the respective field capacity of each stockpile (pers., comm., 2018a). The area surrounding the Beaver Dam mine site experiences approximately 23% infiltration into the ground on an annual basis (GHD, 2019b). Field capacity is defined as the point at which water in the pore spaces of a soil will begin to drain. Based on assumed field capacities of 0.004 and 0.19 for waste rock/ore and till, respectively, it was determined approximately 23% of total rainfall will remain in the waste rock and LGO stockpiles while 37% of total rainfall will remain in the till stockpile. A field capacity of 0.004 for waste rock is equivalent to the field capacity of gravel (Zhan et al,. 2016). A field capacity of 0.19 is equivalent to the field capacity of sandy loam, the predominate soil in the area (Rawls et al., 1983). Water that is unable to be absorbed will leave the stockpile as seepage. Due to the slow movement of water through the stockpile, the seepage is estimated to take approximately one month to leave the stockpile. Thus, the seepage is equal to the previous month's infiltration minus absorption.

For each stockpile, direct runoff was assumed to be clean with no constituents of concern while seepage was assumed to contain the constituents of concern identified in the Lorax Environmental source term model (Lorax Environmental, 2018).

The predictive water quality assessment incorporated groundwater recharge into the surface water ditches and the Killag River. Concentrations of constituents of concern and discharge volumes were taken from GHD's groundwater model for the Beaver Dam site (GHD, 2019b).

Pit Water Balance

During the operational phase of the open pit, dewatering will have to occur since the natural groundwater table is above the mining elevation. In addition, runoff from direct precipitation and snow melt will also contribute to the water within the open pit. The water collected within the pit will be pumped to the North Settling Pond. During PC conditions, the dewatering operations will cease and the pit will naturally fill with groundwater and site runoff. As outlined in Beaver Dam Mine Site - Water Balance Analysis (GHD, 2019a), the filling of the pit will take approximately 14.5 years. Once the pit has filled with water to an elevation of 127 m, additional water will overflow the pit walls through an engineered outfall structure directly into Killag River. During both the EOM and PC phase's water in the pit will also evaporate into the atmosphere.

The pit is expected to produce runoff equal to 85% of total rainfall (pers., comm., 2018a).

The additional inflow to the pit from groundwater seepage was determined using GHD's groundwater model and was estimated to be approximately 636 m^3/day (GHD, 2019b).

During EOM conditions, the precipitation that fell into the pit was assumed to contact the freshly exposed pit walls causing the release of the weathering products, in particular those related to sulphide oxidation (Lorax Environmental, 2018). Groundwater inflows are expected to contain constituents of concern equal to the background groundwater monitoring concentration levels. Average measured groundwater concentrations were used for the base case scenario while maximum measured groundwater concentrations were used for the upper case scenario.

During PC conditions the direct precipitation into the pit is assumed to be clean as it will fall directly onto the lake which has formed in the pit. Groundwater inputs are assumed to remain at background concentrations during PC. While pH was not explicitly analyzed in the water quality assessment however it was considered in the generation of the source terms during PC conditions in the pit lake. The water within the pit lake will likely be at or near a neutral pH after complete mixing of site runoff and groundwater. This has a significant effect on metals such as Aluminum and Iron resulting in precipitation of these metals out of the water. To account for the effect of pH on Aluminum and Iron the concentrations of these two metals were set to have upper bounds associated with the expected pH in the pit during PC conditions. These upper bounds are shown in Table 3-1 and were received from Lorax (pers., comm., 2018b).

Table 3-1 Upper Objectives for Aluminum and Iron Concentration in Pit, PC Conditions

	Aluminum (µg/L)	Iron (µg/L)
Base Case	13	52
Upper Case	50	1,050

3.2 Project Site Discharge Points

It should be noted that there are three discharge points during EOM conditions and PC conditions. During EOM conditions site water from the waste rock, low grade ore stockpiles and the pit will be routed through the North Settling Pond prior to discharge into the Killag River. Additionally, clean water from the site will be diverted and discharged directly to Mud Lake. There will also be clean discharge from the eastern till stockpiles to the Killag River. During PC conditions, site water from the waste rock stockpiles will be routed through the pit prior to discharge into the Killag River. This discharge point is approximately 200m downstream of the EOM discharge point from the North Settling Pond. The North Settling Pond will likely be decommissioned for the PC scenario. Clean water from the site (including the removed low grade ore stockpile area) will continue to be diverted to Mud Lake. Clean runoff from the eastern till stockpiles will continue to be discharged to the Killag River.

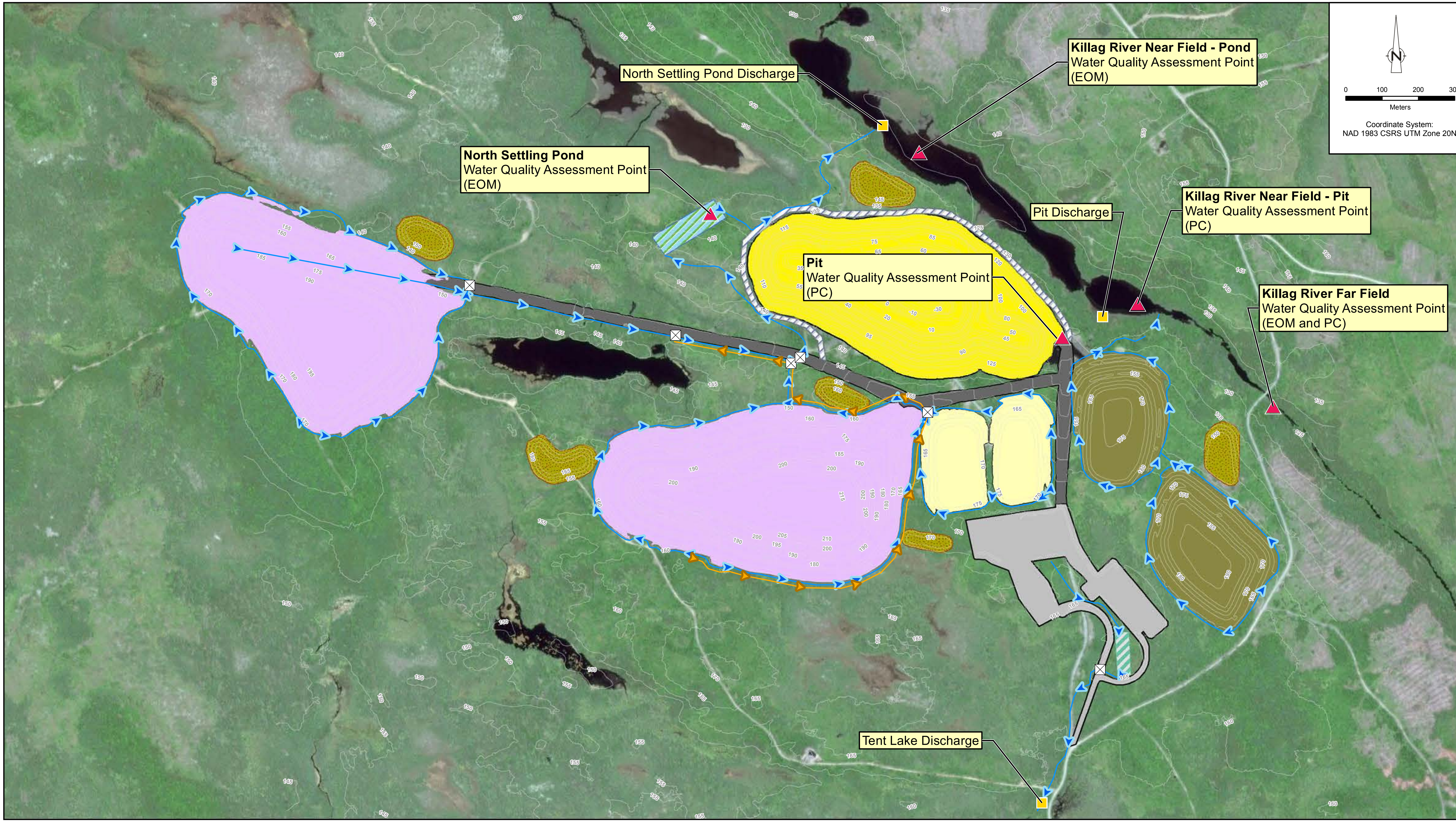
With the expectation that the composition of the material within the till stockpiles will be at or below background constituent levels, it is likely there will be no additional loadings of constituents, from background condition, into the Killag River. In addition, due to the anticipated low infiltration rate and high absorption rate of the till stockpile, there is likely little to no significant seepage expected and therefore no mobilization of constituents into the Killag River from this discharge point. The only discharge points with potential for discharge of impacted mine effluent into the Killag River system are the North Settling Pond (EOM) and the pit (PC).

Constituent concentrations in the receiving water body were calculated at near-field (100 m downstream of each discharge point with the potential for constituent transport) and far-field (approximately 1 km downstream of Near Field – Pit – PC discharge point in the Killag River) locations for both EOM and PC conditions. The discharge and water quality assessment points can be seen in Figure 3-1. Based on previous experience with mixing models in rivers of similar size to the Killag River, it was assumed that full mixing would occur at the near-field location. In addition, based on the requirements set out in MDMER Part 2, 9 (1) (b) in order to assess the effect on the benthic invertebrate community, the concentrations of constituents of concern must be determined at a location that is 100 m from the point at which the effluent enters that watercourse from the final discharge point.

The area draining from the crusher pad into the East Collection Pond (referred to as the Tent Lake drainage area) discharges south, away from the Killag River. The Tent Lake drainage area is not anticipated to have water quality concerns at this time since no permanent stockpile of material will be placed in this area.

The contributing drainage areas to each discharge point during EOM conditions is presented on Figure 3-2. Figure 3-3 depicts the PC drainage conditions with the pit being filled and discharging into Killag River.

The volume produced by Killag River – Far Field is based on the average monthly volumes calculated in the Beaver Dam Mine Site - Water Balance Analysis (GHD, 2019a). The volumes produced by Killag River – Near Field – Pit and Killag River – Near Field - Pond were calculated using a drainage area ratio method.



Stockpile Ditch
SWM Ditch
Contours (5m)
Berm
Soil Stockpile
Settling Pond
Collection Pond
Open Pit
Haul Road
Low Grade Ore Stockpile
Crusher Pad
Till Stockpile
Waste Rock Stockpile
Culvert
Discharge Point
Water Quality Assessment Point
EOM = End of Mine
PC = Post Closure

ATLANTIC MINING NS CORP
BEAVER DAM MINE
SURFACE WATER MANAGEMENT PLAN
PREDICTIVE WATER QUALITY ASSESSMENT

MINE DISCHARGE AND WATER QUALITY ASSESSMENT POINTS FIGURE 3-1

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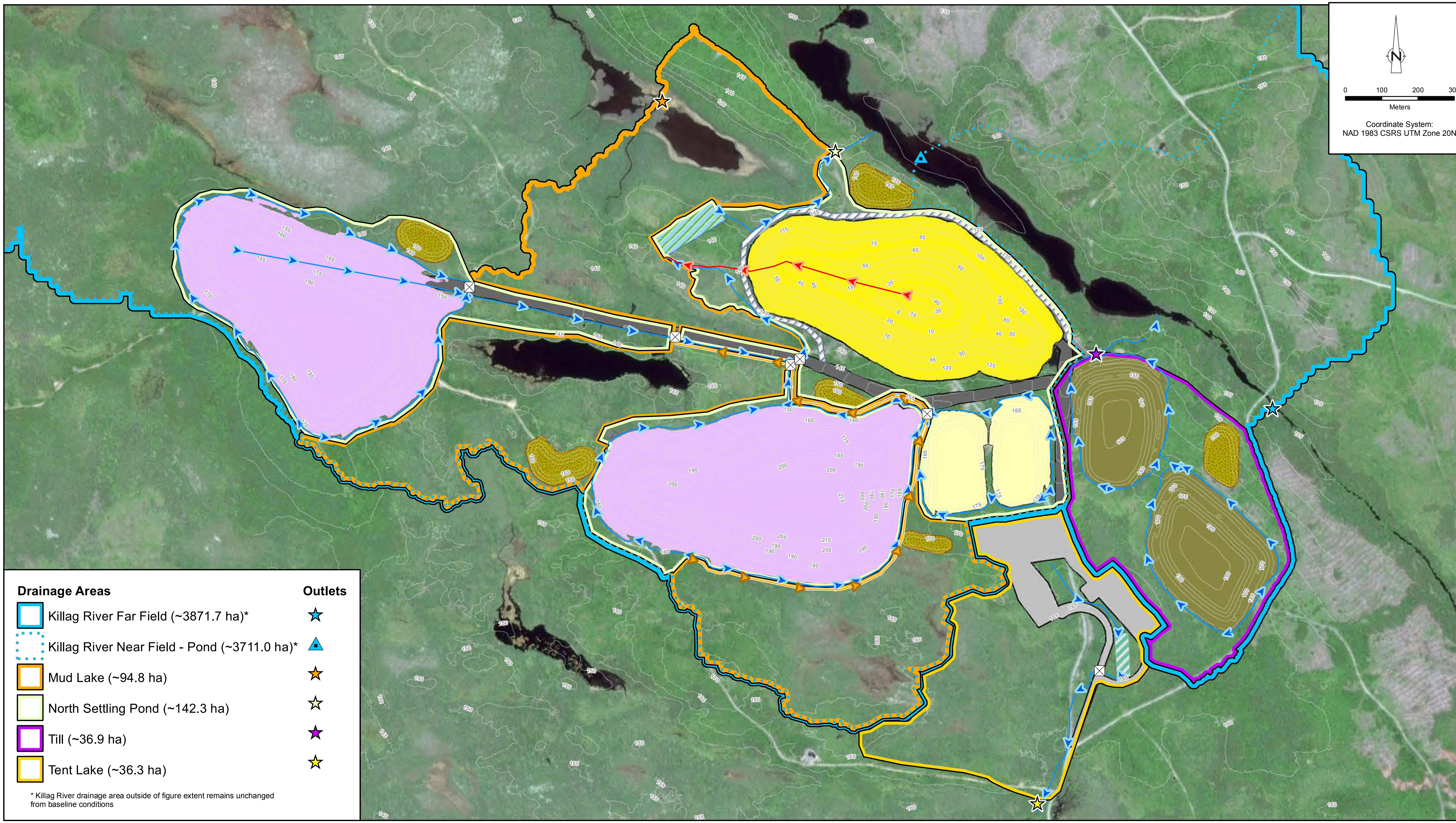

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Imagery: Image ©2019 DigitalGlobe, ©2019 Google, Imagery date: 18/6/2012

NOTES:
1. Mud Lake and Tent Lake Contributing Areas derived from LiDAR measurements supplied by Leading Edge Geomatics, 2015.
2. Killag River Contributing Area derived from a combination of LiDAR measurements, Nova Scotia Department of Natural Resources (Forestry Division) hydrologically-corrected 20m DEM, and interpretations from satellite imagery and topographic maps.

Pumping Path	Berm	Haul Road
Stockpile Ditch	Soil Stockpile	Low Grade Ore Stockpile
SWM Drainage Ditch	Settling Pond	Crusher Pad
Contours (5m)	Collection Pond	Till Stockpile
Culvert	Open Pit	Waste Rock Stockpile

ATLANTIC MINING NS CORP
BEAVER DAM MINE
SURFACE WATER MANAGEMENT PLAN
PREDICTIVE WATER QUALITY ASSESSMENT

DRAINAGE AREA – EOM CONDITIONS

088664-27
Jan 17, 2019

FIGURE 3-2

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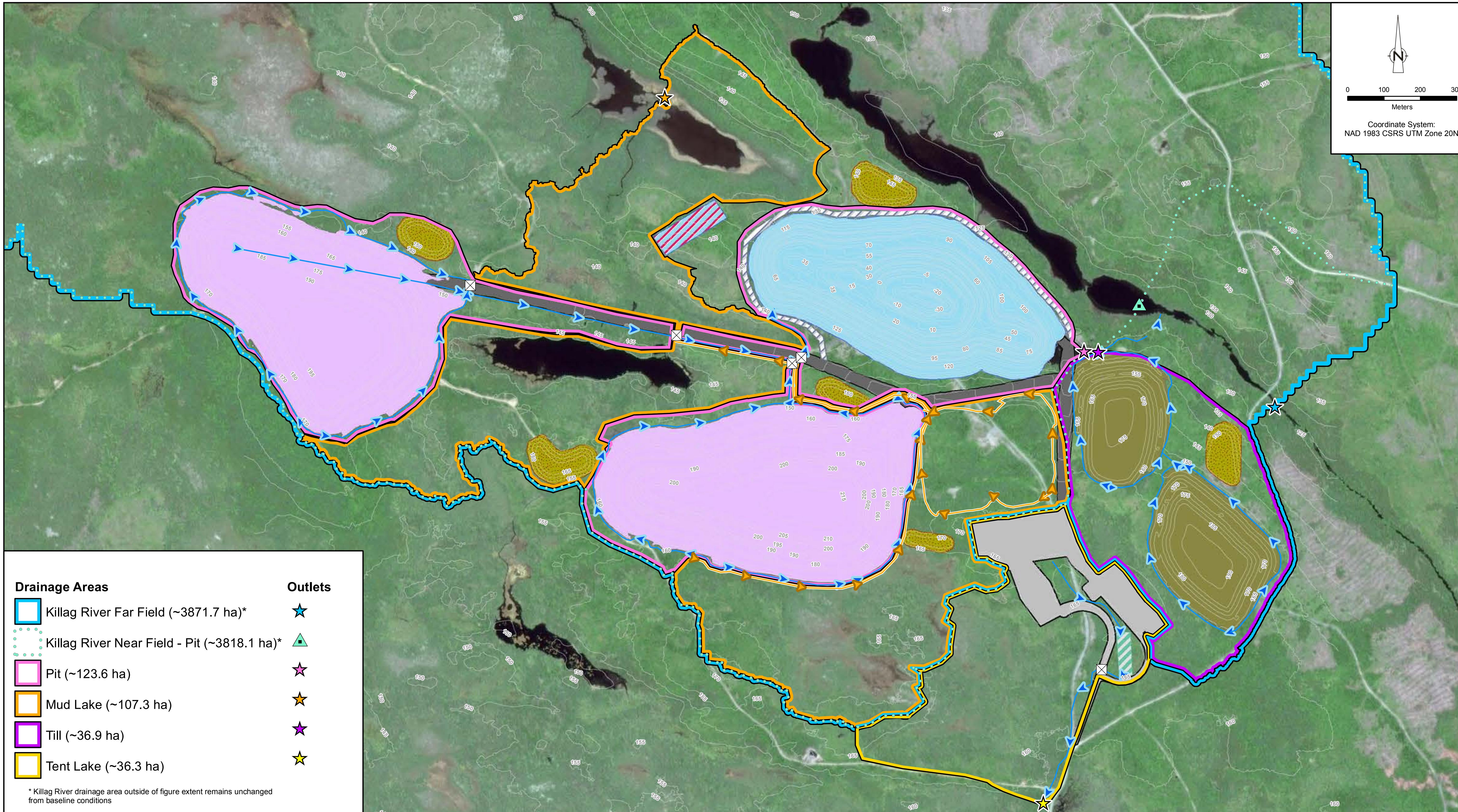

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Imagery: Image ©2019 DigitalGlobe, ©2019 Google, Imagery date: 18/6/2012

NOTES:
1. Mud Lake and Tent Lake Contributing Areas derived from LiDAR measurements supplied by Leading Edge Geomatics, 2015.
2. Killag River Contributing Area derived from a combination of LiDAR measurements, Nova Scotia Department of Natural Resources (Forestry Division) hydrologically-corrected 20m DEM, and interpretations from satellite imagery and topographic maps.

Stockpile Ditch
SWM Ditch
Contours (5m)
Berm
Soil Stockpile
Decommissioned Settling Pond
Collection Pond
Pit Lake
Haul Road
Crusher Pad
Till Stockpile
Waste Rock Stockpile
Culvert

ATLANTIC MINING NS CORP
BEAVER DAM MINE
SURFACE WATER MANAGEMENT PLAN
PREDICTIVE WATER QUALITY ASSESSMENT

DRAINAGE AREA – PC CONDITIONS

088664-27
Jan 17, 2019

FIGURE 3-3

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3.3 Predictive Water Quality Assessment Results

3.3.1 North Settling Pond Water Quality

The constituent concentrations entering the North Settling Pond during EOM conditions for base case and upper case scenarios are presented in Table 3-2 and Table 3-3. The pond will likely be decommissioned for PC conditions.

As demonstrated in Table 3-2 and Table 3-3, MDMER objectives are not exceeded in the North Settling Pond during either base case or upper case scenarios.

3.3.2 Pit Water Quality

Under PC conditions, all site contact water will be routed through the pit prior to discharge into the Killag River. The constituent concentrations within the pit during PC conditions for base case and upper case scenarios are presented in Table 3-4 and Table 3-5.

As demonstrated in Table 3-4, Arsenic exceeds MDMER objectives for most of the year in the pit during the base case scenario. It can be seen in Table 3-5 that Arsenic and Copper exceed MDMER objectives for the majority of the year. Therefore, water quality treatment may be required prior to discharge into the Killag River.

3.3.3 On-Site Water Quality Treatment

During both EOM and PC there is likely to be a need for some form of water quality treatment. The treatment system will be designed to ensure that all site effluent water meets MDMER and CCME or Site Specific objectives. During EOM conditions the treatment system will be placed adjacent to the North Settling Pond. The treatment system during PC conditions will likely be moved to the proposed discharge point from the pit lake. Water quality will be continuously measured in the North Settling Pond, during EOM conditions, and the pit lake, during PC conditions, so that the treatment system can be scaled as needed to meet effluent discharge guidelines. Sufficient freeboard will be provided in both the North Settling Pond and the pit lake to allow for adequate timing to adjust the treatment process as needed.

3.3.4 Killag River – Near Field – Pond – EOM Conditions Water Quality

The North Settling Pond is the only Project Site discharge point with potential for elevated constituent concentrations into the Killag River during EOM conditions. To assess the anticipated level of water quality treatment needed to meet the regulatory guidelines (CCME or Site Specific Criteria) a water quality assessment was completed at the end of the mixing zone, approximately 100m downstream of the discharge point. The analysis assumed no treatment of mine contact water in the North Settling Pond and only analyzed the results from a mass balance (dilution) calculation at the extent of the predicted mixing zone. These results are presented in Table 3-6 and Table 3-7.

As demonstrated in Table 3-6, no other exceedances are expected to occur in the Killag River during EOM Base Case scenario. Table 3-7 shows potential exceedance of Iron for the months of January-

February and July-September. No other exceedances are expected to occur during EOM Upper Case scenario. These predicted water quality values presented in the tables include no treatment within the settling pond and only account for the dilution from the Site and the Killag River upstream of the discharge point.

Table 3-8 and Table 3-9 provide summaries of the anticipated constituent loading removals from the site effluent water required to meet regulator guideline limits during EOM conditions at the Killag River – Near Field – Pond discharge point. The proposed water quality treatment system will be design to remove, at a minimum, these predicted constituent loadings.

3.3.5 Killag River – Near Field – Pit – PC Conditions Water Quality

During PC conditions the pit lake discharges into the Killag River directly. To assess the anticipated level of water quality treatment needed to meet the regulatory guidelines (CCME or Site Specific Criteria) a water quality assessment was completed at the end of the mixing zone. The analysis assumed no treatment of mine contact water in the pit lake and only analyzed the results from a mass balance (dilution) calculation at the extent of the predicted mixing zone. The results from the dilution calculation at the extent of the predicted mixing zone is presented in Table 3-10 and Table 3-11.

As demonstrated in Table 3-10, Copper and Zinc both have the potential to exceed CCME and Site-specific regulations for several months of the year if no water treatment is included. Zinc has the potential to exceed CCME and Site-specific regulations during the summer months from July to September, while Copper has potential to exceed regulatory limits in January and from May to September. Table 3-11 shows anticipated exceedance of Copper year-round. Arsenic and Zinc also are anticipated to exceed CCME and site-specific regulations. Arsenic only has potential to exceed regulatory limits in August while Zinc has the potential to exceed regulatory limits from May-September. It is anticipated that all other constituents will not exceed water quality regulatory limits at any point in the year. It should also be noted that the MDMER guidelines for effluent from a metal mine are not expected to be exceeded by any constituent. These predicted water quality values presented in the tables include no treatment within the pit lake and only account for the dilution from the mine Site and the Killag River upstream of the discharge point.

Table 3-12 and Table 3-13 provide summaries of the anticipated constituent loading removals from the site effluent water required to meet regulator guideline limits during PC conditions at the Killag River Near Field discharge point. The proposed water quality treatment system will be design to remove, at a minimum, these predicted constituent loadings.

3.3.6 Far Field – Killag River

The North Settling Pond and pit ultimately discharge into the Killag River during both EOM and PC conditions. Flow in the Killag River was determined using the WBM (GHD, 2019a) as discussed in Section 3.2. Table 3-14, Table 3-15, Table 3-16 and Table 3-17 display the concentrations in the Killag River after 100% mixing and approximately one kilometer downstream of the pit discharge point. The concentrations in the Killag River were set equal to background when mixing with flow from the North Settling Pond and pit.

Table 3-14 shows no potential for exceedance of any constituent at any point in the year. Table 3-15 demonstrates that during EOM upper case conditions Iron has the potential to exceed CCME or site-specific regulations in February. Table 3-16 shows PC base case results have potential for exceedances of Copper in January and May-September while Zinc is anticipated to exceed CCME and site-specific regulatory limits from July to September. Table 3-17 demonstrated PC upper case conditions result have the potential for exceedances of Copper year-round. Arsenic also has the potential to exceed CCME and site-specific regulations in August while Zinc concentrations have potential to be above CCME and site-specific regulations from May to September. It is anticipated that all other constituents will not exceed water quality regulatory limits at any point in the year.

These predicted water quality values presented in the tables include no treatment within the North Settling Pond, during EOM conditions, or the pit lake, during PC conditions, and only account for the dilution from the mine Site and the Killag River upstream of the far field point. Assuming a similar treatment method as described in Section 3.3.4 and 3.3.5 the concentrations at the Far Field – Killag River assessment point will remain below CCME and site-specific regulations.

Table 3-2 Constituent Concentrations in the North Settling Pond – EOM Conditions Base Case

Constituent	Average Monthly Concentration (µg/L)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Al	16.26	14.76	17.41	21.63	23.80	21.86	22.49	22.87	22.66	21.32	20.82	19.47
As	36.15	27.96	19.25	21.33	54.10	38.02	38.22	38.58	38.47	32.93	33.25	40.22
Cd	0.013	0.012	0.008	0.006	0.014	0.012	0.012	0.012	0.012	0.011	0.010	0.012
Co	0.75	0.70	0.71	0.77	0.93	0.89	0.92	0.93	0.92	0.85	0.82	0.81
Cu	0.97	0.96	0.81	0.71	0.94	0.98	1.03	1.04	1.02	0.92	0.86	0.91
Fe	48.00	50.56	38.33	26.11	33.53	42.08	45.16	45.66	44.28	39.54	35.09	39.04
Hg	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mn	95.67	83.37	61.77	58.46	118.08	96.52	99.03	100.05	98.91	86.29	83.78	97.49
Mo	11.32	9.96	10.33	12.34	16.19	14.04	14.40	14.61	14.49	13.33	13.06	13.06
Ni	2.01	1.87	1.74	1.81	2.41	2.25	2.33	2.36	2.33	2.12	2.04	2.10
Pb	0.35	0.30	0.22	0.22	0.44	0.35	0.36	0.37	0.36	0.32	0.31	0.36
Sb	1.78	1.34	0.87	0.98	2.75	1.86	1.87	1.88	1.88	1.59	1.62	2.01
Se	1.16	0.91	0.61	0.65	1.68	1.20	1.20	1.22	1.21	1.03	1.04	1.27
Tl	0.04	0.04	0.03	0.02	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.04
U	12.17	10.00	9.46	11.58	18.60	14.65	14.87	15.07	15.00	13.51	13.46	14.26
Zn	2.86	2.87	2.22	1.71	2.47	2.66	2.82	2.85	2.78	2.48	2.27	2.52

Notes:
[a] denotes an exceedance of the MDMER Water Quality Regulatory Objectives

Table 3-3 Constituent Concentrations in the North Settling Pond - EOM Conditions Upper Case

Constituent	Average Monthly Concentration (µg/L)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	0.18	0.18	0.13	0.08	0.12	0.15	0.16	0.16	0.16	0.14	0.12	0.14
Al	113.62	120.20	95.51	69.66	81.52	103.21	110.66	111.97	108.68	98.03	87.42	94.24
As	92.78	84.95	58.26	45.76	98.15	85.98	89.20	90.02	88.51	76.46	72.42	87.10
Cd	0.14	0.15	0.10	0.05	0.08	0.11	0.12	0.12	0.11	0.10	0.09	0.10
Co	1.65	1.65	1.45	1.31	1.58	1.69	1.78	1.81	1.77	1.61	1.50	1.55
Cu	2.88	2.98	2.35	1.78	2.28	2.67	2.84	2.87	2.80	2.51	2.27	2.47
Fe	998.62	1,112.35	769.49	374.75	452.73	759.53	835.16	842.78	808.04	711.90	595.70	700.29
Hg	0.07	0.08	0.06	0.03	0.04	0.06	0.06	0.07	0.06	0.06	0.05	0.05
Mn	342.37	349.20	245.72	156.94	257.52	291.95	311.29	314.26	305.37	267.51	239.60	281.40
Mo	43.09	38.09	39.21	46.41	60.88	53.09	54.47	55.28	54.79	50.39	49.30	49.36
Ni	4.17	4.13	3.51	3.11	4.03	4.21	4.43	4.49	4.40	3.98	3.70	3.91
Pb	0.60	0.48	0.38	0.44	0.91	0.67	0.68	0.68	0.68	0.60	0.60	0.68
Sb	3.99	2.97	1.93	2.21	6.23	4.19	4.18	4.22	4.22	3.58	3.65	4.51
Se	2.12	1.57	1.05	1.23	3.36	2.26	2.26	2.28	2.28	1.94	1.98	2.43
Tl	0.05	0.04	0.03	0.03	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.05
U	20.23	17.04	15.71	18.42	29.38	23.72	24.17	24.49	24.32	21.89	21.64	23.03
Zn	19.50	21.16	14.83	8.05	10.73	15.50	16.86	17.02	16.39	14.45	12.39	14.46

Notes:
[a] denotes an exceedance of the MDMER Water Quality Regulatory Objectives

Table 3-4 Constituent Concentrations in the Pit – PC Conditions Base Case

Constituent	Average Monthly Concentration (µg/L)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	0.62	0.50	0.31	0.25	0.89	0.56	0.56	0.57	0.56	0.47	0.47	0.63
Al	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
As	132.39[a]	107.48[a]	65.91	53.32	184.48[a]	118.25[a]	119.05[a]	119.58[a]	118.92[a]	99.59	98.72	133.31[a]
Cd	0.167	0.136	0.083	0.067	0.232	0.149	0.150	0.151	0.150	0.126	0.124	0.168
Co	1.20	1.01	0.62	0.46	1.51	1.04	1.06	1.06	1.05	0.88	0.86	1.16
Cu	26.91	21.77	13.34	10.88	37.84	24.11	24.25	24.36	24.23	20.29	20.14	27.21
Fe	49.31	45.09	37.13	25.87	52.00	49.35	50.74	51.21	50.60	45.23	43.49	49.10
Hg	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mn	131.66	114.06	70.54	49.50	152.99	111.46	113.97	114.47	113.07	95.25	91.45	122.68
Mo	8.09	6.72	4.13	3.19	10.67	7.11	7.19	7.22	7.17	6.01	5.90	7.95
Ni	3.14	2.68	1.66	1.20	3.81	2.69	2.74	2.76	2.73	2.29	2.22	2.98
Pb	0.52	0.44	0.27	0.20	0.63	0.44	0.45	0.45	0.45	0.38	0.36	0.49
Sb	1.41	1.18	0.73	0.55	1.79	1.22	1.24	1.25	1.23	1.04	1.01	1.36
Se	1.29	1.09	0.67	0.50	1.62	1.12	1.13	1.14	1.13	0.95	0.92	1.24
Tl	0.11	0.09	0.06	0.04	0.13	0.09	0.10	0.10	0.10	0.08	0.08	0.10
U	63.05	50.74	31.08	25.62	89.79	56.70	56.98	57.23	56.96	47.67	47.44	64.12
Zn	43.93	35.79	21.96	17.63	60.69	39.13	39.43	39.60	39.37	32.98	32.64	44.06

Notes:
[a] denotes an exceedance of the MDMER Water Quality Regulatory Objectives

Table 3-5 Constituent Concentrations in the Pit – PC Conditions Upper Case

Constituent	Average Monthly Concentration (µg/L)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	1.15	0.90	0.55	0.48	1.76	1.06	1.06	1.06	1.06	0.89	0.89	1.21
Al	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
As	250.11[a]	212.97[a]	131.43[a]	95.86	306.39[a]	214.91[a]	218.80[a]	219.76[a]	217.49[a]	182.91[a]	177.21[a]	238.18[a]
Cd	0.59	0.50	0.31	0.22	0.69	0.50	0.51	0.51	0.50	0.42	0.41	0.55
Co	2.42	2.16	1.34	0.87	2.50	1.98	2.05	2.06	2.02	1.71	1.61	2.15
Cu	161.96[a]	130.73[a]	80.10	65.61	228.95[a]	145.32[a]	146.13[a]	146.77[a]	146.04[a]	122.25[a]	121.50[a]	164.16[a]
Fe	522.71	530.22	516.78	427.94	516.67	570.82	596.75	604.37	594.13	555.55	521.99	509.84
Hg	0.09	0.09	0.06	0.03	0.05	0.07	0.07	0.07	0.07	0.06	0.05	0.07
Mn	454.81	432.85	270.74	151.88	363.29	351.73	369.65	371.29	362.45	308.46	279.41	370.13
Mo	31.27	26.12	16.08	12.23	40.45	27.30	27.67	27.79	27.56	23.14	22.63	30.47
Ni	6.27	5.61	3.48	2.27	6.52	5.15	5.31	5.34	5.25	4.44	4.18	5.59
Pb	0.92	0.75	0.46	0.37	1.25	0.81	0.82	0.83	0.82	0.69	0.68	0.92
Sb	3.58	2.96	1.82	1.42	4.76	3.16	3.19	3.20	3.18	2.67	2.62	3.53
Se	2.47	2.01	1.23	0.99	3.41	2.20	2.21	2.22	2.21	1.85	1.83	2.47
Tl	0.11	0.09	0.06	0.05	0.15	0.10	0.10	0.10	0.10	0.09	0.08	0.11
U	97.62	78.93	48.38	39.48	137.41	87.47	87.99	88.38	87.93	73.61	73.10	98.75
Zn	70.23	61.16	37.85	26.24	80.22	59.17	60.59	60.86	60.08	50.64	48.47	64.99

Notes:
[a] denotes an exceedance of the MDMER Water Quality Regulatory Objectives

Table 3-6 Constituent Concentrations at Killag River – Pond – Near Field – EOM Conditions Base Case

Constituent	Average Monthly Concentration (µg/L)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.05	0.05	0.05
Al	233.35[b]	235.32[b]	244.08[b]	247.41[b]	232.21[b]	226.68[b]	206.90[b]	195.43[b]	210.80[b]	235.91[b]	241.69[b]	238.28[b]
As	3.58	2.93	2.26	2.27	5.79[b]	4.62	6.44[b]	7.59[b]	6.16[b]	3.46	3.05	3.62
Cd	0.018	0.018	0.018	0.019	0.018	0.018	0.017	0.016	0.017	0.018	0.018	0.018
Co	0.31	0.31	0.30	0.31	0.34	0.33	0.36	0.37	0.35	0.32	0.31	0.32
Cu	0.96	0.96	0.98	0.98	0.97	0.96	0.93	0.92	0.94	0.97	0.98	0.97
Fe	479.38[b]	483.57[b]	500.64[b]	506.85[b]	475.02[b]	464.66[b]	424.17[b]	400.59[b]	432.03[b]	483.56[b]	495.33[b]	488.60[b]
Hg	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mn	49.67	48.77	48.44	48.75	53.19	50.79	52.03	52.91	51.91	49.69	49.52	50.17
Mo	1.54	1.40	1.29	1.33	2.17	2.03	2.71	3.14	2.61	1.68	1.51	1.59
Ni	1.02	1.01	1.01	1.02	1.09	1.06	1.11	1.14	1.10	1.04	1.03	1.03
Pb	0.33	0.32	0.33	0.33	0.34	0.33	0.32	0.31	0.32	0.33	0.33	0.33
Sb	0.55	0.52	0.50	0.51	0.67	0.59	0.65	0.68	0.64	0.55	0.54	0.57
Se	0.52	0.50	0.50	0.50	0.58	0.54	0.56	0.57	0.56	0.52	0.52	0.53
Tl	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.05	0.05	0.05	0.05
U	0.73	0.53	0.36	0.39	1.51	1.25	2.02	2.50	1.90	0.82	0.63	0.77
Zn	3.76	3.78	3.85	3.88	3.77	3.71	3.54	3.44	3.57	3.78	3.83	3.81

Notes:
[b] denotes an exceedance of the CCME Freshwater Aquatic Life Guidelines
[c] denotes an exceedance of the Site Specific Guidelines

Table 3-7 Constituent Concentrations at Killag River – Pond – Near Field – EOM Conditions Upper Case

Constituent	Average Monthly Concentration (µg/L)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	0.06	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.05	0.05	0.05
Al	238.80[b]	240.44[b]	246.63[b]	248.82[b]	236.75[b]	233.36[b]	218.61[b]	210.00[b]	221.46[b]	240.31[b]	244.57[b]	242.06[b]
As	6.75[b]	5.69[b]	3.53	2.99	9.25[b]	8.56[b]	13.22[b]	16.01[b]	12.36[b]	5.95[b]	4.74	6.00[b]
Cd	0.025	0.025	0.022	0.020	0.023	0.026	0.031	0.034	0.030	0.023	0.022	0.023
Co	0.36	0.35	0.33	0.32	0.39	0.40	0.47	0.52	0.46	0.36	0.34	0.35
Cu	1.07	1.06	1.03	1.02	1.08	1.10	1.17	1.22	1.16	1.06	1.04	1.05
Fe	532.59[bc]	535.13[bc]	524.51[b]	517.06[b]	507.96[b]	523.48[b]	529.13[bc]	530.93[bc]	526.67[bc]	522.12[b]	519.55[b]	522.08[b]
Hg	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01
Mn	63.48	61.68	54.44	51.64	64.15	66.81	80.24	87.94	77.50	60.08	56.25	59.48
Mo	3.32	2.77	2.23	2.32	5.69	5.23	8.04	9.79	7.60	3.81	3.07	3.43
Ni	1.14	1.12	1.07	1.05	1.22	1.22	1.39	1.48	1.36	1.14	1.10	1.13
Pb	0.34	0.33	0.33	0.34	0.37	0.35	0.36	0.36	0.36	0.34	0.34	0.35
Sb	0.68	0.60	0.54	0.55	0.94	0.78	0.95	1.07	0.93	0.66	0.63	0.69
Se	0.57	0.53	0.51	0.52	0.71	0.62	0.70	0.75	0.69	0.57	0.56	0.59
Tl	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
U	1.18	0.87	0.56	0.59	2.35	1.99	3.25	4.04	3.06	1.30	0.98	1.21
Zn	4.70	4.67	4.26	4.06	4.42	4.76	5.40	5.76	5.26	4.47	4.27	4.41

Notes:
[b] denotes an exceedance of the CCME Freshwater Aquatic Life Guidelines
[c] denotes an exceedance of the Site Specific Guidelines

Table 3-8 Required Constituent Loading Removals to Meet Regulatory Guidelines (g/month) – EOM Conditions Base Case

Constituent	Average Monthly Loadings (g)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	0	0	0	0	0	0	0	0	0	0	0	0
Al	0	0	0	0	0	0	0	0	0	0	0	0
As	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0
Co	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0	0	0	0	0	0	0	0	0	0
Fe	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0
Mn	0	0	0	0	0	0	0	0	0	0	0	0
Mo	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0
Sb	0	0	0	0	0	0	0	0	0	0	0	0
Se	0	0	0	0	0	0	0	0	0	0	0	0
Tl	0	0	0	0	0	0	0	0	0	0	0	0
U	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0	0	0	0	0

Table 3-9 Required Constituent Loading Removals to Meet Regulatory Guidelines (g/month) – EOM Conditions Upper Case

Constituent	Average Monthly Loadings (g)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	0	0	0	0	0	0	0	0	0	0	0	0
Al	0	0	0	0	0	0	0	0	0	0	0	0
As	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0
Co	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0	0	0	0	0	0	0	0	0	0
Fe	11,192	13,468	0	0	0	0	3,247	3,743	1,420	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0
Mn	0	0	0	0	0	0	0	0	0	0	0	0
Mo	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0
Sb	0	0	0	0	0	0	0	0	0	0	0	0
Se	0	0	0	0	0	0	0	0	0	0	0	0
Tl	0	0	0	0	0	0	0	0	0	0	0	0
U	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0	0	0	0	0

Table 3-10 Constituent Concentrations at Killag River – Pit – Near Field – PC Condition Base Case

Constituent	Average Monthly Concentration (µg/L)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	0.07	0.07	0.06	0.05	0.09	0.08	0.10	0.12	0.10	0.07	0.06	0.07
Al	235.00[b]	235.82[b]	244.10[b]	247.76[b]	237.89[b]	228.51[b]	208.38[b]	196.67[b]	212.46[b]	236.93[b]	242.96[b]	240.53[b]
As	7.29[b]	6.04[b]	3.62	3.05	10.44[b]	9.29[b]	14.53[b]	17.72[b]	13.57[b]	6.34[b]	5.03[b]	6.50[b]
Cd	0.025	0.023	0.021	0.020	0.029	0.027	0.032	0.035	0.031	0.024	0.022	0.024
Co	0.32	0.31	0.30	0.30	0.35	0.33	0.36	0.37	0.35	0.32	0.31	0.32
Cu	2.08[b]	1.82	1.36	1.25	2.74[b]	2.47[b]	3.48[b]	4.10[b]	3.30[b]	1.89	1.64	1.94
Fe	482.81[b]	484.29[b]	500.87[b]	508.06[b]	489.01[b]	470.00[b]	429.80[b]	406.45[b]	437.97[b]	486.70[b]	498.78[b]	494.04[b]
Hg	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mn	50.36	49.56	48.58	48.46	52.57	50.70	51.99	52.82	51.77	49.58	49.38	50.25
Mo	1.26	1.20	1.08	1.05	1.44	1.35	1.60	1.75	1.56	1.21	1.15	1.23
Ni	1.05	1.03	1.00	1.00	1.11	1.07	1.11	1.14	1.10	1.03	1.02	1.05
Pb	0.33	0.33	0.33	0.33	0.34	0.33	0.32	0.32	0.32	0.33	0.33	0.33
Sb	0.52	0.51	0.50	0.50	0.55	0.53	0.54	0.55	0.54	0.51	0.51	0.52
Se	0.51	0.50	0.50	0.50	0.54	0.52	0.53	0.54	0.53	0.51	0.51	0.51
Tl	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
U	2.77	2.15	0.99	0.72	4.35	3.77	6.33	7.89	5.86	2.32	1.68	2.40
Zn	5.53	5.13	4.44	4.30	6.59	6.10	7.56[b]	8.45[b]	7.29[b]	5.24	4.89	5.34

Notes:
b denotes an exceedance of the CCME Freshwater Aquatic Life Guidelines
c denotes an exceedance of the Site Specific Guidelines

Table 3-11 Constituent Concentrations at Killag River – Pit – Near Field – PC Condition Upper Case

Constituent	Average Monthly Concentration (µg/L)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	0.10	0.08	0.06	0.06	0.13	0.11	0.16	0.18	0.15	0.09	0.08	0.09
Al	238.42[b]	239.11[b]	246.01[b]	249.05[b]	240.78[b]	232.94[b]	216.07[b]	206.26[b]	219.49[b]	239.99[b]	245.04[b]	243.03[b]
As	12.34[b]	10.36[b]	5.58[b]	4.16	16.28[b]	15.60[b]	25.47[b]	31.38[bc]	23.58[b]	10.29[b]	7.72[b]	10.33 [b]
Cd	0.043	0.038	0.028	0.024	0.051	0.050	0.071	0.084	0.067	0.038	0.032	0.038
Co	0.37	0.36	0.32	0.31	0.39	0.39	0.46	0.51	0.45	0.35	0.34	0.36
Cu	7.91[b]	6.34[b]	3.37[b]	2.68[b]	11.91[b]	10.43[b]	16.93[b]	20.89[b]	15.74[b]	6.76[b]	5.14[b]	6.96[b]
Fe	502.93[b]	503.98[b]	515.03[b]	518.43[b]	511.17[b]	503.77[b]	489.16[b]	481.21[b]	492.69[b]	510.70[b]	515.07[b]	510.74[b]
Hg	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01
Mn	64.10	62.50	54.49	51.10	62.60	66.28	79.82	87.57	76.90	59.62	55.78	59.23
Mo	2.26	2.00	1.44	1.29	2.87	2.68	3.85	4.56	3.63	2.02	1.73	2.05
Ni	1.18	1.15	1.06	1.03	1.24	1.23	1.39	1.49	1.36	1.13	1.09	1.14
Pb	0.35	0.34	0.33	0.34	0.37	0.35	0.36	0.37	0.36	0.34	0.34	0.35
Sb	0.61	0.58	0.53	0.52	0.69	0.65	0.76	0.82	0.74	0.59	0.56	0.60
Se	0.56	0.54	0.51	0.51	0.63	0.59	0.65	0.69	0.64	0.55	0.54	0.56
Tl	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
U	4.26	3.32	1.51	1.08	6.64	5.79	9.75	12.16	9.02	3.56	2.57	3.67
Zn	6.65	6.16	4.91	4.52	7.52[b]	7.40[b]	9.86[b]	11.33[b]	9.38[b]	6.07	5.43	6.10

Notes:
[b] denotes an exceedance of the CCME Freshwater Aquatic Life Guidelines
[c] denotes an exceedance of the Site Specific Guidelines

Table 3-12 Required Constituent Loading Removals to Meet Regulatory Guidelines (g/month) – PC Conditions Base Case

Constituent	Average Monthly Loadings (g)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	0	0	0	0	0	0	0	0	0	0	0	0
Al	0	0	0	0	0	0	0	0	0	0	0	0
As	1,891	389	0	0	10,534	1,569	1,549	1,583	1,543	0	0	2,915
Cd	0	0	0	0	0	0	0	0	0	0	0	0
Co	0	0	0	0	0	0	0	0	0	0	0	0
Cu	224	0	0	0	2,078	751	1,237	1,385	1,177	0	0	0
Fe	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0
Mn	0	0	0	0	0	0	0	0	0	0	0	0
Mo	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0
Sb	0	0	0	0	0	0	0	0	0	0	0	0
Se	0	0	0	0	0	0	0	0	0	0	0	0
Tl	0	0	0	0	0	0	0	0	0	0	0	0
U	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	856	1,309	666	0	0	0

Table 3-13 Required Constituent Loading Removals to Meet Regulatory Guidelines (g/month) – PC Conditions Upper Case

Constituent	Average Monthly Loadings (g)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	0	0	0	0	0	0	0	0	0	0	0	0
Al	0	0	0	0	0	0	0	0	0	0	0	0
As	8,767	5,867	3,254	0	25,737	9,884	9,658	9,682	9,585	8,432	9,048	12,093
Cd	0	0	0	0	0	0	0	0	0	0	0	0
Co	0	0	0	0	0	0	0	0	0	0	0	0
Cu	8,204	5,619	4,908	6,295	26,031	11,275	11,236	11,369	11,203	10,377	10,902	12,071
Fe	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0
Mn	0	0	0	0	0	0	0	0	0	0	0	0
Mo	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0
Sb	0	0	0	0	0	0	0	0	0	0	0	0
Se	0	0	0	0	0	0	0	0	0	0	0	0
Tl	0	0	0	0	0	0	0	0	0	0	0	0
U	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	1,371	533	2,147	2,598	1,937	0	0	0

Table 3-14 Constituent Concentrations at Far Field in Killag River – EOM Condition Base Case

Constituent	Average Monthly Concentration (µg/L)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Ag	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.05	0.05	0.05
Al	230.44[b]	232.44[b]	242.86[b]	247.05[b]	230.84[b]	223.63[b]	201.20[b]	188.26[b]	205.72[b]	233.97[b]	240.55[b]	236.61[b]
As	3.48	2.85	2.22	2.25	5.62[b]	4.48[b]	6.22[b]	7.33[b]	5.95[b]	3.37	2.98	3.53
Cd	0.018	0.018	0.018	0.019	0.018	0.017	0.016	0.016	0.017	0.018	0.018	0.018
Co	0.31	0.30	0.30	0.31	0.34	0.33	0.35	0.36	0.34	0.32	0.31	0.31
Cu	0.95	0.95	0.97	0.98	0.97	0.94	0.91	0.89	0.91	0.96	0.97	0.96
Fe	473.37[b]	477.64[b]	498.13[b]	506.13[b]	472.25[b]	458.41[b]	412.50[b]	385.89[b]	421.63[b]	479.59[b]	493.00[b]	485.18[b]
Hg	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mn	48.91	48.07	48.13	48.62	52.59	49.92	50.50	51.00	50.52	49.13	49.17	49.67
Mo	1.51	1.37	1.27	1.31	2.12	1.98	2.62	3.03	2.52	1.64	1.48	1.56
Ni	1.00	0.99	1.00	1.01	1.08	1.04	1.07	1.09	1.07	1.03	1.02	1.02
Pb	0.32	0.32	0.33	0.33	0.33	0.32	0.31	0.30	0.31	0.32	0.33	0.33
Sb	0.54	0.52	0.50	0.51	0.66	0.58	0.63	0.66	0.62	0.54	0.54	0.56
Se	0.51	0.50	0.49	0.50	0.57	0.53	0.54	0.55	0.54	0.51	0.51	0.52
Tl	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.05	0.05	0.05
U	0.70	0.51	0.34	0.37	1.45	1.20	1.94	2.42	1.83	0.79	0.61	0.74
Zn	3.71	3.73	3.83	3.87	3.74	3.65	3.44	3.31	3.48	3.75	3.81	3.78

Notes:
[b] denotes an exceedance of the CCME Freshwater Aquatic Life Guidelines
[c] denotes an exceedance of the Site Specific Guidelines

Table 3-15 Constituent Concentrations at Far Field in Killag River – EOM Condition Upper Case

Constituent	Average Monthly Concentration (µg/L)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Ag	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.05	0.05	0.05
Al	235.68[b]	237.36[b]	245.31[b]	248.40[b]	235.21[b]	230.05[b]	212.50[b]	202.32[b]	215.99[b]	238.20[b]	243.32[b]	240.24[b]
As	6.53[b]	5.51[b]	3.45	2.93	8.95[b]	8.27[b]	12.76[b]	15.45[b]	11.93[b]	5.77[b]	4.61	5.81[b]
Cd	0.025	0.024	0.021	0.020	0.023	0.025	0.030	0.033	0.029	0.023	0.021	0.023
Co	0.35	0.34	0.33	0.32	0.38	0.39	0.46	0.50	0.45	0.36	0.34	0.35
Cu	1.05	1.04	1.02	1.01	1.07	1.08	1.14	1.17	1.13	1.05	1.03	1.04
Fe	524.50[b]	527.16[bc]	521.04[b]	515.92[b]	503.94[b]	514.99[b]	513.67[b]	511.68[b]	512.82[b]	516.63[b]	516.26[b]	517.33[b]
Hg	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01
Mn	62.18	60.47	53.89	51.39	63.13	65.33	77.68	84.81	75.17	59.12	55.63	58.61
Mo	3.22	2.68	2.18	2.27	5.50	5.06	7.75	9.45	7.34	3.69	2.98	3.32
Ni	1.12	1.10	1.06	1.05	1.20	1.20	1.34	1.43	1.32	1.13	1.09	1.11
Pb	0.33	0.33	0.33	0.34	0.37	0.35	0.35	0.35	0.35	0.34	0.34	0.34
Sb	0.66	0.59	0.53	0.54	0.92	0.76	0.92	1.03	0.90	0.65	0.62	0.68
Se	0.56	0.53	0.51	0.52	0.70	0.61	0.68	0.72	0.67	0.56	0.55	0.58
Tl	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.05	0.05	0.05	0.05
U	1.13	0.84	0.54	0.57	2.27	1.92	3.14	3.90	2.95	1.25	0.95	1.17
Zn	4.61	4.58	4.22	4.05	4.36	4.66	5.23	5.55	5.11	4.41	4.23	4.36

Notes:
[b] denotes an exceedance of the CCME Freshwater Aquatic Life Guidelines
[c] denotes an exceedance of the Site Specific Guidelines

Table 3-16 Constituent concentrations at Far Field in Killag River – PC Condition Base Case

Constituent	Average Monthly Concentration (µg/L)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	0.07	0.07	0.06	0.05	0.09	0.08	0.10	0.11	0.10	0.07	0.06	0.07
Al	232.64[b]	233.54[b]	243.09[b]	247.38[b]	236.51[b]	225.95[b]	203.72[b]	190.82[b]	208.28[b]	235.29[b]	241.95[b]	239.09[b]
As	7.23[b]	5.99[b]	3.60	3.03	10.33[b]	9.21[b]	14.39[b]	17.56[b]	13.44[b]	6.28[b]	4.99	6.44[b]
Cd	0.025	0.023	0.021	0.020	0.029	0.027	0.032	0.035	0.031	0.024	0.022	0.024
Co	0.32	0.31	0.30	0.30	0.34	0.33	0.35	0.36	0.35	0.31	0.31	0.32
Cu	2.06[b]	1.81	1.35	1.25	2.72[b]	2.45[b]	3.44[b]	4.05[b]	3.26[b]	1.88	1.63	1.92
Fe	477.93[b]	479.58[b]	498.79[b]	507.28[b]	486.16[b]	464.72[b]	420.18[b]	394.37[b]	429.34[b]	483.32[b]	496.70[b]	491.07[b]
Hg	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mn	49.86	49.08	48.37	48.37	52.22	50.15	51.00	51.57	50.87	49.23	49.15	49.93
Mo	1.25	1.19	1.07	1.05	1.43	1.34	1.57	1.72	1.53	1.20	1.14	1.22
Ni	1.04	1.02	1.00	1.00	1.10	1.05	1.09	1.11	1.08	1.02	1.02	1.04
Pb	0.33	0.32	0.33	0.33	0.34	0.32	0.32	0.31	0.32	0.33	0.33	0.33
Sb	0.51	0.50	0.50	0.50	0.55	0.52	0.53	0.54	0.53	0.51	0.51	0.52
Se	0.51	0.50	0.49	0.50	0.54	0.51	0.52	0.52	0.52	0.50	0.50	0.51
Tl	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
U	2.75	2.14	0.98	0.71	4.30	3.73	6.27	7.83	5.81	2.30	1.67	2.38
Zn	5.48	5.09	4.42	4.29	6.54	6.04	7.45[b]	8.32[b]	7.20[b]	5.20	4.86	5.30

Notes:
[b] denotes an exceedance of the CCME Freshwater Aquatic Life Guidelines
[c] denotes an exceedance of the Site Specific Guidelines

Table 3-17 Constituent concentrations at Far Field in Killag River – PC Condition Upper Case

Constituent	Average Monthly Concentration (µg/L)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ag	0.09	0.08	0.06	0.06	0.13	0.11	0.15	0.18	0.15	0.09	0.08	0.09
Al	236.47[b]	237.22[b]	245.18[b]	248.74[b]	239.65[b]	230.83[b]	212.23[b]	201.43[b]	216.04[b]	238.64[b]	244.21[b]	241.84[b]
As	12.23[b]	10.27[b]	5.54[b]	4.13	16.10[b]	15.45[b]	25.23[b]	31.09[bc]	23.35[b]	10.20[b]	7.65[b]	10.23[b]
Cd	0.042	0.038	0.027	0.024	0.050	0.049	0.071	0.083	0.066	0.038	0.032	0.038
Co	0.37	0.36	0.32	0.31	0.39	0.39	0.46	0.50	0.44	0.35	0.33	0.35
Cu	7.85[b]	6.29[b]	3.35[b]	2.66[b]	11.78[b]	10.33[b]	16.78[b]	20.71[b]	15.60[b]	6.70[b]	5.09[b]	6.89[b]
Fe	497.81[b]	499.03[b]	512.76[b]	517.52[b]	508.04[b]	498.07[b]	478.83[b]	468.28[b]	483.40[b]	507.01[b]	512.78[b]	507.55[b]
Hg	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01
Mn	63.42	61.87	54.21	50.99	62.13	65.53	78.50	85.94	75.71	59.14	55.48	58.80
Mo	2.24	1.98	1.43	1.28	2.84	2.65	3.81	4.51	3.59	2.01	1.71	2.04
Ni	1.17	1.14	1.05	1.02	1.23	1.21	1.37	1.46	1.34	1.13	1.09	1.13
Pb	0.34	0.34	0.33	0.33	0.37	0.35	0.36	0.36	0.36	0.34	0.34	0.35
Sb	0.61	0.58	0.53	0.52	0.69	0.65	0.75	0.81	0.73	0.59	0.56	0.60
Se	0.56	0.54	0.51	0.51	0.62	0.58	0.64	0.67	0.63	0.55	0.53	0.56
Tl	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
U	4.23	3.30	1.50	1.07	6.56	5.73	9.67	12.06	8.94	3.53	2.54	3.63
Zn	6.59	6.11	4.89	4.51	7.46[b]	7.32[b]	9.73[b]	11.17[b]	9.26[b]	6.02	5.39	6.05

Notes:
[b] denotes an exceedance of the CCME Freshwater Aquatic Life Guidelines
[c] denotes an exceedance of the Site Specific Guidelines

4. Future Works

The predictive water quality assessment provides insight into the potential effect of the Beaver Dam mining operation on Mud Lake and the Killag River. MDMER objectives are only anticipated to be exceeded during PC in the upper case scenario if no water quality treatment is provided on-Site. The predictive water quality assessment determined potential for exceedance of the CCME and site-specific regulatory limits within the Killag River system during all modelled scenarios. Specifically, Arsenic, Copper, Iron, and Zinc have potential to exceed CCME and site-specific regulatory limits.

This water quality assessment demonstrates the need for treatment of the mine effluent water prior to discharge into Mud Lake and the Killag River. Specifically, Arsenic and Copper will likely require treatment in the post-closure scenario to reduce concentrations below MDMER objectives. Additionally, several constituents have the potential to regularly exceed allowable limits within Mud Lake and the Killag River due to mining activities if treatment is not undertaken. Therefore, AGC proposes to construct a water treatment system on Site to treat all contact water in order to ensure Site effluent water meets discharge water quality criteria.

Additionally, GHD recommends the source terms be re-evaluated on an annual basis in order to confirm the predicted water quality impacts of the proposed Project to Mud Lake and the Killag River.

5. References

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