Back River Project
Water and Load Balance Report

Prepared for

Sabina Gold & Silver Corp.

Prepared by

SRK Consulting (Canada) Inc.
1CS020.008
October 2015

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Project No: 1CS020.008

File Name: FEIS_BackRiver_WaterLoadBalance_Report_1CS020.008_spb_emr_20151104_FNL

Executive Summary

As part of the Back River Final Environmental Impact Statement (FEIS), SRK Consulting (Canada) Inc. was retained by Sabina Gold & Silver Corp. to develop a site-wide water and load balance model to evaluate water demands and predict water quality for the Back River Project (the Project).

The Project is located in Nunavut, 160 km south of Bathurst Inlet, and is comprised of two distinct sites: the Goose Property and the Marine Laydown Area (MLA). Mining will be completed using both open pit and underground methods. The Goose Property includes four open pits and four underground developments and the Project has an estimated mine life of ten years with a total production of 19.8 million tonnes (Mt) of ore.

A GoldSim model was developed to optimize the water management strategy and tailings deposition schedule, and to evaluate water treatment needs during Operations and Closure to meet water quality guidelines. The water and load balance model is based on mass balance principles, available hydrology inputs, mining and production schedules, developed water management plans, and best available water chemistry and source load inputs.

Water quality predictions were evaluated in all open pits, tailings facilities, and in predefined locations downstream of the Goose Property. Results were compared to Metal Mining Effluent Regulations (MMER) and Canadian Council of Ministers for the Environment (CCME) water quality guidelines.

Water quality predictions indicate that water treatment will be required for the Project to meet the anticipated discharge limits during Construction, Operations, and Closure. With this proposed water treatment strategy, predicted water quality of open pit and tailings facility overflows at Closure meets MMER limits, and long-term water quality (Post-Closure) is expected to meet CCME guidelines in Goose Lake.

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1 Introduction

1.1 Background

As part of the Back River Final Environmental Impact Statement (FEIS), SRK Consulting (Canada) Inc. was retained by Sabina Gold & Silver Corp. to develop a site-wide water and load balance model for the Back River Project (the Project). The model was designed to evaluate water management needs and predict water quality at the Project and its downstream receptors.

The Project is located in the territory of Nunavut, 160 km south of Bathurst Inlet. It is comprised of two distinct sites: the Goose Property and the Marine Laydown Area (MLA). The MLA is located approximately 130 km north of the Goose Property adjacent to Bathurst Inlet (Figure 1-1).

Mining will be completed using both open pit and underground methods at the Goose Property and the Project mine life is estimated to be ten years, with a total of 19.8 million tonnes (Mt) of ore processed at a rate of 6,000 tpd.

1.2 Scope of Work

The scope of work for the water and load balance model is to develop a site wide model for the Project to evaluate water demands and provide water quality predictions. The model is based on the Project mine and production schedule (LOM Schedule 20150204, JDS 2015a) and developed water management plans (SRK 2015).

Other key objectives of the model were to optimize the water management plan, tailings deposition plan, and required treatment during Operations and Closure to meet water quality guidelines.

1.3 Report Layout

Section 2 of this report provides a summary of the mine infrastructure and Project timeline, and how they were incorporated in the model. Water balance and load model descriptions and inputs are presented in Sections 3 and 4, respectively.

Section 5 provides a summary of the model implementation, including the structure and approach used in developing the water and load balance model. Section 6 and 7 provide a summary of water balance and water quality results for the Goose Property and MLA. Section 8 provides a summary of the limitations and Section 9 describes the results of the sensitivity analysis.

The calendar years presented in the result figures and tables of the water and load balance report are not representative of the true mine operation calendar. The software used to develop the water and load balance requires a set calendar start and finish year, and it was assumed that Year 1 of mining would take place in 2019. This assumption has since been changed, and Year 1 of mining is now in 2020.

All result items should be interpreted as being 1 calendar year offset from the actual mine life calendar. The mine life years reported in this document are however accurate.

2 Model Framework

2.1 Mine Infrastructure

2.1.1 General

The water and load balance model was developed for the Goose Property and MLA area. The Goose Property is composed of four open pits, four underground mines, four waste rock storage areas, three tailings deposition locations, underground mining pads, an ore stockpile, camp, process plant, airstrip and roads. The MLA infrastructure is composed of only pads and access roads.

Figure 2-1 illustrates the MLA infrastructure and Figure 2-2 illustrates the Goose Property infrastructure, as well as important water bodies such as the location of Goose Lake and Big Lake.

The following sections provide a brief description of all reservoirs available to store water at the Goose Property that were included in the water and load balance model.

2.1.2 Tailings Storage Facility (TSF)

Based on the mine schedule (see Section 2.2), tailings deposition in the Tailings Storage Facility (TSF) will last for two years of the Project life, resulting in 3.15 Mm^3 of deposited tailings. In addition to the tailings volume, the TSF was designed to contain site-wide contact water, mill process water, as well as saline groundwater from Llama open pit dewatering. The capacity of the TSF up to the full supply level (FSL) is 6.7 Mm^3. After tailings deposition in the TSF ceases, the available water storage up to the FSL level is 3.4 Mm^3. Once tailings deposition in the TSF is complete, the remaining supernatant water in the TSF will be reclaimed to the Goose Process Plant.

The closure plan for the TSF is to cover the exposed tailings and the containment dam with waste rock originating from the Goose Main open pit and convert the TSF into a waste rock storage area (TSF WRSA). This WRSA will in turn be covered with a 5 m cap of non-potentially acid generating (NPAG) waste rock. The Goose Main open pit is located 2 km north, and downstream of the TSF. Development of the Goose Main open pit is scheduled to overlap for three months with active tailings deposition in the TSF. It is assumed that waste rock will be deposited on the tailings beaches and the upstream and downstream face of the TSF dam.

Following the dewatering of supernatant water in the TSF, a portion of the TSF containment dam will be used to store contact water until the start of Closure (SRK 2015a). The available capacity of the pond at this point is 1.2 Mm^3. At Closure, runoff from the Goose WRSA will naturally flow downstream into Goose Main open pit; now named Goose tailings facility (TF).

2.1.3 Umwelt Open Pit and Tailings Facility (Umwelt TF)

The Umwelt open pit is the first pit to be mined at the Goose Property and is scheduled to start one year before milling begins. Pit dewatering flows will be pumped to Llama Lake, followed by the TSF once milling operations begin. After completion of Umwelt open pit mining, the open pit will be used for storage of mine water, tailings deposition, and the Goose Process Plant reclaim water as the Umwelt tailings facility (Umwelt TF). Based on available pit shell information, the estimated total storage capacity of the Umwelt open pit is 7.8 Mm^3, measured below a discharge elevation of 299.7 metres above sea level (masl).

Tailings will be deposited in the Umwelt TF until the solids are at an elevation 5 m below the discharge elevation. A total of 7.1 Mm^3 of tailings will be deposited in the Umwelt TF over a period of about four years. Once the Goose open pit mining is complete, excess water from the Umwelt TF during Operations will be pumped to the Goose Main TF.

At Closure, 5.0 m of water will cover the tailings deposited in the Umwelt TF (total water volume of 0.7 Mm^3). After Closure and once site specific water quality discharge criteria are met, excess water from the Umwelt TF will be directed to Goose Lake.

2.1.4 Llama Open Pit and Reservoir Facility

The Llama open pit is expected to be developed and mined in just under three years. The Llama open pit is the only pit on the Property that will be developed in an open talik and where groundwater inflows are expected to be encountered during mining. Additional information on the subject of groundwater inflows to the Llama open pit is further described in Section 3.2.7 of this report and the Hydrogeological Characterization and Modeling Report (SRK 2015b). Pit dewatering flows will be routed to the TSF, followed by the Umwelt TF once it becomes active.

Following the completion of Llama open pit mining, the pit will be used to store excess site-wide contact water during Operations and hypersaline water (as the Llama Reservoir). At Closure, once site specific water quality discharge criteria are met, excess water will be routed to Goose Lake. The available storage capacity of the Llama open pit below a discharge elevation of 294.4 masl is 5.6 Mm^3.

2.1.5 Goose Main Open Pit and Tailings Facility (Goose Main TF)

The Goose Main open pit will be mined and developed within four years, and will be used in Year 7 as a tailings facility. Pit dewatering flows will be pumped to the TSF, followed by the Umwelt TF once it becomes active.

The available storage capacity of the Goose Main open pit after development is 10.8 Mm^3 below a discharge elevation of 279.2 masl. Based on the mine schedule and milling rate, approximately 6.2 Mm^3 of tailings will be deposited to an elevation of 247.9 masl, providing 4.6 Mm^3 of storage for process water and site-wide contact water, and 31 m of water cover above the tailings surface. Process water inventory from the Goose Main TF will be treated during Operations and Closure and pumped back to the Goose Main TF until water quality discharge criteria are met.

2.1.6 Echo Open Pit

The Echo open pit is scheduled to be mined in one year and to overlap with the Goose Main open pit operation. After development, the Echo open pit will have a pit shell volume of 401,377 m^3 below a discharge elevation of 307.0 masl.

Echo underground development includes the recovery of the crown pillar below the bottom of the Echo open pit. Water will need to be continuously dewatered from the Echo open pit until the underground mining is complete. The open pit cannot be used to store mine water or runoff until the Echo underground development is complete, which occurs at the end of the mine life. During Operations, excess water from the open pit will be routed to the Umwelt TF, followed by the Goose Main TF once it becomes active. The Echo open pit will be allowed to fill at Closure and a pit lake is expected to form from direct precipitation and upstream runoff. Once discharge criteria are met, excess water from the Echo open pit will be routed to Goose Lake.

2.1.7 Llama Lake

Based on available bathymetry, Llama Lake has a total storage capacity of 1.1 Mm^3.

As described in the Water Management Plan (SRK 2015c), the intent is to initially dewater Llama Lake to 450,000 m^3 to provide adequate storage for site-wide contact water from the Umwelt open pit dewatering and waste rock runoff during the construction of the TSF.

2.1.8 Umwelt Lake and Saline Water Pond

During the underground development of Umwelt, Llama, and Goose Main, it is expected that a significant volume of groundwater will need to be dewatered as underground development will occur in open taliks (Section 3.2.7). As chloride concentrations in the groundwater are expected to be high (Section 4.2.3), it was determined that the groundwater from the underground workings would need to be separated from the site-wide contact and process water managed on site.

The Umwelt Lake will be dewatered and the Saline Water Pond will be constructed in its footprint. Intercepted groundwater from underground development will be stored in the Saline Water Pond until water can be pumped to the Llama Reservoir and into the Llama, Umwelt, and Goose Main underground workings once mining is complete.

Based on available bathymetry, the Umwelt Lake and Saline Water Pond have total capacities of 362,480 m^3 and 1.1 Mm^3, respectively.

At Closure, once the Saline Water Pond is dewatered, the top sediments will be tested to determine if it is necessary to remove. For modelling purposes, it was assumed that the first 2 m of sediments (773,817 m^3) would be excavated and transferred to the Goose Main TF.

2.1.9 Underground Workings

Underground workings will be backfilled with waste rock during the mining process for stability reasons. Once underground mining is complete and all workings are backfilled, sufficient void volume will exist for the storage of saline water in these workings.

Table 2-1 provides a summary of the total available storage volume underground once underground development and backfilling is complete.

Table 2-1: Summary of Available Underground Void Space

Deposit	Total Void Volume (m^3)
Umwelt Underground	763,134
Llama Underground	324,234
Goose Main Underground	391,630
Echo Underground	150,812

Source: email from Harald Goetz (JDS 2014b)

2.2 Mine Schedule and Mine Phases

The life of mine ore production will be approximately ten years. A total of 19.8 Mt of ore will be processed from open pit and underground developments (JDS 2014a).

Appendix A contains a detailed plan of the mine life incorporated in the water and load balance. Table 2-2 provides a summary of the mine schedule as it relates to the mine infrastructure at the Goose Property.

Table 2-2: Summary of Mine Schedule

Mine Operation	Start	End	Total Days*
Open Pit Development			
Umwelt open pit	Y-2,Q2	Y2,Q1	1,096
Llama open pit	Y1,Q1	Y3,Q3	1,004
Goose Main open pit	Y2,Q3	Y6,Q1	1,370
Echo open pit	Y4,Q3	Y5,Q3	457
Underground Development			
Umwelt underground mine	Y2,Q1	Y10,Q2	3,104
Llama underground mine	Y1,Q1	Y4,Q3	1,369
Goose Main underground mine	Yr5,Q1	Yr9,Q1	1,551
Echo underground mine	Y6,Q1	Y9,Q4	1,461

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Analysis\BackRiver_Timeline_Rev01_SPB.xlsx

Note: * Total number of days based on calendar days

The total mine life of the Project from Construction to the end of Closure is estimated to be approximately 21 years. The mine life was divided into five phases and three stages to describe key periods. Table 2-3 provides a summary of the five phases of the Project, with Phase 2 broken down into stages by the tailings deposition plan.

Table 2-3: Mine Phase and Stage

Phase	Stage	Description	Start	End	Comment
1	-	Construction	Yr-3,Q1 1/1/2016	Yr-1,Q3 10/1/2018	Building TSF and start Umwelt open pit mining and underground mining
2	1	TSF Operation	Yr-1,Q4 10/1/2018	Yr2,Q3 10//1/2020	Begin milling and tailings deposition in TSF
	2	Umwelt TF Operation	Yr2,Q4 10/1/2020	Yr6,Q3 10/1/2024	Tailings deposition in Umwelt TF
	3	Goose Main TF Operation	Yr6,Q4 10/1/2024	Yr10,Q2 7/1/2028	Tailings deposition in Goose Main TF
3	-	Closure	Yr10,Q3 7/1/2028	Yr18,Q3 10/1/2036	Active site closure, continue water treatment and remove site infrastructure
4	-	Post-Closure	Yr18,Q3 10/1/2036	Yr23,Q3 10/1/2041	Site closed. Performance monitoring

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Analysis\BackRiver_Timeline_Rev01_SPB.xlsx

2.3 Conceptual Model

The water and load balance model was used as a tool to analyze water management options during the life of the Project. The focus of the water management strategy was to control the inventory of mine water stored on site, and to maximize the separation, saline, contact, and non-contact water. Where necessary, treatment and discharges of mine water were assessed to manage excess site-wide contact water and meet water quality guidelines downstream of discharge points from the Property.

A detailed description of the water management plan during the four phases of the Project can be found in the Water Management Plan (SRK 2015c).

Appendix B provides a number of schematics illustrating the conceptual water management plan that forms the basis of the water and load balance model. These figures illustrate inflows and outflows from key mine infrastructure at the Goose Property. The MLA is not included in these schematics as it does not require any pond or diversion infrastructure for water management. Runoff from pads at the MLA will follow existing flow paths towards Bathurst Inlet.

3 Water Balance Model Description

3.1 Water Balance Overview

The water balance tracks all inputs, outflows, and available storage at the site. The water balance can be represented in a simplistic form as follows:

$$Water\ Storage = Water\ Input - Water\ Output \qquad \text{(eq. 3a)}$$

Where the total water inputs to the site are groundwater from taliks and precipitation, as further described in this Section 3.2 of the report. The primary sources of storage available at the Goose Property are the open pits, TSF, tailings pores, and waste rock voids. Water outputs from the Property are discharges such as treated effluent, pit overflows to downstream receptors, evaporation, and seepage. Image 1 shows a schematic of the open pit and WRSA water balances included in the water and load balance model.

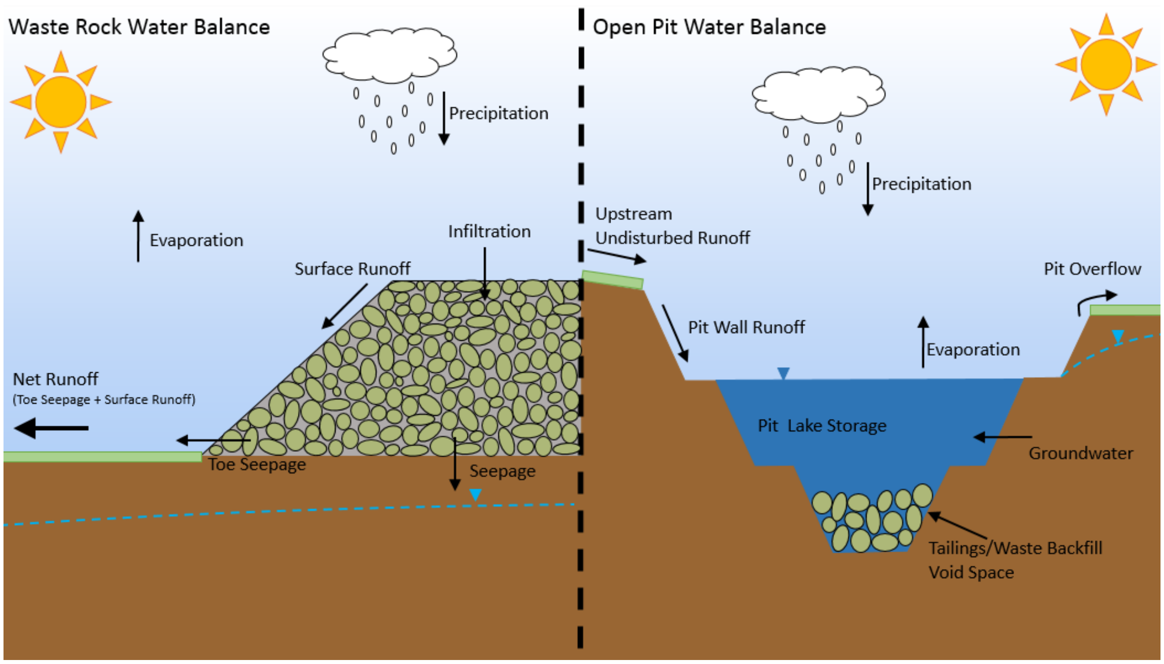


Image 1: Water Balance Schematic

The open pit water balance illustrates inflows, outflows, and available storage accounted for in the model. Undisturbed runoff and pit wall runoff are modelled as a function of precipitation, where the runoff coefficient accounts for losses such as evaporation and infiltration. In general terms, runoff and direct precipitation on ponded areas can be represented as follows:

$$Surface\ Runoff = Area\ \times Precipitation\ \times\ Runoff\ Coefficient \qquad \text{(eq. 3b)}$$

$$Direct\ Precipitation\ Rate = Pond\ Area \times \mathrm{P}recipitation\ Release\ Rate \qquad \text{(eq. 3c)}$$

The modelling of the WRSAs was simplified in the water balance. A runoff coefficient was applied to estimate the net total runoff at the toe of a WRSA. This runoff coefficient accounts for all losses such as evaporation, seepage to the groundwater table, and loss of storage in the waste rock voids. As such, runoff from a waste rock surface area was evaluated using equation 3b.

3.2 Water Balance Inputs

3.2.1 General

There are a number of inputs used to calculate water volumes in the site wide water balance. Precipitation and groundwater are the key inputs at the Property. Other important inputs include catchment areas, available storage capacities, and volumes of solids to be stored.

Table 3-1 provides a summary of the required inputs to the water balance model, which are further discussed in the following sections.

Table 3-1: Inputs Required for Water Balance Model

Water Balance Component	Input Required
Surface Runoff and Direct Precipitation	Annual runoff and precipitation volumes Open water evaporation rates Catchment areas Runoff coefficients Typical monthly hydrograph
Groundwater	Open talik inflows Through talik inflows
Water Storage	Open pit volumes Tailings and waste rock deposition (void volumes)
Milling	Water content in ore Reclaim demand Freshwater requirement
Water Released to Downstream Receptors	Calculated by the water balance model

3.2.2 Hydrology

Hydrological inputs for the water balance model are based on the hydrology analysis for the Project (SRK 2015d). The water balance model calculates monthly volumes of surface runoff based on annual runoff volumes and an average monthly runoff distribution developed for the Project. A runoff analysis was completed using site-specific and regional data. The undisturbed mean annual runoff (MAR) for the Project was estimated to be 149 mm/year. Site-specific precipitation data was analyzed along with regional data to estimate annual precipitation at the Property. An average annual precipitation undercatch factor was estimated for the Project based on factors published by Environment Canada for the region (SRK 2015d). The correction for undercatch is important in the Arctic as precipitation measurements are typically affected by systematic errors, in particular snowfall measurements, leading to an underestimation of actual precipitation. The mean annual precipitation (MAP) for the Project was estimated to be 412 mm/year, based on an average annual undercatch factor of 1.61.

The mean annual lake evaporation was determined to be 324 mm/year using Morton's WREVAP program and site-specific data. Table 3-2 provides a summary of the monthly distribution of runoff, precipitation, and evaporation estimated for the Project. Table 3-3 provides a summary of the frequency analysis of annual runoff and precipitation used to evaluate water volumes for a range of hydrological conditions (i.e. wet and dry year events).

Table 3-2: Summary of Mean Hydrologic Inputs

Month	Runoff		Effective Precipitation (mm)	Evaporation	
	Distribution (%)	Mean (mm)		Distribution (%)	Mean (mm)
January	0.0%	0.0	0.0	0.0%	0
February	0.0%	0.0	0.0	0.0%	0
March	0.0%	0.0	0.0	0.0%	0.1
April	0.0%	0.0	0.0	1.8%	5.9
May	4.0%	5.9	16.4	8.0%	25.8
June	50.5%	75.3	208.1	29.8%	96.4
July	19.0%	28.3	78.2	33.0%	106.7
August	8.7%	12.9	35.8	20.3%	65.8
September	11.9%	17.8	49.1	6.9%	22.4
October	5.5%	8.2	22.7	0.1%	0.4
November	0.4%	0.6	1.7	0.0%	0
December	0.0%	0.0	0.0	0.0%	0
Annual	100.0%	149.0	412.1	100.0%	323.6

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Analysis\Hydrology\Monthly_Water_Balance_Rev1_SPB.xlsx

Note: The monthly runoff distribution was applied to the annual precipitation to estimate the effective precipitation in the water balance model.

Table 3-3: Summary of Frequency Analysis

Hydrological Condition	Return Period	Annual Runoff (mm)	Annual Precipitation (mm)
Wet	200	269	658
	100	258	632
	50	245	603
	20	227	562
	10	210	527
	5	190	487
Average	-	149	412
Dry	5	112	344
	10	92	311
	20	75	284
	50	56	256
	100	44	238
	200	32	221

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\Task 6100_Water_Management\Hydrology\Time series for WB.xlsx

3.2.3 Catchment Delineation

Mine infrastructure and upstream catchments were delineated for the Project using AutoCad based on existing topography, final footprints of mine infrastructure, and the water management plan. In the water and load balance model, it was assumed that mine infrastructure such as pits and pads would reach their final footprint as soon as the facility becomes active according to the Project schedule.

Figure 3-1 illustrates the catchment delineations for the Goose Property and Table 3-4 provides a summary of total catchment delineations and associated infrastructure areas. As further described in Section 5.3 of this report, a total of 14 prediction nodes were included in the water balance to describe the hydrology and water quality effects from the Project. Figure 3-2 illustrates the location of the 14 prediction nodes that were included in the water and load balance model.

The total area of mine infrastructure to be developed at the Goose Property is 4.8 km^2, which is 6 % of the total Goose Lake watershed. The Project impacted area will change depending on the phase of the Project. The greatest Project impacted area will occur during pit filling when diversions are broken and upstream catchment areas are used to fill the pits. The greatest Project impacted area, when all pits are filling, could be as high as 11.1 km^2. Note that this includes the Project specific hydrology applied in the water balance as described below in Section 3.2.4.

Table 3-4: Goose Property Catchment Areas

Catchment ID	Description	Total Area (m^2)	Infrastructure Area (m^2)
PN01	Prediction Node 01	6,486,915,000	-
PN02	Prediction Node 02	108,869,073	-
PN03	Prediction Node 03	10,212,788	-
	Total road area (PN03)		277,695
PN04	Prediction Node 04	14,973,533	-
UW	Total area from Umwelt WRSA	506,475	394,720
UP	Total area to Umwelt open pit	227,445	161,800
UU	Umwelt underground pad	96,908	96,908
GooStock	Total area from Goose Stockpile	134,365	134,365
GooMA*	Total from Goose mill area	453,591	453,591
	Total road area (PN04,PN10)	214,373	214,373
PN05	Prediction Node 05	124,108,331	-
PN06	Prediction Node 06	2,881,008	-
GD	Upstream diversion of Goose Main open pit	31,515,358	-
GP	Total area to Goose Main open pit	283,364	237,400
TSF	Total area to TSF (tailings and WRSA)	2,048,050	1,190,578**
GU	Goose Main underground pad	98,948	98,948
	Total road area (PN06)		155,806
PN07	Prediction Node 07	32,801,358	-
PN08	Prediction Node 08	1,727,415	-
PN09	Prediction Node 09	1,400,610	-
ED	Upstream diversion of Echo open pit	567,056	-
EP	Total area to Echo open pit	65,730	32,900
EW	Total area from Echo WRSA	57,542	13,731
EU	Echo underground pad	13,731	13,731
	Total road area (PN09)		43,516
PN10	Prediction Node 10	3,855,217	-
LD1	Upstream Llama Lake diversion	567,617	-
LD2	Upstream Llama Lake diversion	185,602	-
LL	Total area to Llama Lake	474,561	-
LP	Total area to Llama open pit	163,654	129,700
LW	Total area from Llama WRSA	375,472	375,471
LU	Llama underground pad	70,786	70,786
RO	Saline Water Pond	524,569	524,569
PN11	Prediction Node 11	2,240,695	-

Catchment ID	Description	Total Area (m^2)	Infrastructure Area (m^2)
PN12	Prediction Node 12	25,158,763	-
PN13	Prediction Node 13	10,873,657	-
PN14	Prediction Node 14	24,905,106	-

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\Analysis\Total_Areas_Rev00_SPB.xlsx

Notes:

Total Areas presented for the prediction nodes are total cumulative upstream areas (i.e.PN04 in Table 3-4 = PN10 + PN04 from Figure 3-2)

* Total mine facility area includes plant and camp areas.
** Footprint of the TSF WRSA.

3.2.4 Site Specific Hydrology

As described in the Hydrology Report (SRK 2015d), it was found that a number of local hydrometric stations installed at the Goose Property experienced significantly higher unit flows than other watersheds monitored on the Goose Property. ERM provided an explanation for this variance (Rescan ERM 2015), including the fact that due to minimal topography, the catchment boundaries are not well defined in some areas with some watersheds spilling over into adjacent watersheds during high flows.

Figure 3-2 illustrates the identified watersheds experiencing site specific conditions and Table 3-5 provides a summary of the estimated percent flow transferred and equivalent area transferred from one watershed to the adjacent watershed.

Table 3-5: Site Specific Hydrology Inputs

Flows from	Transferred to	Equivalent Area Transferred
PN13	PN10	2.2 km^2
PN11	PN10	1.1 km^2
PN12	PN10	1.1 km^2
PN07	PN08	5.3 km^2

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Analysis\Hydrology\ Rescan Baseline Reports Hydrology Compilation_FEIS_Rev05_spb_SAB.xlsx

3.2.5 Runoff Coefficients

Runoff coefficients were used in the water balance to describe precipitation losses for catchment and infrastructure surfaces and account for losses due to evapotranspiration, soil storage, and infiltration for different surface types. Specific runoff coefficients were assigned to each area depending on land use and surface cover characteristics (Table 3-6).

The Property is located in a continuous permafrost zone. Waste rock will be deposited on permafrost where, over a period of time, the WRSA is expected to develop a permafrost layer within its core. Based on the available data and literature, the hydrological behaviour of a WRSA placed on permafrost is expected to change over time. During the initial wet-up period, greater losses are expected. Once the permafrost layer is fully developed within the WRSA, losses are found to be less significant, generating a larger amount of runoff at the toe of the waste rock pile. Appendix F provides a detailed literature review of the hydrological behaviour of waste rock in northern climates and justification of runoff coefficients applied to WRSAs for the Project. For the purpose of predicting runoff volumes from WRSAs, a runoff coefficient of 0.3 was applied during the wet-up period of the WRSA and a coefficient of 0.6 was applied during steady state frozen conditions.

Table 3-6: Runoff Coefficients

<table>
<tr><th>Land Use</th><th colspan="2">Runoff Coefficient Value</th><th>Comment</th></tr>
<tr><td>Undisturbed Area</td><td colspan="2">0.36</td><td>Based on hydrology analysis (SRK 2015d). Accounts for losses due to evapotranspiration, infiltration, and storage.</td></tr>
<tr><td rowspan="2">Waste Rock Storage Area</td><td>Unfrozen</td><td>0.30</td><td rowspan="2">Assumed value to account for losses due to evapotranspiration and storage in WRSAs and pads constructed of waste rock.</td></tr>
<tr><td>Frozen</td><td>0.60</td></tr>
<tr><td>Pit Walls</td><td colspan="2">0.80</td><td>Assumed value applied to open pit areas. Accounts for losses due to evapotranspiration and storage.</td></tr>
<tr><td>Tailings Beach Area</td><td colspan="2">0.80</td><td>Assumed value to account for losses due to evaporation and loss to voids.</td></tr>
<tr><td>Underground/Industrial Pads</td><td colspan="2">0.30</td><td>Value applied to pad surfaces due to evaporation and infiltration.</td></tr>
<tr><td>Road Surface Area</td><td colspan="2">0.30</td><td>Value applied to road surfaces due to evaporation and infiltration.</td></tr>
<tr><td>Ponded Area</td><td colspan="2">1.00</td><td>Value applied to water surfaces to account for direct precipitation.</td></tr>
</table>

3.2.6 Milling Quantities and Freshwater Demand

The tailings production rate for the Project increases from approximately 2,400 tpd for the first few months of Operations, to 6,000 tpd for the remainder of the mine life, which is roughly ten years. Table 3-7 illustrates the ramp-up schedule included in the water balance and Table 3-8 provides a summary of the parameters used to calculate water lost to tailings voids, reclaim demand, and storage capacity consumed by tailings deposition.

Table 3-7: Ramp-Up Production Schedule

Start	Production Rate (tpd)	% Rate
Yr-1,Q4	2,380	40%
Yr1,Q1	4,258	71%
Yr1,Q2	5,114	85%
Yr1,Q3	5,654	94%
Yr1,Q4	6,000	100%

Source: JDS 2015a

Table 3-8: Milling Rates and Parameters

Parameter	Value
Average Production Rate	6,000 tpd
Specific Gravity of Tailings	2.88
Tailings Dry Density	1.20
Void Ratio*	1.40
Slurry Percent Solids	50%
Ore Moisture Content	3%
Average Reclaim Rate	4,914 m^3/d
Process Freshwater Demand	900 m^3/d
Water Loss to Voids	3,000 m^3/d

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Analysis\ Back River LOM Schedule 20150204 issuecopy_REV00_SPB.xlsx

Note: * The void rate was calculated based on material properties.

Based on the tailings properties, the slurry will result in 6,000 m^3/d of water and 5,000 m^3/d of solids. The volume of water entrained in tailings voids is a function of the void ratio and tailings density. During Operations, water consumption requirements from Goose Lake include 900 m^3/d of freshwater make-up year round and 400 m^3/d for dust suppression during the open water season.

Table 3-9 provides a summary of freshwater consumption requirements for all phases of the Project where freshwater for project use will be sourced from Big Lake and Goose Lake.

Table 3-9: Summary of Freshwater Demands

Purpose	Phase	Extraction (m^3/d)	Timing	Source
Milling	Construction	-	-	-
	Operation	900	Year Round	Goose lake
	Closure	-	-	-
Domestic	Construction	211	Year Round	Big Lake
	Operation	148		
	Closure	7		
Dust Suppression & Construction Use	Construction	400	Year Round	Goose Lake
	Operation	400	June to October	
	Closure	400	Year Round	
Additional Freshwater Allowance	Construction	200	Year Round	Big Lake
	Operation	200	Year Round	Big Lake
	Closure	-	-	-

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Analysis\ Hatch Water Review 20150623.xlsx

The maximum water consumption from Goose Lake is 900 m^3/d and 1,300 m^3/d during the winter and summer respectively. The maximum water consumption from Big Lake is 411 m^3/d year round.

3.2.7 Permafrost and Groundwater

The Property is located in the continuous permafrost region of the Canadian Arctic. Although permafrost may extend in excess of 400 meters below the ground surface (mbgs), it is expected that some of the underground development may extend below the permafrost layer into unfrozen soil and rock referred to as taliks. In addition, both open pit and underground development will occur underneath or in close proximity to lakes associated with taliks. As such, groundwater inflows are expected during open pit and underground mining.

Image 2 illustrates a representation of the permafrost and possible groundwater sources from taliks for the Property. As part of the Project, a groundwater prediction model was completed to estimate potential groundwater inflows during mining at the Goose Property. The following sections provide a summary of estimated groundwater inflows for the Property. A more detailed description of the groundwater prediction model and results can be found in the Hydrogeological Characterization and Modelling Report for the Project (SRK 2015b).

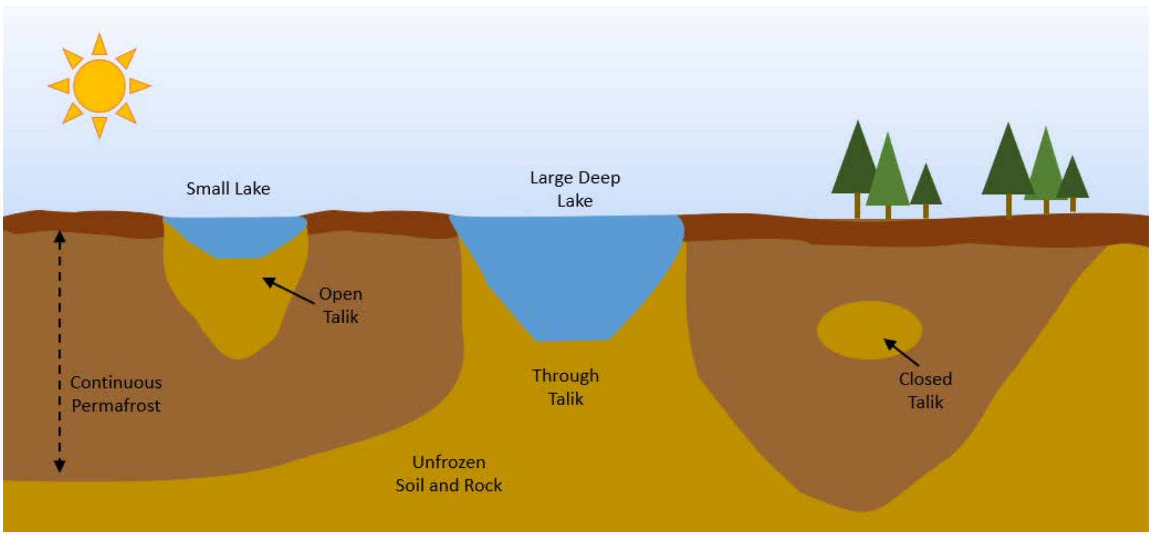


Image 2: Permafrost and Taliks

At the Goose Property, the developments which were determined to capture groundwater inflows are Llama underground, Umwelt underground, Goose Main underground, and Llama open pit.

Llama underground and open pit mining will be developed below Llama Lake within a through talik that is connected to the groundwater system. It is also expected that Llama, Umwelt, and Goose Main underground stopes will intercept the groundwater system below the permafrost layer. In the water balance model, average annual groundwater inflows were included. Table 3-10 provides a summary of groundwater inflows at the Goose Property.

Table 3-10: Goose Property Groundwater Inflows (SRK 2015b)

Year	Year No.	Flow in m³/d			
		Umwelt Underground	Llama Underground	Llama Open Pit	Goose Main Underground
2017	-2	0	0	0	0
2018	-1	0	168	0	0
2019	1	0	334	120	0
2020	2	89	350	109	0
2021	3	543	264	702	0
2022	4	440	246	Interpolated	0
2023	5	596	0	Interpolated	0
2024	6	498	0	Interpolated	21
2025	7	405	0	Interpolated	85
2026	8	359	0	Interpolated	77
2027	9	329	0	Interpolated	64
2028	10	312	0	Interpolated	0

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\Analysis\BackRiver_Predictions_20150127_SPB.xlsx

Note: * Umwelt underground completed Yr10Q2, Llama underground completed Yr4Q3, Llama open pit completed Yr3Q3 and Goose Main underground completed Yr9Q1. Llama Pit flooding was not simulated in the groundwater modelling study. The maximum inflow when the pit shell is empty was assumed to equal to 39 m^3/d.

Highlighted grey cells illustrate underground pre-development and blue cells illustrate mining period.

In order to evaluate groundwater inflows during pit filling, linear interpolation was assumed for groundwater flow into Llama open pit. A maximum of 702 m^3/d was applied for an elevation of 165 masl and 0 m^3/d at 285 masl.

4 Load Balance Model Description

4.1 Load Balance Overview

The load balance for the Project was developed to evaluate the potential effects of water quality parameter loadings from mine components on water quality in downstream receptors, such as Goose Lake and Propeller Lake. The load balance and water quality predictions were also used as a tool to optimize the water management and treatment requirements during Operations and Closure.

The load balance is based on conservation of mass. Loadings and concentrations were calculated for each mine component, and loading rates were generated for each corresponding inflow of the water balance. There are two types of loading rates included in the load balance model:

- Direct loadings based on a defined input source term; and
- Linked loading from reservoirs (i.e. open pits or lakes).

The majority of the loading rates are calculated based on the concentrations of source terms (eq. 4a), but can also be based on loading per unit volumes (eq. 4b).

$$Inflow\ Loading\ Rate = Inflow \times Source\ Term\ Concentration \qquad \text{(eq. 4a)}$$

$$Inflow\ Loading\ Rate = Load\ per\ Unit\ Volume \times Rock\ Volume\ Flooded \times Flush\ Factor \qquad \text{(eq. 4b)}$$

Linked inflow loading rates (eq. 4c) from another facility are calculated based on the calculated concentration (eq. 4d) for the facility and associated inflow from the water balance.

$$Inflow\ Loading\ Rate = Inflow \times Calculated\ Concentration \qquad \text{(eq. 4c)}$$

$$Concentration = \frac{Load\ (L)}{Volume\ (V)} \qquad \text{(eq. 4d)}$$

4.2 Load Balance Inputs

4.2.1 General

Table 4-1 shows a summary of geochemical source terms developed for the Project where each source term represents an estimate of runoff water quality (mg/L) or parameter loadings (mg/year) contributed by a Project component. The following sections provide more detailed explanations of the source terms included in the load balance.

Table 4-1: Summary of Load Balance Source Terms

Source Term	Units	Applies to
Background Surface Concentrations	mg/L	Undisturbed catchments, initial water quality in lakes and non-contact runoff
Groundwater Concentration	mg/L	Groundwater inflows from open pit and underground mining
Ore Stockpile Concentration	mg/L	Stockpile areas (pre-operation, operation and closure)
Waste Rock Concentration	mg/L	Waste rock surface areas
Pit Wall Concentration	mg/L	Pit wall area below overburden elevation
High Wall Concentration	mg/L	Pit wall area above overburden elevation
Industrial Pad Concentration	mg/L	Mill area, roads, dykes and underground pads
Tailings Beach Concentration	mg/L	Tailings beach surface area from subaerial deposition
Tailings Slurry Concentration	mg/L	Tailings slurry supernatant (i.e. process water)
Blasting Residue	mg/year	WRSA, underground pads and roads

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\WaterQuality\Water_Quality_Model_Inputs_Rev02_SPB_LMC.xlsx

4.2.2 Background Water Quality

SRK was provided with water quality data collected at the Property, dated from 1993 to 2013 (Rescan ERM 2014). In order to detect any seasonal variation in the water quality, the following parameters were analysed: alkalinity, arsenic, cadmium, calcium, chloride, copper, iron, nickel, sulphate, and zinc. Data collected from lakes and streams at the Goose Property were analyzed individually. Due to large time gaps in the data, the water quality measurements were plotted on a monthly basis. No seasonal variation was identified for any of the parameters examined in the data from the lakes, or streams. For this reason, annual water quality medians were used as inputs in the load balance model. In the calculation of the medians, any measurement below the detection limit was taken to be equal to the detection limit. Appendix C provides a summary of the water quality data used in the load balance model.

4.2.3 Groundwater Inflows

Groundwater quality included in the load balance is based on results from the Westbay well (13-GSE-319) installed adjacent to the Umwelt deposit at the Goose Property. Data from the well was corrected for the concentrated calcium chloride drilling brine used to avoid freezing during drilling. For the purpose of this analysis, an average from Westbay well Zone 3 and Zone 5 concentrations was applied in the model. Table 4-2 provides a summary of the average groundwater quality expected during mine operations.

Table 4-2: Groundwater Water Quality Parameters

Parameter	Concentration (mg/L)	Parameter	Concentration (mg/L)	Parameter	Concentration (mg/L)
Sulphate	50	Beryllium	0.001	Nickel	0.011
Alkalinity	13.3	Bismuth	0.04	Potassium	244
Chloride	depth dependent	Boron	3.94	Selenium	0.009
Nitrate as N	0.5	Cadmium	0.001	Silicon	0.6
Nitrite as N	0.1	Calcium	16,333	Silver	0.001
Ammonia as N	0.201	Chromium	0.006	Sodium	6,770
TDS	depth dependent	Cobalt	0.009	Strontium	326
Total CN as N	0	Copper	0.008	Tellurium	0
WAD as CN	0	Iron	3.81	Thallium	0.004
CNO as N	0	Lead	0.004	Thorium	0
SCN as N	0	Lithium	7.06	Tin	0.009
Hardness	44,889	Magnesium	1018	Titanium	0.1
Aluminum	0.08	Manganese	2.87	Vanadium	0.03
Antimony	0.004	Mercury	0.00001	Zinc	0.30
Arsenic	0.0071	Phosphorus	3.3	Zirconium	0
Barium	6.11	Molybdenum	0.0424	-	-

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\WaterQuality\Water_Quality_Model_Inputs_Rev02_SPB_LMC.xlsx

Groundwater inflows for the Property are expected to be more saline than sea water (salinity of 57 to 76%), where calcium chloride and sodium chloride are the dominant salts. Based on collected data, it is also expected that salinity concentrations will increase with depth.

Table 4-3 provides a summary of the total dissolved solids and chloride concentrations of groundwater inflows assuming 60% of measured total dissolved solids (TDS) is composed of chloride. It was found that the estimated salinities used in the model are of similar concentrations to those reported for other sites situated in continuous permafrost environments (e.g. Meliadine[1], Hope Bay[2]) (SRK 2015b).

[1] Meliadine Gold Project, Agnico Gold, Nunavut, Advanced Exploration
[2] Hope Bay, TMAC, Nunavut, Historical Drilling / Advanced Exploration

Table 4-3: Goose Property Groundwater TDS and Chloride Concentrations

Year	Year No.	Umwelt Underground		Llama Underground		Llama Open Pit		Goose Main Underground	
		TDS (mg/L)	Chloride (mg/L)	TDS (mg/L)	Chloride (mg/L)	TDS (mg/L)	Chloride (mg/L)	TDS (mg/L)	Chloride (mg/L)
2017	-2	0	0	0	0	0	0	0	0
2018	-1	0	0	15,533	9,320	0	0	0	0
2019	1	0	0	17,128	10,277	8,758	5,255	0	0
2020	2	32,157	19,294	21,004	12,603	10,888	6,533	0	0
2021	3	40,901	24,540	21,911	13,147	12,000	7,200	0	0
2022	4	49,820	29,892	22,344	13,407	12,000	7,200	0	0
2023	5	58,826	35,296	0	0	12,000	7,200	0	0
2024	6	57,571	34,543	0	0	12,000	7,200	29,021	17,413
2025	7	58,198	34,919	0	0	12,000	7,200	31,467	18,880
2026	8	58,919	35,351	0	0	12,000	7,200	33,017	19,810
2027	9	59,681	35,809	0	0	12,000	7,200	34,360	20,616
2028	10	60,224	36,135	0	0	12,000	7,200	0	0

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\Analysis\BackRiver _Predictions_20150127_SPB.xlsx

Note: Highlighted grey cells illustrate underground pre-development and blue cells illustrate mining period.

4.2.4 Geochemical Source Terms

Source concentrations for water in contact with the WRSA, tailings facilities, exposed mine workings and other earthworks that are part of the Project were developed by SRK for use in the load balance model (SRK 2015e). The approach used to predict the source concentrations was based on a combination of scale-up calculations, geochemical modelling, and extrapolation of monitoring data from geologically similar mine sites in the area. The hydrological inputs for these predictions were based on an average hydrological year and assumed infiltration rate. Table 4-4 provides a summary of the arsenic and sulphate concentrations for developed source terms included in the model. A summary of all parameters is included in Appendix C.

Table 4-4: Summary of Geochemical Source Terms (SRK 2015e)

Source Term	Descriptor	Sulphate (mg/L)	Arsenic (mg/L)
Ore Stockpile	Pre-Operation	910	0.096
	Operation	1,700	0.220
	Post-Operation	296	0.096
Waste Rock (unfrozen)	Umwelt	1,700	0.220
	Llama	1,700	0.220
	TSF WRSA	439	0.140
	Echo	717	0.220
Waste Rock (frozen)	Umwelt / Llama / Echo	296	0.096
	TSF WRSA	318	0.096
Pit Wall	Umwelt	53	0.094
	Llama	59	0.095
	Goose Main	38	0.055
	Echo	40	0.076
High Wall	Umwelt	14	0.009
	Llama	27	0.021
	Goose Main	5	0.0006
	Echo	24	0.012
Industrial Pads/Roads/Dykes		38	0.045
Tailings Beach		1,174	0.540

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\WaterQuality\Water_Quality_Model_Inputs_Rev02_SPB_LMC.xlsx

4.2.5 Process Water Effluent

Table 4-5 presents a summary of the process water chemistry included in the load balance. These parameters were used to represent the discharge of tailings decant water during mine operations from the Goose Process Plant. The ammonia and dissolved copper concentrations in the process water were determined to be 51 mg/L and 0.16 mg/L, respectively. Further details on metallurgical data and the analysis conducted to develop process water chemistry can be found in the Geochemical Characterization Report (SRK 2015e).

Table 4-5: Process Water Chemistry

Parameter	Concentration (mg/L)	Parameter	Concentration (mg/L)	Parameter	Concentration (mg/L)
Sulphate	1010	Beryllium	0.000025	Nickel	0.0049
Alkalinity	79	Bismuth	0.00025	Potassium	77.9
Chloride	92.40	Boron	0.07	Selenium	0.0035
Nitrate as N	0.13	Cadmium	0.00012	Silicon	1.90
Nitrite as N	0.14	Calcium	193	Silver	0.0018

Parameter	Concentration (mg/L)	Parameter	Concentration (mg/L)	Parameter	Concentration (mg/L)
Ammonia as N	51.10	Chromium	0.0025	Sodium	338
TDS	1900	Cobalt	0.11	Strontium	0.72
Total CN as N	0.59	Copper	0.16	Tellurium	0.00037
WAD as CN	0.20	Iron	3.19	Thallium	0.00002
CNO as N	20.00	Lead	0.0018	Thorium	0.00007
SCN as N	22.74	Lithium	0.010	Tin	0.0010
Hardness	617	Magnesium	33.10	Titanium	0.0055
Aluminum	0.68	Manganese	0.085	Vanadium	0.0074
Antimony	0.15	Mercury	0.00005	Zinc	0.0030
Arsenic	0.17	Phosphorus	0.30	Zirconium	0.0009
Barium	0.04	Molybdenum	0.26	-	-

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\WaterQuality\Water_Quality_Model_Inputs_Rev02_SPB_LMC.xlsx

4.2.6 Sewage Treatment Plant (STP) Treated Effluent Water

Concentrations of treated effluent discharged to Llama Lake during Construction and tailings facilities during Operations are based on typical performance estimates from packaged sewage treatment plants (PJ Equipment Sales Corp., SRK 2011).

Table 4-6 provides the estimated parameter concentrations applied to the domestic demand from the start of Construction (Year -2) to end of Closure (Year 18).

Table 4-6: Treated Effluent Water Quality Input

Parameter	Concentration (mg/L)	Parameter	Concentration (mg/L)
Ammonia as N	10	Iron	0.025
Nitrate as N	1.0	Lead	0.0001
Nitrite as N	30	Molybdenum	0.0001
Aluminum	0.052	Nickel	0.0005
Arsenic	0.0002	Phosphorus	1.0
Cadmium	0.0001	Uranium	0.0002
Chromium	0.0025	Zinc	0.002
Copper	0.0020	-	-

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\WaterQuality\Water_Quality_Model_Inputs_Rev02_SPB_LMC.xlsx

4.2.7 Blasting Residuals

Modelled blasting residues (ammonia, nitrite, and nitrate) applied to blasted rock placed as backfill or in WRSAs were derived from the methods described by Ferguson and Leask (1998). The following equation (eq. 4e) and input parameters (Table 4-7) were included in the load balance to evaluate nutrient loading from blasting.

$$NH_4NO_3 - N = Wr * Pf * ANc * Nc * Rf \qquad \text{(eq. 4e)}$$

Where:

NH_4NO_3 – N = annual release of total ammonium nitrate as nitrogen

Pf = powder factor

ANc = fraction of ammonium nitrate in ANFO

Nc = fraction of nitrogen content in ammonium nitrate

Rf = residual nitrogen remaining

Table 4-7: Blast Residue Assumptions

Parameter	Label	Value
ANFO : NH_4NO_3	Anc	1 : 0.94
NH_4NO_3 : NH_4NO_3 as N	Nc	1 : 0.35
Surface Rock Powder Factor	Pf	0.40 kg ANFO / tonne rock
Underground Powder Factor	Pf	1.14 kg ANFO / tonne rock
Residual ANFO Factor*	Rf	5%
Annual Flush Rate		40%

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\Analysis\Nutrient Load Model Example.xlsx

Note: * The residual ANFO factor (1%) specified by Furguson and Leask (1998) was increase by a factor of five.

The total nitrogen was proportioned to ammonia, nitrate, and nitrite based on the following speciation of nitrogen in the blast residues: 37% ammonia, 60% nitrate, and 3% nitrite.

Table 4-8 provides a summary of the total waste rock and fill included in the model. The model does not account for the segregation of material placed as infrastructure fill or in WRSAs. Pads made of fill (i.e. underground pads and roads) were based on a 2-m thickness and total surface area as described in Section 3.2.3. The annual distributions of nutrient loads were calculated based on the annual hydrograph distribution (Table 3-2) and assuming that 40% of the residue would be flushed annually.

Table 4-8: Total Quarried Rock

Rock Source	Mass (tonne)
Open Pit Waste Rock	64,281,398
Open Pit Ore	9,476,344
Underground Waste Rock	Negligible
Underground Ore	7,252,469
Roads/Dykes	4,511,786
Underground Pads/Mill Area	3,255,044

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\Analysis\Back River LOM Schedule 20150204 issuecopy_REV00_SPB.xlsx

Loadings from all WRSAs, road, dykes, and underground pads were included in the model. Loadings from the Goose ore stockpile area prior to milling were also included in the model. However, loads during milling operations were not included in the model as it was determined that the turn-over time of the ore in the stockpile before milling would not generate a significant flushed nutrient load.

4.2.8 Cryoconcentration

During the winter season, the model conservatively assumes that there will be 100% exclusion of parameters from the ice, resulting in higher concentrations in the water bodies. Cryoconcentration was applied to water bodies modelled as reservoirs in the load balance (i.e. lakes and open pits).

A maximum ice thickness of 2.0 m was applied to water bodies modelled. Ice was assumed to form in October to a maximum depth in February, receding to a zero ice thickness by the start of the open water season in July. Table 4-9 provides a summary of ice thickness in the model. These assumptions are reasonable based on observations recorded during the freshwater baseline study performed by Rescan ERM (2012).

Table 4-9: Ice Thickness Input

Month	Average Ice Thickness (m)
January	1.8
February	2.0
March	1.8
April	1.2
May	0.7
June	0.2
July	0.0
August	0.0
September	0.0
October	0.3
November	0.8
December	1.3

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\WaterQuality\Water_Quality_Model_Inputs_Rev02_SPB_LMC.xlsx

4.2.9 Degradation Reactions

Cyanide degradation (oxidation) occurs naturally, but can be enhanced by adding nutrients to promote biological activity (enhanced natural removal, ENR). Mass balance calculations on cyanide and intermediate degradation products can be used to estimate degradation rates.

SRK derived degradation rates for total cyanide (TCN), cyanate (OCN-), thiocyanate (SCN-), and ammonia (NH4+). There are four relevant degradation reactions for these species, which are summarized in Table 4-10. Other species involved in the reactions (such as sulphate and carbon dioxide) are omitted for clarity.

Table 4-10: Degradation Reactions and Relevant Species

No.	Degradation Reaction	Losing Species	Gaining Species
1	TCN degrades to OCN-	TCN	OCN-
2	OCN- degrades to NH4+	OCN-	NH4+
3	SCN- degrades to NH4+	SCN-	NH4+
4	NH4+ degrades to a variety of other forms of nitrogen	NH4+	Various N forms

SRK used mass balance data from the Colomac Mine[3] to estimate both natural and enhanced degradation rates. The masses of TCN, OCN-, SCN-, and NH4+ in the Colomac tailings lake had been calculated periodically before adding nutrients (2000 and 2001) and after adding nutrients (2002 and 2003), so it was possible to calculate the net change in mass for each of these species (SRK 2004).

To determine degradation rates, SRK performed the following calculations:

- The masses of TCN, OCN-, SCN-, and NH4+ from the Colomac dataset were converted to an equivalent mass on a nitrogen basis (e.g., TCN as N) to easily track mass changes between species.
- The total change in mass (on a nitrogen basis) for each species was calculated for each of the four years of data. The losses of TCN and SCN- were straightforward, but OCN- and NH4+ are both degradation products from other species and are themselves degraded.
- The total mass change for each species was divided by the duration to calculate daily rates of mass change (in tonnes as N per day), which were then converted to daily rates of mg/m^2/day using the area of the Colomac tailings lake.
- The lowest degradation rates were extracted for use in the water and load balance model (Table 4-11).

Table 4-11: Summary of Degradation Rates

Parameter	Degradation Rate	Units
TCN-N	-291	mg/m^2/day
CNO-N	-439	mg/m^2/day
CNS-N	-1033	mg/m^2/day
NH4-N	-1113	mg/m^2/day

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\WaterQuality\Ndegradation rates 20141230 for use in Back River_LMC.xlsx

[3] Colomac Mine, Closed Mine (1997), Northwest Territories

5 Model Implementation

5.1 Model Version

The water and load balance model for the Project was developed using the GoldSim software package (version 11.1.2) (GoldSim Technology Group 2014).

5.2 Modelling Approach

5.2.1 Time Step

The model is run on a daily time step. Although the input data for several parameters are provided on a monthly time step, this is accommodated in GoldSim by converting the monthly inputs to daily rates for these parameters.

The run length is from Year -2 (2017) to Year 42 (2060). This run length was chosen as it allows the model to run until steady-state conditions are reached in pits and downstream receptors.

5.2.2 Stochastic Water Balance Model

Water balance results were generated by running the model as a Monte Carlo simulation. Monte Carlo simulations are well suited for situations where the actual value of a key input is not known, but where its distribution (how it may vary) is known or can be adequately estimated. Total annual precipitation for the Project is an example of such a variable. Although it is not possible to know the annual precipitation in any given year, it is possible to estimate it from a probability distribution function.

In the water balance Monte Carlo simulations, the model randomly selects a value of annual runoff depth from the probability distribution developed for the Project (Table 3-3). Runoff volumes are then calculated by multiplying the annual runoff depth by the average monthly runoff distribution according to the typical hydrograph, a runoff factor based on the surface type and the catchment area (Section 3). The model was run in this manner with a randomly generated runoff depth for each year. All results were recorded and stored by the model. A total of 100 model runs were completed using this approach. At the end of 100 model runs, all results were compiled and probability distributions of the results were generated (i.e. 5^{th}, 50^{th} and 95^{th} percentiles).

5.2.3 Deterministic Load Balance Model

Water quality predictions were completed using deterministic model runs (i.e., a single run with no probabilistic elements) and average hydrological conditions. In these cases, the mean annual precipitation (412 mm) was applied. This approach was taken to be consistent with the source terms, which were derived based on average hydrological conditions.

5.3 Water Quality Objectives

The objective of the water and load balance model is to predict water quality at the Goose Property as well as the effect to downstream receptors.

Predictions were evaluated in pits and ponds at the Property as well as downstream control points. Figure 3-2 illustrates the selected downstream prediction nodes for the Goose Property. The prediction nodes were strategically chosen to assess the flow and water quality effects from Project infrastructure and to optimize the required water treatment to meet water quality objectives. Water balance and water quality prediction results were not evaluated for PN05 and PN14 as bathymetry and Big Lake outflows were not available to effectively model the outlet of Big Lake (PN14). As such, the downstream prediction node PN05 and PN14 could not be modelled and are not included in the discussion of results in Sections 6 and 7.

Results were compared to Metal Mining Effluent Regulations (MMER) (EC 2012) and Canadian Council of Ministers for the Environment (CCME) water quality guidelines. In addition, water quality results for arsenic and copper were also compared to site specific objectives developed by ERM Rescan (Sabina 2015). The site specific limit for arsenic and copper were determined to be 0.01 mg/L and 0.0042 mg/L, respectively.

5.4 Water Treatment

5.4.1 Concept

The water and load balance model was used to evaluate water treatment needs. Water quality predictions indicate that water treatment will be required for the Project to meet anticipated discharge limits during Construction, Operations, and Closure.

During the Construction period, Llama Lake and Umwelt Lake will need to be pre-dewatered to allow for storage of contact water in Llama Lake and saline underground water in Umwelt Lake. All water from Umwelt Lake will be pumped to Goose Lake; 50% of this water will be discharged directly, while the remaining 50% will be treated during the open water season prior to discharge. In order to manage the inventory of contact water in Llama Lake during the Construction period of the TSF, water from Llama Lake will also need to be treated and discharged during the open water season. This water is expected to have high arsenic and suspended solid concentrations.

Treatment will be inactive between Years -1 and 6, but will begin again year round in Year 7 to treat water from the Goose Main TF to reduce copper concentrations. Once mining is complete, water treatment continues throughout the Closure period during the open water season till the end of Closure in Year 18.

Note that the water treatment plants during Construction, Operations, and Closure are modular, can be relocated, and combined as necessary to achieve the appropriate water treatment at different phases of the Project.

Table 5-1 provides a summary of the required treatment for the Goose Property during Construction, Operations, and Closure.

Table 5-1: Goose Property Treatment Summary

Phase	From	To	Start	End	Flow Rate (m^3/d)	Primary Constituent	Comment
Construction	Umwelt Lake	Goose Lake	Yr-2,Q3 (7/1/2017)	Yr-2,Q3 (10/1/2017)	1,390	TSS	Treat final 50% of Umwelt Lake volume. Open Water Season.
	Llama Lake	Goose Lake	Yr-2,Q3 (7/1/2017)	Yr-2,Q3 (10/1/2017)	15,000	TSS, Arsenic	Treat final dewatering before open pit mining over one open water season. Open Water Season.
Operations	Goose Main TF	Goose Main TF	Yr7,Q4 (10/1/2025)	Yr10,Q2 (7/1/2028)	8,500	TSS, Arsenic, Copper	Year Round Treatment.
Closure	Goose Main TF	Goose Main TF	Yr10,Q2 (7/1/2028)	Yr16,Q1 (4/1/2034)	8,500	TSS, Arsenic, Copper	Open Water Season till Goose Main TF Full.

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Analysis\Treatment_Input_Rev00_SPB.xlsx

5.4.2 Treatment System Description

Water treatment during Construction will employ ballasted clarification with iron chloride addition to coagulate/co-precipitate arsenic. This treatment will be primarily used to remove total suspended solids (TSS) and arsenic, and will be operated during the open water season. The treated water will be pumped to Goose Lake.

During Operations and Closure, it was also determined that water from the Goose Main TF will need to be treated to remove high arsenic and copper concentrations. Water treatment will include an oxidation of residual cyanide process using hydrogen peroxide, which will liberate copper and other metals that may be complexed with cyanide and oxidize available arsenite to arsenate. Ferric chloride will also be added to co-precipitate arsenic and potentially copper. During Operations, treatment will be year round, and during the Closure period, treatment will be limited to the open water season. Treated water will be pumped back into Goose Main TF.

Table 5-2 provides the effluent water quality that can be achieved from the water treatment plant.

Table 5-2: Treated Effluent Water Quality

Parameter	Construction	Operations / Closure
Aluminum	n/a	0.100
Arsenic	0.015	0.015
Copper	n/a	0.003
Iron	n/a	0.300

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Analysis\Treatment_Input_Rev00_SPB.xlsx

6 Water Balance Results

6.1 Context

As described in Section 5.2, water balance results were generated by running the model as a Monte Carlo simulation. Results are presented for the 5th, 50th and 95th percentiles, where the 50th percentile represents the median of all outcomes. The median values represent the results that are most likely to occur, (i.e. which have the highest probability of occurrence). During Operations, when water storage is a key element, the median water volumes summarized represent several consecutive years of average precipitation or alternating dry and wet years. Only when several wet years occur in succession (which is relatively improbable) does the model produce results that show greater than median water volumes in pits and tailings storage facilities. For facilities with relatively short durations, as with some of the facilities modelled, consecutive wet years may be a likely occurrence that could have a significant impact on the operation of the facility. Consequently, the Monte Carlo simulation is an effective tool for simulating the effects of variable hydrology on a given facility.

Figures B-1 to B-6 presented in Appendix B illustrate water balance result for an average hydrological year during the four identified phases of the Project. These figures illustrate the water management strategy that was implemented for the Project, cumulative volumes and change in storage over the period of a specified Project phase. As previously mentioned, MLA results are not presented in these water balance schematic as runoff from pad infrastructure follow existing flow paths to Bathurst Inlet.

The following sections provide a summary of water balance results using a stochastic approach. The results presented in the water balance schematics are based on a deterministic model run where it is expected that the 50th percentile result would be different than the average used in the deterministic model run.

6.2 Llama Lake

During the Construction period of the TSF, all site contact water will be pumped and stored in Llama Lake. This includes Umwelt pit dewatering, Umwelt WRSA runoff, Llama Underground Pad runoff and ore stockpile runoff. Prior to storing contact water, Llama Lake will be pre-dewatered from 1,112,799 m^3 to 450,000 m^3 to Goose Lake to provide storage capacity for contact water during the construction phase. In order to provide adequate storage for two years of construction and fully dewater the lake prior to Llama open pit development (Yr1, Q1), contact water from Llama Lake will need to be treated over one open water season at a rate of 15,000 m^3/d.

Table 6-1 provides a summary of the predicted total volumes of contact water treated by the water treatment plant during the Construction phase of the Project. During average hydrological conditions, approximately 0.75 Mm^3 of water will be treated and discharged to Goose Lake.

Table 6-1: Llama Lake Treated Volumes during TSF construction

Result	5th Percentile	50th Percentile	95th Percentile
Total Volume Treated (m^3)	630,000	753,750	888,750

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Results\Back River Report Results_Rev01_spb.xlsx

Note: these volumes are for the total treatment established during the construction of the TSF and do not include the initial dewatering of Llama Lake.

Figure 6-1 illustrates the probability of total volumes in Llama Lake where the peak volume to be stored in Llama Lake during the Construction phase was determined to be 726,010 m^3.

6.3 Tailings Storage Facility

Tailings will be deposited in the TSF for a total of 2 years beginning Yr-1, Q4 of the Project. The Goose Process Plant will take approximately 12 months to reach a steady state mill operation. At steady state, slurry will be pumped to the TSF with a composition of 5,000 m^3/d of solids and 6,000 m^3/d of process water. At the end of tailings deposition in the TSF, the total volume of solids deposited was determined to be 3.1 Mm^3 at a settling density of 1.2 tonne/m^3. Based on milling requirements, water will be reclaimed at an average rate of 4,914 m^3/d and 3,000 m^3/d will be lost to tailings voids. Additional contact water generated on the Goose Property will also be pumped to the TSF during this two year period.

The water balance for the TSF was determined to be positive where water will be accumulated during the deposition period. Figure 6-2 illustrates the maximum volume of water (1,539,136 m^3) at the end of deposition in the TSF (Yr2, Q3). Once deposition is complete, water will continue to be reclaimed in the TSF until insufficient water is available and reclaim is switched to Umwelt TF.

These water balance results do not account for the co-disposal of the waste rock. It was assumed that once waste rock begins to be placed on the TSF facility, beach runoff becomes waste rock runoff.

Following the end of reclaim in the TSF, the dam structure will be maintained on the west side of the TSF and utilized as a contact water pond for TSF WRSA runoff. During Operations, runoff will be pumped to the Umwelt TF and Goose Main TF. At Closure, accumulated runoff will continue to be pumped to the Goose Main TF until full.

6.4 Umwelt Open Pit and Tailings Storage Facility

During Umwelt open pit mining, contact water generated in the pit will be pumped to Llama Lake during Construction and to the TSF once milling starts.

During active tailings deposition in the Umwelt TF, site-wide contact water will be pumped to this facility to provide sufficient reclaim water for processing. The total amount of tailings deposited in Umwelt TF over four years will be approximately 7.1 Mm^3, providing 5.0 m (0.7 Mm^3) of water cover above the tailings surface (Figure 6-3). During the deposition period in Umwelt TF and post-deposition prior to Closure, water levels in Umwelt TF will need to be maintained to prevent overtopping. To ensure adequate reclaim volume during Goose Main TF deposition and ensure water levels in Umwelt TF are maintained, water from Umwelt TF is pumped to Goose Main TF.

Table 6-2 provides a summary of total volumes of water pumped from Umwelt TF to Goose Main TF using a 5,000 m^3/d pumping rate.

Table 6-2: Umwelt Pumped Volumes

Result	5th Percentile	50th Percentile	95th Percentile
Total Pumped Volume (m^3)	179,520	1,106,160	2,274,720

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Results\Back River Report Results_Rev01_spb.xlsx

A 5,000 m^3/d pump rate to Goose Main TF will be maintained until Closure of the Goose Property in Year 18, where Umwelt TF will then be allowed to naturally fill and ultimately outflow to Goose Lake.

6.5 Llama Open Pit and Reservoir Facility

During Llama open pit mining, pit wall runoff and groundwater inflows will be pumped to the TSF and Umwelt TF. Following completion of the Llama open pit mining, the pit will become the Llama Reservoir and will be used to store hypersaline water from the underground development. Water from the Saline Water Pond will be pumped to Llama Reservoir at a pump rate of 500 m^3/d and the reservoir will fill with open pit groundwater inflows, pumped saline water from the Saline Water Pond, upstream runoff, and direct precipitation creating a meromictic lake. For the purpose of this water and load balance, it was assumed that the Llama Reservoir is stratified. A more detailed description of the stratification assessment conducted by Pieters and Lawrence (2015) for the Llama Reservoir can be found in Appendix F.

Table 6-3 provides a summary of total volumes of saline water pumped from the Saline Water Pond to Llama Reservoir and Figure 6-4 illustrates the total water volume (saline + freshwater) in Llama Lake.

Table 6-3: Pumped Saline Water Volumes to Llama Reservoir

Result	5th Percentile	50th Percentile	95th Percentile
Total Pumped Volume (m^3)	1,189,072	1,211,107	1,238,192

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Results\Back River Report Results_Rev01_spb.xlsx

Diversions upstream of Llama open pit will be maintained until the end of Llama open pit mining (Year 3) and Llama Lake diversions will be maintained till start of Closure (Year 10) and will then be breached, allowing upstream runoff to naturally flow into the pit and overflow to Goose Lake.

6.6 Goose Open Pit and Tailings Storage Facility

During Goose Main open pit mining, contact water generated in the pit will be pumped to the TSF for one mining quarter, and then to Umwelt TF for the remainder of mining.

Once Goose Main TF tailings deposition is initiated, site-wide contact water will be pumped to the Goose Main TF to provide sufficient reclaim water for processing. The total amount of tailings deposited in Goose Main TF over three and half years will be approximately 6.2 Mm^3, providing 31.0 m (4.6 Mm^3) of water cover above the tailings surface at Closure. During the active tailings deposition period in Goose Main TF, water will be treated to reduce copper and arsenic levels at a rate of 8,500 m^3/d. Treatment will be established year-round until Closure in Year 10. At Closure, treatment will continue during the open water season until Goose Main TF is full. Table 6-4 provides a summary of total treated water discharged during Operations and Closure.

Table 6-4: Goose Main TF Treated Volumes

Result	5th Percentile	50th Percentile	95th Percentile
Operations - Pumped Volume (m^3)	0	14,637,940	14,712,640
Closure - Pumped Volume (m^3)	6,722,029	8,331,063	8,767,750

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Results\Back River Report Results_Rev01_spb.xlsx

As illustrated in Table 6-4, zero treatment is established for the 5th percentile scenario as there would not be sufficient water for reclaim.

Diversions upstream of Goose Main TF will be maintained until the Goose Main TF is full (Year 18), which will then be breached, allowing upstream runoff to naturally flow into the pit and overflow to Goose Lake.

Figure 6-5 illustrates the water volume in Goose Main TF during Operations and the amount of time it takes to fill Goose Main TF at Closure. As illustrated, on average it is expected that it would take approximately 8 years post-operations to fill Goose Main TF (Year 18).

6.7 Echo Open Pit

The Echo open pit needs to be continually dewatered until the end of Echo underground development, where contact water accumulated in the open pit during this time will be pumped to Goose Main TF until the end of Year 9.

Once underground development is completed, upstream diversions will be breached to allow upstream runoff to naturally fill Echo open pit. As shown in Figure 6-6, a pit lake is expected to be achieved between Years 13 and 15.

6.8 Saline Water Pond and Underground Storage

As previously stated, during the underground development of Umwelt, Llama, and Goose Main, it is expected that a significant volume of groundwater will be intercepted.

Since groundwater has very high salinity levels, it was determined that groundwater from the underground workings will be stored in the Saline Water Pond during Operations and pumped to Llama Reservoir and into underground workings once available.

The total volume of groundwater intercepted from Umwelt, Llama, and Goose Main underground developments was determined to be 1,768,433 m^3 based on estimated groundwater flows from the hydrogeological modelling performed by SRK (2015b). As summarized in Table 2-1, a total volume of 1,478,998 m^3 is available underground once underground development is complete (not including Echo underground). With the addition of direct precipitation into the Llama Reservoir, approximately 1.0 Mm^3 of hypersaline water will be pumped to Llama Reservoir. In order to handle total groundwater flows and direct precipitation, it was determined that the Saline Water Pond will need to have a capacity of 1.1 Mm^3 capacity. Figure 6-7 illustrates that the volume of water stored in the Saline Water Pond gets pumped to the underground and Llama Reservoir before the end of Year 10.The first drop in volume in Year 5 illustrates that a portion of the saline water stored in the Saline Water Pond gets pumped to the underground. The final drop in 2028 illustrates the final pumping to the underground and Llama Reservoir. Once all water from the Saline Water Pond is pumped, it was assumed that the top 2 m of soil would be excavated and transferred to the Goose Main TF if found to exceed acceptable limits. The berms will be breached and the surface runoff will be directed towards Goose Lake. It is expected that it would take less than one year to fill back Umwelt Lake; however, this was not included in the water balance. It was assumed that once the saline water pond berms are breached, water flows towards Goose Lake.

6.9 Summary of Pit Filling Times

Table 6-5 provides a summary of the time to fill pits and reservoirs at the Goose Property after mining operations are completed (Yr10, Q3).

Table 6-5: Goose Property Pit and Reservoir Fill Time

Facility	Result	5th Percentile	50th Percentile	95th Percentile
Umwelt TF	Fill Date	Yr15, Q3	Yr14, Q2	Yr13, Q2
	No. days	1,828	1,443	1,083
Llama Reservoir	Fill Date	Yr15, Q2	Yr13, Q2	Yr12, Q2
	No. days	1,797	1,075	721
Goose Main TF	Fill Date	Yr21, Q3	Yr18, Q3	Yr16, Q3
	No. days	4,018	2,982	2,279
Echo Pit	Fill Date	Yr15, Q2	Yr14, Q2	Yr13, Q2
	No. days	1,824	1,449	1,080

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Results\Back River Report Results_Rev01_spb.xlsx

6.10 Prediction Nodes

In order to assess the effect of the Project to baseline hydrology, the change in monthly flows at each prediction node and water levels for Goose Lake and Propeller Lake for the 5th, 50th and 95th percentile water balance predictions are required. Appendix G includes a detailed monthly summary of the results for each prediction nodes. Figures 6-8 through 6-13 provides a summary of annual flows for the downstream prediction nodes and Figure 6-14 provides a summary of the average annual change in water levels for Goose Lake and Propeller Lake. As previously explained in Section 5.3, PN05 and PN14 were not modelled.

The prediction node PN01 has negligible effects from the Project as it includes a large catchment area compared to the Project infrastructure. PN02 and PN03 are located at the outlet of Propeller Lake and Goose Lake, respectively. These prediction nodes illustrate that during Operations and Closure, downstream flows are reduced as water is kept on site for water reclaim and pit filling. During Post-Closure, flows are greater than baseline as runoff coefficients from the Property infrastructure (i.e. frozen WRSA) are greater than natural conditions.

PN04 illustrate flows downstream of Llama and Umwelt open pit. As expected, flows during Operations are lower than baseline as water from Project infrastructure is captured and used for Operations.

PN06 Project flows are greater than baseline as PN07 flows are directed towards PN07 during Construction, Operation, Closure and Post-Closure. This is due to the Goose Main open pit located immediately upstream of PN07 cutting off flows to PN07.

PN08 flows are not affected by Project infrastructure and PN09 flows are lower during Operations and a portion of Closure until Echo open pit is filled. PN10 illustrate flows downstream of Llama open pit and the Saline Water Pond. As expected, flows during Operations are lower than baseline as water from Project infrastructure is captured and used for Operations.

PN11, PN12 and PN13 Project flows are greater than baseline during Operations as Llama Lake diversions prevent the natural spill that typically occurs at freshet towards. Once, the diversions are removed at Closure, flow return to baseline conditions.

7 Water Quality Results

7.1 MLA Water Quality Predictions

Water quality predictions for the MLA were not included in the water and load balance model as runoff from the Property infrastructure will follow existing flow paths to Bathurst Inlet. Table 7-1 provides a summary of expected concentrations from the infrastructure pads at the MLA to Bathurst Inlet.

Table 7-1: MLA Water Quality Predictions

Parameter	Marine CCME (mg/L)	Concentration (mg/L)
Total CN as N		0.00
Chloride		0.00
Ammonia		0.00
Nitrate as N		0.00
Nitrite as N		0.00
Aluminum		0.22
Arsenic	0.0125	0.045
Boron		0.00
Cadmium	0.12	0.00
Copper		0.0028
Iron		0.42
Lead		0.00
Mercury	0.016	0.000008
Molybdenum		0.00083
Nickel		0.058
Selenium		0.00035
Silver		0.000013
Thallium		0.00
Uranium		0.00
Zinc		0.015

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Results\MLA_SourceTerms.xlsx

7.2 Goose Property Water Quality Predictions

Monthly average water quality predictions for dissolved metal concentrations were evaluated for all open pits and downstream prediction points to understand the required water treatment and assess the parameters that are predicted to be elevated in comparison to CCME guidelines and MMER limits.

The predicted water quality concentrations are based on a deterministic modelling approach, assuming average hydrological conditions. This approach is consistent with the derivation of source terms, which are developed based on average hydrology. The predicted water quality under these conditions provides the most likely results to occur.

Table 7-2 provides a summary of the parameters modelled in the load balance model. Water quality predictions summarized in the following sections are presented only for parameters with MMER limits or CCME guidelines. Water quality predictions for all remaining parameters are included in Appendix D.

Since the model is based on mass balance only and does not account for solubility controls, the predicted concentrations of some parameters may be overestimated. It should also be mentioned that the model assumes fully mixed conditions.

Table 7-2: Parameters Modelled in the Load Balance

TDS	Nitrite as N	Bismuth	Mercury	Thallium
Free CN as N	Alkalinity	Boron	Molybdenum	Thorium
Total CN as N	Ortho Phosphate	Cadmium	Nickel	Tin
WAD as CN	Phosphate	Calcium	Phosphorus	Titanium
CNO as N	TOC	Chromium	Potassium	Uranium
SCN as N	Hardness	Cobalt	Selenium	Vanadium
Sulphate	Aluminum	Copper	Silicon	Zinc
Chloride	Antimony	Iron	Silver	Zirconium
Ammonia as N	Arsenic	Lead	Sodium	
Nitrate as N	Barium	Lithium	Strontium	
Nitrate as N	Beryllium	Manganese	Tellurium	

Note: Highlighted grey cells are not included in the results section of this report but are presented in Appendix D.

7.3 Open Pit and TF Overflows and Long-Term Steady State Predictions

Table 7-3 provides a summary of the average monthly concentrations at the time of flooding and the average open water long-term steady state. These predictions are compared to MMER, discharge limits. All parameters meet MMER limits at the time of flooding and long-term steady state conditions. The following section provides a summary of the effect of pit and TF overflows in the receiving environment.

Table 7-3: Water Quality Results for the Goose Property

Parameter	MMER	Umwelt TF		Llama Reservoir		Goose Main TF		Echo Open Pit	
		At Flooding[1]	Long-term[2]	At Flooding[1]	Long-term[2]	At Flooding[1]	Long-term[2]	At Flooding[1]	Long-term[2]
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Total CN as N	1	0.000073	0.000058	0.000055	0.000065	0.000038	0.00017	0.00051	0.00051
Chloride	n/a	0.16	0.14	170	2.3	110	0.92	0.94	0.94
Ammonia	6	0.052	0.00045	0.0031	0.0004	0.0024	0.0011	0.0047	0.0047
Nitrate as N	n/a	2.3	0.0027	0.37	0.011	2.6	0.006	0.0061	0.0061
Nitrite as N	n/a	0.11	0.00023	0.028	0.0012	0.49	0.00092	0.00094	0.00094
Aluminum	n/a	0.26	0.28	0.034	0.035	0.14	0.037	0.023	0.013
Arsenic	0.5	0.099	0.068	0.0063	0.006	0.028	0.0068	0.0025	0.00045
Boron	n/a	0.00079	0.0007	0.47	0.0085	0.014	0.0046	0.0047	0.0047
Cadmium	n/a	0.0000016	0.0000014	0.00011	0.00001	0.000024	0.0000092	0.0000094	0.0000094
Copper	0.3	0.0072	0.0076	0.0022	0.0019	0.0047	0.002	0.0017	0.0014
Iron	n/a	0.3	0.31	0.48	0.046	0.29	0.042	0.026	0.016
Lead	0.2	0.0000079	0.000007	0.00055	0.00005	0.00033	0.000046	0.000047	0.000047
Mercury	n/a	0.000033	0.000034	0.000008	0.000012	0.000027	0.000013	0.0000099	0.0000096
Molybdenum	n/a	0.0032	0.0034	0.0051	0.00037	0.047	0.0004	0.00007	0.000052
Nickel	0.5	0.042	0.044	0.005	0.0071	0.022	0.0072	0.0049	0.0035
Selenium	n/a	0.0013	0.0013	0.0011	0.00021	0.0013	0.00023	0.00011	0.0001
Silver	n/a	0.000027	0.000028	0.00011	0.000012	0.00033	0.000012	0.00001	0.0000097
Thallium	n/a	0.0000079	0.000007	0.00055	0.00005	0.000014	0.000046	0.000047	0.000047
Uranium	n/a	0.0000016	0.0000014	0.00011	0.00001	0.0000034	0.0000092	0.0000094	0.0000094
Zinc	0.5	0.012	0.012	0.038	0.0041	0.0068	0.0039	0.0034	0.003

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\Analysis\Water Quality Results.xlsx

Note: 1 – Monthly Average, 2 – Annual Open Water Average

7.4 Goose Property Downstream Water Quality Predictions

Table 7-4 to Table 7-6 provide summaries of the absolute maximum monthly concentration and average long-term annual concentrations during the open water season that were modelled at the downstream water quality prediction nodes. Water quality prediction results are not presented for PN05 and PN14 as they were not included in the water quality prediction model as previously described in Section 5.3. The predictions summarized in Table 7-4 to Table 7-6 are compared to MMER, CCME and site specific criteria developed for the Property except for PN10. PN10 is only compared to MMER discharge limit as it is located immediately downstream of Umwelt TF, Umwelt WRSA and Llama WRSA. Table 7-7 provides a summary of water quality predictions at PN10. Water quality at the time of flooding and long term steady state meet MMER discharge limits.

Identified in Table 7-4 to Table 7-6 are short term exceedances for chloride, nitrite, arsenic, aluminum, silver and iron. Figures 7-1 to Figure 7-3 illustrate the time series and location of these identified exceedances.

As illustrated, exceedances are short term for the exception the rise in nitrite concentrations is associated with ANFO residual from roads and pads. The first spike in 2017 (Year -2) are from the initial construction of the roads. The spike in 2028 (Year 10) is from the Echo WRSA pond draining to PN09 and the final spike in 2036 (Year 18) is from the Goose Main TF overflow to PN06. The short-term silver and aluminum spikes at PN06 are also associated with the Goose Main TF overflow to downstream Goose Lake.

Chloride concentrations at PN04 spike in 2028 (Year 10) once the Saline Water Pond is decommissioned. During operations, the Saline Water Pond will be unlined and it is expected that chloride will diffuse into the underlying sediments. Once the pond is decommissioned, chloride will naturally diffuse upwards into surface runoff and Umwelt Lake which ultimately flows to Goose Lake. For the purpose of this water and load balance a release load was assumed to evaluate the effect of decommissioning of the Saline Water Pond.

The prediction node PN03 demonstrates the outflow concentration during flow conditions (open water). Table 7-8 provides a summary of maximum monthly concentration and average long-term annual concentrations. These results are greater than the ones summarized for PN03 because of cryoconcentration during the freeze-up period. Figure 7-4 illustrates the time series of arsenic concentration in Goose Lake and at the outlet of Goose Lake (PN03).

Table 7-4: Downstream Prediction Node Water Quality Results (PN01 to PN04)

Parameter	Guidelines			PN01		PN02		PN03		PN04	
	MMER	CCME	Site Specific	Max[1]	Long-term[2]	Max[1]	Long-term[2]	Max[1]	Long-term[2]	Max[1]	Long-term[2]
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Total CN as N	1	n/a	n/a	0.00053	0.00053	0.00059	0.00044	0.0007	0.00034	0.00052	0.00038
Chloride	n/a	120	n/a	1.5	0.99	16	1.1	34	1.3	180	2
Ammonia	6	n/a	n/a	0.0068	0.0049	0.066	0.0038	0.14	0.0026	0.96	0.0035
Nitrate as N	n/a	2.9	n/a	0.015	0.0064	0.29	0.0066	0.66	0.0067	1.6	0.0075
Nitrite as N	n/a	0.06	n/a	0.0036	0.00098	0.08	0.001	0.18	0.001	0.078	0.001
Aluminum	n/a	0.1	n/a	0.012	0.011	0.03	0.019	0.049	0.027	0.042	0.037
Arsenic	0.5	0.005	0.01	0.00033	0.00025	0.0044	0.002	0.0086	0.004	0.0096	0.0065
Boron	n/a	1.5	n/a	0.0054	0.0049	0.019	0.0051	0.035	0.0052	0.12	0.0057
Cadmium	n/a	0.001	n/a	0.00001	0.0000098	0.000014	0.0000099	0.000018	0.0000098	0.000035	0.0000094
Copper	0.3	0.002	0.0042	0.0014	0.0014	0.002	0.0016	0.0026	0.0018	0.0021	0.0019
Iron	n/a	0.3	n/a	0.015	0.014	0.054	0.023	0.094	0.033	0.14	0.048
Lead	0.2	0.001	n/a	0.00005	0.000049	0.000085	0.00005	0.00012	0.000049	0.00018	0.000047
Mercury	n/a	0.000026	n/a	0.0000099	0.0000099	0.000013	0.000011	0.000016	0.000012	0.000013	0.000012
Molybdenum	n/a	0.073	n/a	0.00018	0.000052	0.0041	0.00014	0.0081	0.00023	0.0014	0.00034
Nickel	0.5	0.025	n/a	0.0034	0.0033	0.0066	0.0046	0.0098	0.0059	0.0086	0.0077
Selenium	n/a	0.001	n/a	0.0001	0.000099	0.00026	0.00013	0.00041	0.00017	0.00041	0.00021
Silver	n/a	0.00010	n/a	0.000011	0.0000099	0.00004	0.000011	0.00007	0.000011	0.000036	0.000012
Thallium	n/a	0.00080	n/a	0.00005	0.000049	0.00007	0.00005	0.000091	0.000049	0.00018	0.000047
Uranium	n/a	0.015	n/a	0.00001	0.0000098	0.000014	0.0000099	0.000018	0.0000098	0.000035	0.0000094
Zinc	0.5	0.03	n/a	0.003	0.003	0.0045	0.0033	0.0062	0.0037	0.012	0.0041

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\Analysis\Water Quality Results.xlsx

Note: Highlighted red cells exceed Site Specific Guidelines and highlighted orange cells exceed CCME Guidelines

1 –Monthly Average, 2 – Annual Open Water Average

Table 7-5: Downstream Prediction Node Water Quality Results (PN06 to PN09)

Parameter	Guidelines			PN06		PN07		PN08		PN09	
	MMER	CCME	Site Specific	Max[1]	Long-term[2]	Max[1]	Long-term[2]	Max[1]	Long-term[2]	Max[1]	Long-term[2]
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Total CN as N	1	n/a	n/a	0.00054	0.00025	0	0	0.00054	0.00054	0.00053	0.00048
Chloride	n/a	120	n/a	82	0.95	0	0	1	1	0.99	0.89
Ammonia	6	n/a	n/a	0.24	0.0019	0	0	0.005	0.005	1.4	0.0044
Nitrate as N	n/a	2.9	n/a	1.9	0.0062	0	0	0.0065	0.0065	2.3	0.0058
Nitrite as N	n/a	0.06	n/a	0.36	0.00095	0	0	0.001	0.001	0.11	0.00089
Aluminum	n/a	0.1	n/a	0.11	0.033	0	0	0.011	0.011	0.049	0.036
Arsenic	0.5	0.005	0.01	0.023	0.0057	0	0	0.0002	0.0002	0.01	0.0057
Boron	n/a	1.5	n/a	0.012	0.0047	0	0	0.005	0.005	0.0049	0.0044
Cadmium	n/a	0.001	n/a	0.000021	0.0000095	0	0	0.00001	0.00001	0.0000099	0.0000089
Copper	0.3	0.002	0.0042	0.0041	0.0019	0	0	0.0014	0.0014	0.0018	0.0017
Iron	n/a	0.3	n/a	0.23	0.039	0	0	0.014	0.014	0.082	0.056
Lead	0.2	0.001	n/a	0.00026	0.000047	0	0	0.00005	0.00005	0.000049	0.000044
Mercury	n/a	0.000026	n/a	0.000024	0.000012	0	0	0.00001	0.00001	0.000011	0.00001
Molybdenum	n/a	0.073	n/a	0.035	0.00033	0	0	0.00005	0.00005	0.00025	0.0002
Nickel	0.5	0.025	n/a	0.019	0.0067	0	0	0.0033	0.0033	0.013	0.009
Selenium	n/a	0.001	n/a	0.001	0.00021	0	0	0.0001	0.0001	0.00017	0.00015
Silver	n/a	0.00010	n/a	0.00025	0.000012	0	0	0.00001	0.00001	0.000011	0.000011
Thallium	n/a	0.00080	n/a	0.00005	0.000047	0	0	0.00005	0.00005	0.000049	0.000044
Uranium	n/a	0.015	n/a	0.00001	0.0000095	0	0	0.00001	0.00001	0.0000099	0.0000089
Zinc	0.5	0.03	n/a	0.0063	0.0038	0	0	0.003	0.003	0.005	0.0042

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\Analysis\Water Quality Results.xlsx

Note: Highlighted red cells exceed Site Specific Guidelines and highlighted orange cells exceed CCME Guidelines

1 –Monthly Average, 2 – Annual Open Water Average

Table 7-6: Downstream Prediction Node Water Quality Results (PN11 to PN13)

Parameter	Guidelines			PN11		PN12		PN13	
	MMER	CCME	Site Specific	Max[1]	Long-term[2]	Max[1]	Long-term[2]	Max[1]	Long-term[2]
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Total CN as N	1	n/a	n/a	0.00054	0.00054	0.00054	0.00054	0.00054	0.00054
Chloride	n/a	120	n/a	1	1	1	1	1	1
Ammonia	6	n/a	n/a	0.005	0.005	0.005	0.005	0.005	0.005
Nitrate as N	n/a	2.9	n/a	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065
Nitrite as N	n/a	0.06	n/a	0.001	0.001	0.001	0.001	0.001	0.001
Aluminum	n/a	0.1	n/a	0.011	0.011	0.011	0.011	0.011	0.011
Arsenic	0.5	0.005	0.01	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Boron	n/a	1.5	n/a	0.005	0.005	0.005	0.005	0.005	0.005
Cadmium	n/a	0.001	n/a	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Copper	0.3	0.002	0.0042	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
Iron	n/a	0.3	n/a	0.014	0.014	0.014	0.014	0.014	0.014
Lead	0.2	0.001	n/a	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Mercury	n/a	0.000026	n/a	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Molybdenum	n/a	0.073	n/a	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Nickel	0.5	0.025	n/a	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033
Selenium	n/a	0.001	n/a	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Silver	n/a	0.00010	n/a	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Thallium	n/a	0.00080	n/a	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Uranium	n/a	0.015	n/a	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Zinc	0.5	0.03	n/a	0.003	0.003	0.003	0.003	0.003	0.003

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\Analysis\Water Quality Results.xlsx

Note: Highlighted red cells exceed Site Specific Guidelines and highlighted orange cells exceed CCME Guidelines

1 –Monthly Average, 2 – Annual Open Water Average

Table 7-7: Downstream Prediction Node PN10 Water Quality Results

Parameter	MMER	Max[1]	Long-term[2]
Units	(mg/L)	(mg/L)	(mg/L)
Total CN as N	1	0.00054	0.00017
Chloride	n/a	1,700	3.7
Ammonia	6	0.014	0.0014
Nitrate as N	n/a	0.54	0.0093
Nitrite as N	n/a	0.031	0.0011
Aluminum	n/a	0.071	0.059
Arsenic	0.5	0.019	0.012
Boron	n/a	0.34	0.0069
Cadmium	n/a	0.000082	0.000009
Copper	0.3	0.0028	0.0025
Iron	n/a	0.35	0.072
Lead	0.2	0.00041	0.000045
Mercury	n/a	0.000015	0.000014
Molybdenum	n/a	0.0037	0.00068
Nickel	0.5	0.013	0.011
Selenium	n/a	0.00085	0.00033
Silver	n/a	0.000083	0.000014
Thallium	n/a	0.00041	0.000045
Uranium	n/a	0.000082	0.000009
Zinc	0.5	0.029	0.0049

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\Analysis\Water Quality Results.xlsx

Note: 1 –Monthly Average, 2 – Annual Open Water Average

Table 7-8: Goose Lake Water Quality Predictions

Parameter	MMER	CCME	Site Specific	Max[1]	Long-term[2]
Units	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Total CN as N	1	n/a	n/a	0.0012	0.00034
Chloride	n/a	150	n/a	59	1.3
Ammonia	6	n/a	n/a	0.14	0.0026
Nitrate as N	n/a	2.9	n/a	1.1	0.0067
Nitrite as N	n/a	0.06	n/a	0.31	0.001
Aluminum	n/a	0.1	n/a	0.084	0.027
Arsenic	0.5	0.005	0.01	0.015	0.004
Boron	n/a	1.5	n/a	0.059	0.0052
Cadmium	n/a	0.001	n/a	0.000031	0.0000098
Copper	0.3	0.002	0.0042	0.0044	0.0018
Iron	n/a	0.3	n/a	0.16	0.033
Lead	0.2	0.001	n/a	0.0002	0.000049
Mercury	n/a	0.000026	n/a	0.000028	0.000012
Molybdenum	n/a	0.073	n/a	0.014	0.00023
Nickel	0.5	0.025	n/a	0.017	0.0059
Selenium	n/a	0.001	n/a	0.0007	0.00017
Silver	n/a	0.00010	n/a	0.00012	0.000011
Thallium	n/a	0.00080	n/a	0.00016	0.000049
Uranium	n/a	0.015	n/a	0.000031	0.0000098
Zinc	0.5	0.03	n/a	0.011	0.0037

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.006_FS_Study\!020_Project_Data\010_SRK\Water Balance\Analysis\Water Quality Results.xlsx

Note: Highlighted red cells exceed Site Specific Guidelines and highlighted orange cells exceed CCME Guidelines

1 –Monthly Average, 2 – Annual Open Water Average

8 Limitations of the Water and Load Balance Model

8.1 Context

The model results presented in this report are based on the provided mine timeline, water management plans and best available input data. As with any model representing a complex system, there are a number of uncertainties associated with inputs and modelled processes. For most cases, uncertainties are accounted for by incorporating conservative assumptions. The following sections describe uncertainties that may affect the accuracy of the model results and Section 9 provides a sensitivity analysis for runoff coefficients, source terms and groundwater inflows.

8.2 Hydrology Inputs

Hydrology inputs such as annual runoff, precipitation, evaporation, and monthly distributions were evaluated based on available local and regional data. Multiplying annual runoff depths by a fixed monthly distribution does not reflect the true behaviour of hydrological systems. In some cases, a wetter year could occur based solely on a larger than average freshet with average or below average runoff during other months. This could lead to underestimates in required storage capacities during wetter years and in water supply requirements during dryer years.

8.3 Runoff Coefficients

The undisturbed runoff coefficient of 0.36 is based on calibrated regional data. All other runoff coefficients for mine facilities were based on professional judgement and available documentation.

Two different runoff coefficients were applied to waste rock to illustrate the change in runoff from an unfrozen and frozen WRSA. As a conservative approach, SRK chose to apply a waste rock runoff coefficient of 0.3 and 0.6 for an unfrozen and frozen WRSA, respectively. A lower runoff coefficient would result in less water stored during Operations. In addition, a lower waste rock runoff coefficient for a frozen WRSA would result in longer pit filling times. The sensitivity analysis presented in Section 9 provides a more detailed description of the effect runoff coefficients have to the water balance predictions.

8.4 Groundwater Inflows

Groundwater inflows are highly sensitive to assumptions relating to the hydraulic conductivity and permafrost. Further details on the assumptions used to evaluate groundwater flows and quality (TDS) profiles with depth are described in the Hydrogeological Characterization Report (2015b). A change in groundwater inflows during underground development could affect the sizing of the Saline Water Pond and total volumes pumped to the Llama Reservoir. A further description of the sensitivity analysis for groundwater is provided in the following section.

8.5 Geochemical Factors

A number of geochemical factors that are not reflected in the model, such as attenuation of parameters along surface and subsurface flow paths, tailings diffusion, and removal of chemical loads in open pits and tailings storage facilities, may affect the total loads included in the model and the water quality predictions presented in this report.

The model does not account for solubility controls and possible precipitation of some parameters and reactions are assumed to occur instantly. As such, predicted concentrations of some parameters may be overestimated.

8.6 Dry Bulk Density of Tailings

A 1.2 tonne/m^3 bulk density was applied to tailings deposited in the TSF and open pits. Variations in the placed density of tailings will affect the volume of water stored in the tailings pore space and the remaining capacity of the facilities modelled. Depending on the potential discrepancy between actual and modelled densities, water quality loadings and volumes of water to be managed during Operations could be overestimated or underestimated.

8.7 Fully Mixed Conditions and Cryoconcentration

In order to simplify the model, water quality predictions were evaluated assuming completely mixed systems. This may not reflect the true behaviour of parameters flowing through the system. In some cases, flows may not fully mix in a lake, causing higher than predicted concentrations at the outlet.

During under-ice conditions, the model conservatively assumes that there will be 100% exclusion of parameters from the ice, resulting in higher concentrations in the water bodies. The majority of available baseline water quality data for the Project are during the summer season. However, available datasets for April and May do not exhibit increased concentrations as the modelled cryoconcentration suggests. Water quality predictions during under-ice conditions may be overestimated.

9 Sensitivity Analysis

To account for the uncertainty in input parameters and provide an understanding of the magnitude it affects final results, a sensitivity analysis was completed for runoff coefficients, arsenic source terms and groundwater inputs. All of the sensitivity analysis scenarios were run under average hydrological conditions.

Table 9-1 provides an outline of the scenarios modelled in the sensitivity analysis. The factor determines how much the variable that is being changed differs from the base case value. Information and results of specific inputs associated with each variable is provided in the following Sections.

Table 9-1: Scenarios Modelled

Scenario	Description	Variable	Factor
1A	Base case arsenic sources	Arsenic source terms listed in Table 9-2	1
1B	Upper case arsenic sources	Arsenic source terms listed in Table 9-2	2
1C	Lower case arsenic sources	Arsenic source terms listed in Table 9-2	0.5
2A	Base case runoff	All runoff factors	1
2B	Upper case runoff from road surfaces and underground pads	Runoff factors – road surfaces/UG pads	+ 25%
2C	Lower case runoff from road surfaces and underground pads	Runoff factors – road surfaces/UG pads	- 25%
2D	Upper case runoff from pit walls	Runoff factor – pit walls	+ 25%
2E	Lower case runoff from pit walls	Runoff factor – pit walls	- 25%
2F	Upper case runoff from waste rock	Runoff factors – waste rock	+ 25%
2G	Lower case runoff from waste rock	Runoff factors – waste rock	- 25%
2H	Upper case runoff from beach tailings	Runoff factor – beach tailings	+ 25%
2I	Lower case runoff from beach tailings	Runoff factor – beach tailings	- 25%
2J	Upper case runoff from all disturbed features	Runoff factors – road surfaces, UG pads, pit walls, waste rock and beach tailings	+ 25%
2K	Lower case runoff from all disturbed features	Runoff factors – road surfaces, UG pads, pit walls, waste rock and beach tailings	- 25%
3A	Base case groundwater inflows	Groundwater inflows and chloride	See Section 9.3
3B	Upper case groundwater inflows	Groundwater inflows and chloride	See Section 9.3

9.1 Source Terms

Source terms were varied in the sensitivity analysis by multiplying the arsenic terms in Table 9-2 (base case) by a factor of 2 and 0.5.

Table 9-2: Arsenic Source Terms Included in Sensitivity Analysis

Source Term	Base Case Arsenic Concentration (mg/L)		
	Pre-Operations	Operations	Closure/Post-Closure
Waste Rock			
Umwelt Waste Rock	0.22	0.22	0.10
Llama Waste Rock	0.22	0.22	0.10
TSF Waste Rock	0.14	0.14	0.10
Echo Waste Rock	0.22	0.22	0.10
Pit Wall			
Umwelt Pit Wall	0.094	0.094	0.094
Umwelt Highwall	0.10	0.10	0.10
Llama Pit Wall	0.095	0.095	0.095
Llama Highwall	0.022	0.022	0.022
Goose Pit Wall	0.055	0.055	0.055
Goose Highwall	0.00060	0.00060	0.00060
Echo Pit Wall	0.076	0.076	0.076
Echo Highwall	0.012	0.012	0.012
Stockpile			
Goose Stockpile	0.10	0.22	0.10
Other			
Beach Tailings	0.54	0.54	0.54
Industrial Pad	0.045	0.045	0.045

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Sensitivity Analysis\FEIS_Goose_Rev17H_SensitivityAnalysis_spb_kpw.gsm

The three scenarios for varying arsenic source terms were modelled. The resulting predicted arsenic concentrations in Goose Lake are presented in Figure 9-1. In the upper case, arsenic terms were multiplied by 2, while in the lower case, they were divided in half.

The predicted arsenic concentrations in Goose Lake for the upper case scenario are found to be above the site specific limit of 0.01 mg/L in the winter. The model simulates lower water volumes in the winter due to freezing, which results in predicted spikes in the concentrations over the winter. This is a conservative scenario as 100% cryoconcentration is assumed and the arsenic concentrations have been doubled in this case.

9.2 Runoff Coefficients

Runoff depths for the features in the model are estimated by multiplying the runoff factors in Table 9-3 by the estimated undisturbed runoff depth. For the purposed of the sensitivity analysis, these factors were varied by +/- 25%.

Table 9-3: Runoff Factors Included in Sensitivity Analysis

Feature	Base Case Runoff Factor
Pit Wall	0.80
Waste Rock – Unfrozen	0.30
Waste Rock – Frozen	0.60
Tailings	0.80
Road Surface / Underground Pad	0.30

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Sensitivity Analysis\FEIS_Goose_Rev17H_SensitivityAnalysis_spb_kpw.gsm

Eleven scenarios were modelled to analyze the influence of runoff factors on the water balance results. The impact on predicted pit filling times and Mill water withdrawal volumes from Goose Lake are presented below.

9.2.1 Pit Filling Timeframes

Table 9-4 provides a summary of the time of overflows under average hydrological conditions for each pit and TF. The variation in assumed runoff factors has minimal impact on Llama and Echo pits, and the largest impact on Umwelt and Goose Main TF. The predicted fill dates range from the end of 2023 (Yr5) for the upper case and the 2032 (Yr14) for the lower case scenarios for Umwelt TF. An overflow in Umwelt TF prior to end of mining (Yr10) illustrates that the pump rate from Umwelt TF to Llama Reservoir or Goose TF would need to be increased to ensure zero overflows during operations. For Goose Main TF, the predicted fill dates range from 2033 (Yr15) to 2038 (Yr20) for the upper case and lower case scenarios, respectively.

Table 9-4: Predicted Dates of Pit/TF Flooding

Scenario	Date Pit/TF is Flooded			
	Umwelt	Llama	Goose Main	Echo
Scenario 2A - Base Case	06/06/32	10/23/30	08/22/34	06/07/32
Scenario 2B - Upper Case Roads/UG Pads	06/02/32	10/07/30	08/02/34	06/07/32
Scenario 2C - Lower Case Roads/UG Pads	06/12/32	05/18/31	06/03/35	06/07/32
Scenario 2D - Upper Case Pit Wall	06/23/24	09/11/30	07/24/34	06/04/32
Scenario 2E - Lower Case Pit Wall	06/09/32	06/01/31	07/18/35	06/11/32
Scenario 2F - Upper Case Waste Rock	03/20/24	08/05/30	07/31/33	06/07/32
Scenario 2G - Lower Case Waste Rock	08/01/32	10/31/30	08/11/36	06/07/32
Scenario 2H - Upper Case Beach Tailings	06/28/24	10/01/30	08/11/34	06/07/32
Scenario 2I - Lower Case Beach Tailings	06/07/32	10/23/30	10/01/34	06/07/32
Scenario 2J - Upper Case All Features	12/14/23	06/19/30	07/04/33	06/04/32

Scenario	Date Pit/TF is Flooded			
	Umwelt	Llama	Goose Main	Echo
Scenario 2K - Lower Case All Features	09/24/32	06/04/31	06/13/38	06/11/32

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Sensitivity Analysis\FEIS_Goose_Rev17H_SensitivityAnalysis_spb_kpw.gsm

Figures 9-2 to 9-5 illustrate the predicted filling curves for each pit and TF. Figure 9-6 illustrates runoff coefficients do not affect the make-up water withdrawals from Goose Lake.

9.3 Groundwater Inflows

Base case and upper case groundwater inputs were modelled for the sensitivity analysis. The groundwater inflows and chloride concentrations for both cases modelled are provided in Table 9-5 and Table 9-6, respectively.

Table 9-5: Groundwater Inflows Applied in Sensitivity Analysis

Year	Groundwater Inflow (m^3/d)							
	Base Case				Upper Case			
	Umwelt UG	Llama UG	Llama Pit	Goose Main UG	Umwelt UG	Llama UG	Llama Pit	Goose Main UG
2017	0	0	0	0	0	0	0	0
2018	0	168	0	0	0	169	0	0
2019	0	334	120	0	0	334	391	0
2020	89	350	109	0	89	350	76	0
2021	543	264	702*	0	627	263	133*	0
2022	440	246	Interpolated	0	492	249*	Interpolated	0
2023	596	0	Interpolated	0	931	0	Interpolated	0
2024	498	0	Interpolated	21	728	0	Interpolated	21
2025	405	0	Interpolated	85	588	0	Interpolated	85
2026	359	0	Interpolated	77	514	0	Interpolated	77
2027	329	0	Interpolated	64	466	0	Interpolated	64
2028	312	0	Interpolated	0	437*	0	Interpolated	0

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Back River\1CS020.008_FEIS\!080_Deliverables\WLB Sensitivity Analysis\020_Tables\Groundwater Sensitivity Parameters_rev06.xlsx

Note: * Umwelt underground completed Yr10Q2, Llama underground completed Yr4Q3, Llama open pit completed Yr3Q3 and Goose Main underground completed Yr9Q1. Llama Pit flooding was not simulated in the groundwater modelling study. The maximum inflow when the pit shell is empty was assumed to equal to the value in 2021.

Table 9-6: Groundwater Chloride Concentrations Applied in Sensitivity Analysis

Year	Chloride Concentration (mg/L)							
	Base Case				Upper Case			
	Umwelt UG	Llama UG	Llama Pit	Goose Main UG	Umwelt UG	Llama UG	Llama Pit	Goose Main UG
2017	0	0	0	0	0	0	0	0
2018	0	9,320	0	0	0	9,202	0	0
2019	0	10,277	5,255	0	0	10,463	5,940	0
2020	19,294	12,603	6,533	0	19,258	13,492	8,100	0
2021	24,540	13,147	7,200	0	25,087	14,686	9,727	0
2022	29,892	13,407	7,200	0	30,904	15,263	9,727	0
2023	35,296	0	7,200	0	40,809	0	9,727	0
2024	34,543	0	7,200	17,413	40,732	0	9,727	17,421
2025	34,919	0	7,200	18,880	41,313	0	9,727	18,867
2026	35,351	0	7,200	19,810	41,799	0	9,727	19,957
2027	35,809	0	7,200	20,616	42,288	0	9,727	21,094
2028	36,135	0	7,200	0	42,632	0	9,727	0

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Back River\1CS020.008_FEIS\!080_Deliverables\WLB Sensitivity Analysis\020_Tables\Groundwater Sensitivity Parameters_rev06.xlsx

The upper case scenario for groundwater inputs corresponds to a model where:

- The vertical K distribution is based on the arithmetic mean of the site measurements calculated over depth intervals, as well as a trend of decreasing K with depth; and
- All the major faults identified on the Goose Property are assumed to behave as potential conduits relative to the rock mass. Faults are assumed to be vertical and characterized by a thickness of 5 m and a hydraulic conductivity of 2×10^{-7} m/s. The K value assigned to the fault is one order of magnitude higher than the K test measurement in drillhole 12GSE206 (2×10^{-8} m/s), which was the only test associated with a fault and a higher K measurement relative to other tests completed at the same depth interval.

Additional information on the groundwater input for the sensitivity analysis can be obtained in the Hydrogeological Characterization and Modelling Report (SRK 2015b).

Figures 9-7 and 9-8 illustrate the effect of the upper case groundwater flows for Saline Water Pond and Llama Reservoir water volumes, respectively. The upper case groundwater scenario results in a larger pumped volume to the Saline Water Pond and causes Llama Reservoir to overflow much sooner.

Figure 9-9 illustrates the effect of the upper case concentrations to the Saline Water Pond. The upper case scenario causes the mixed chloride concentration in the Saline Water Pond to be slightly greater.

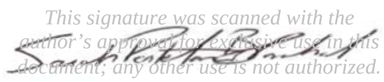
10 Conclusions

The water and load balance model for the Project was created to provide water quantity and quality estimates based on the mine and production schedule and water management plans. The model was created to optimize the water management strategy and tailings deposition schedule, and to evaluate water treatment needs during Construction, Operations, and Closure to meet water quality guidelines. Water quality predictions were evaluated in all open pits, tailings facilities, and predefined locations downstream of the Goose Property. Results were compared to Metal Mining Effluent Regulations (MMER), Canadian Council of Ministers for the Environment (CCME) water quality guidelines, and site specific criteria developed by ERM Rescan (Sabina 2015). Water quality predictions indicate that treatment during specific periods of Construction, Operations, and Closure will be required to meet MMER discharge limits, CCME, and site specific guidelines in the downstream environment.

At the Goose Property, water will be managed where discharges during Construction will be treated for TSS and arsenic. During Operations, water from the underground development of Umwelt, Llama, and Goose Main will be intercepted, stored in the Saline Water Pond and pumped into Llama Reservoir and underground workings once underground development is completed. In order to lower copper concentrations in the Goose Main TF prior to end of Closure, year-round treatment will be required during Goose Main TF deposition and open water treatment during the Closure phase to meet site specific criteria at PN06 and Goose Lake.

Water quality estimates for Llama Reservoir, Umwelt TF, Goose Main TF, and Echo open pit overflows at Closure are expected to meet MMER guidelines. However, some identified downstream prediction nodes were found to exceed a number of CCME/site specific guidelines. Long-term water quality predictions (Post-Closure) are expected to meet CCME guidelines in Goose Lake.

This report, “Back River Project Water and Load Balance Report”, was prepared by SRK Consulting (Canada) Inc.



Sarah Portelance-Blanchard, PEng
Consultant

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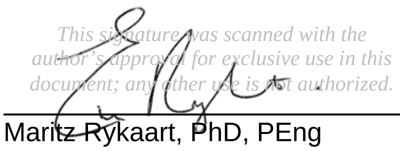

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Principal Consultant

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

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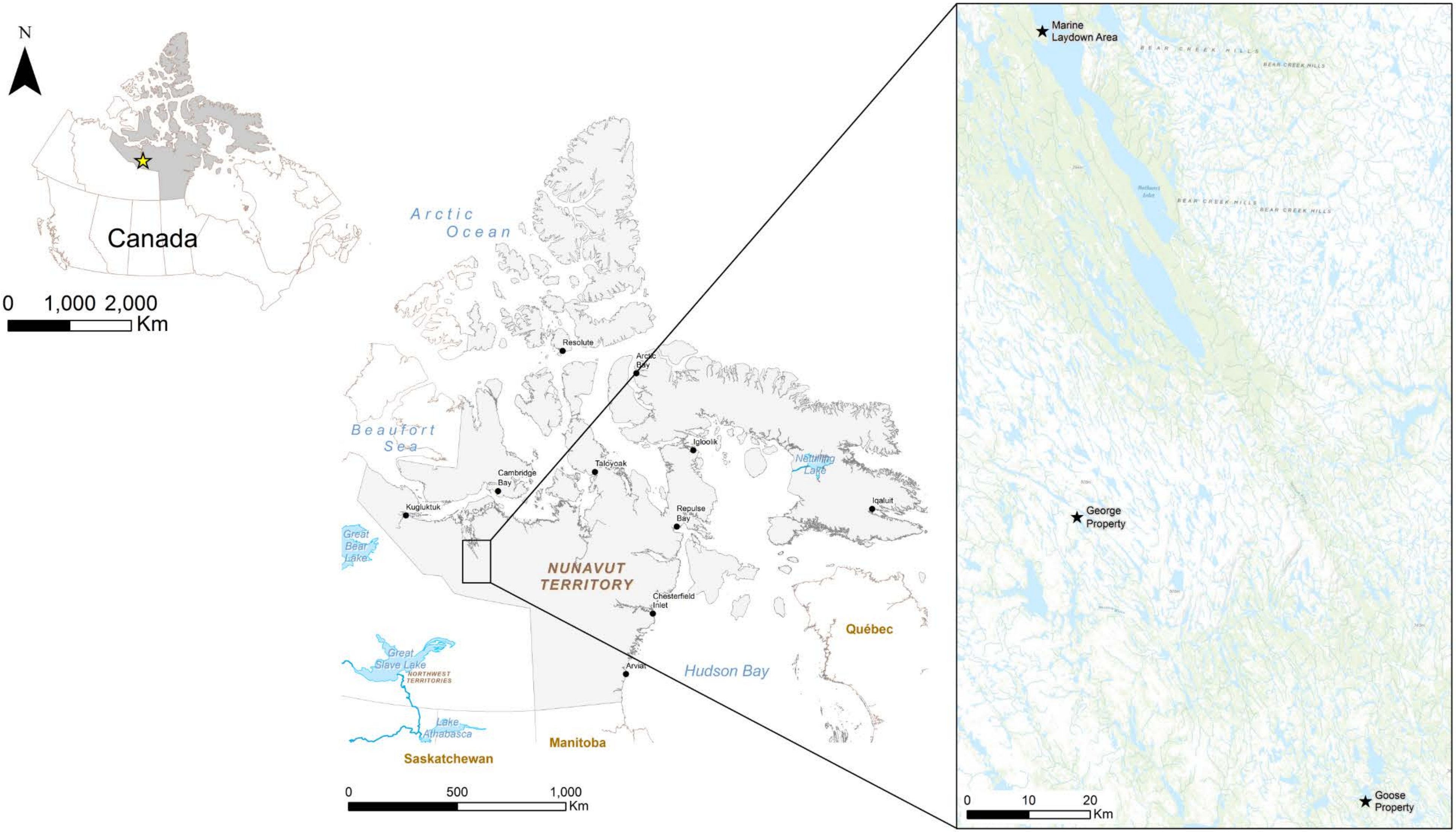
Figures



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Coordinate System: NAD 1983 UTM Zone 13N

srk consulting	Sabina GOLD & SILVER CORP.	Water and Load Balance Report
		Site Location Plan
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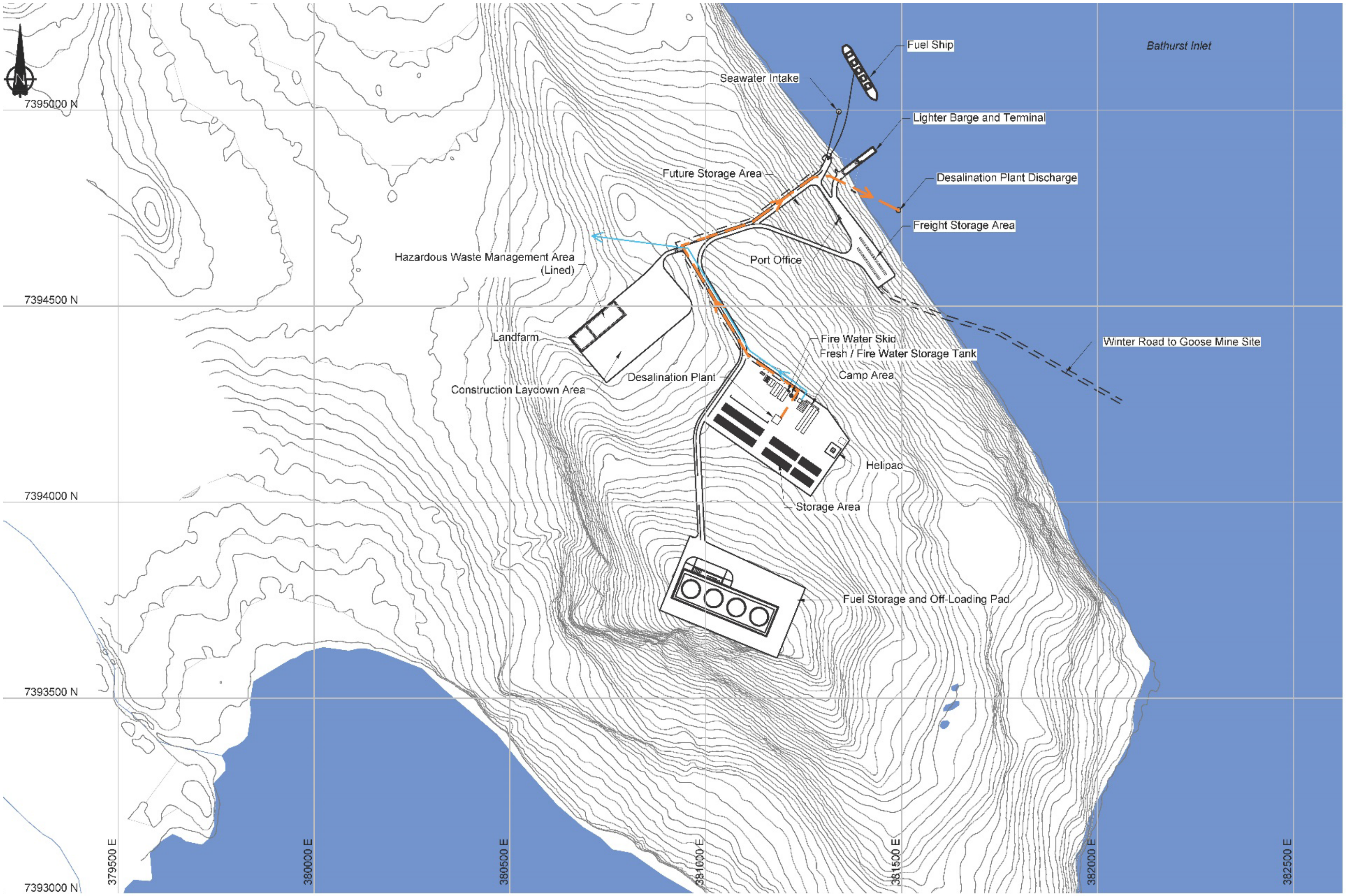

LEGEND

- Major Contour
- Minor Contour
- Intake Line
- Pumped Saline Water Pipeline
- Greywater Pipeline
- Proposed Road Infrastructure
- Laydown Pad
- Waterbody

NOTES

1. Contours shown at 2m intervals.

REFERENCE

NAD83 UTM Zone 13.
NTS Mapsheet: 096H

0m 100 200 300 400

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Water and Load Balance Report

MLA Infrastructure

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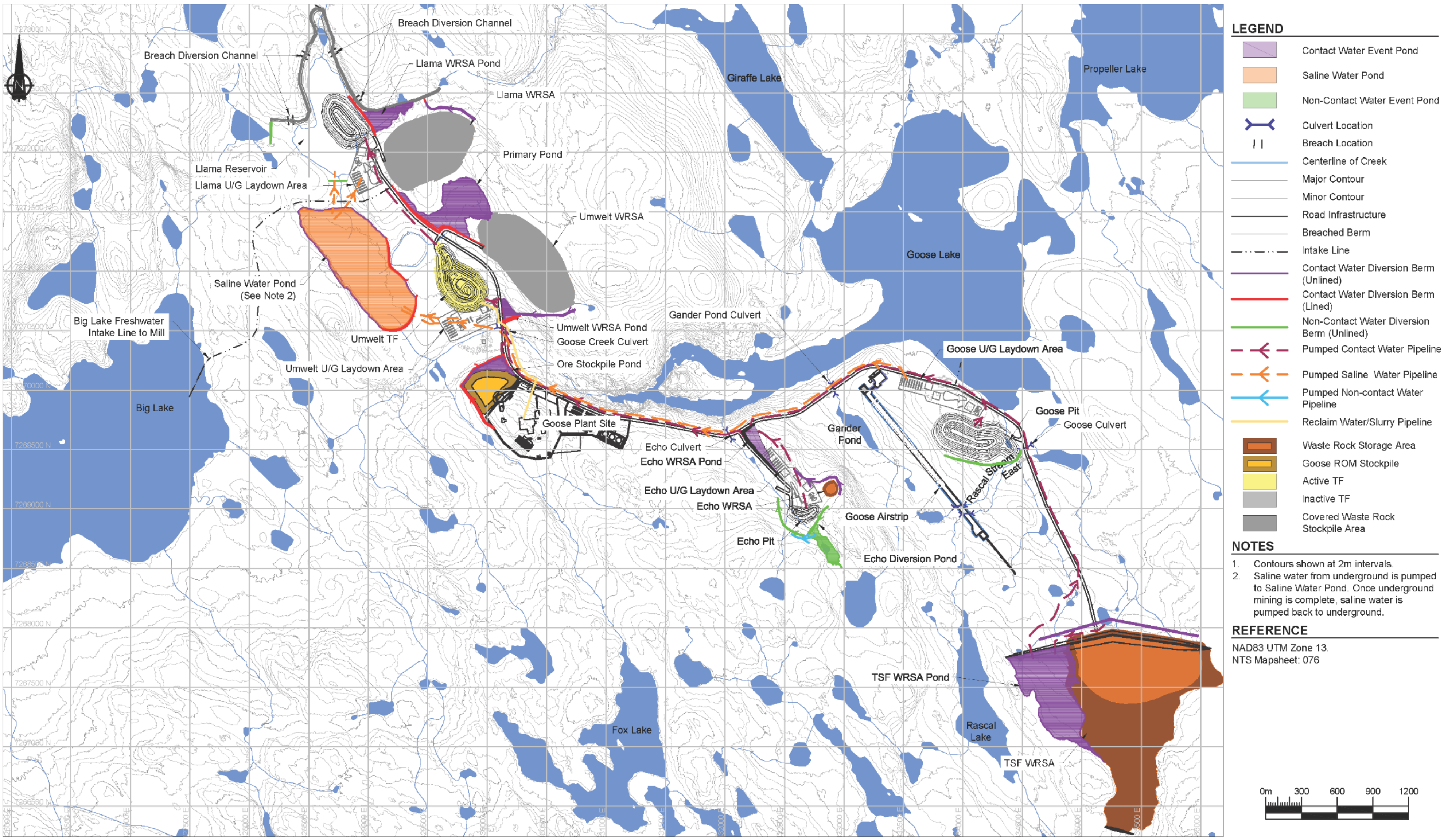

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Water and Load Balance Report

Goose Property Infrastructure

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