GALAXY LITHIUM (CANADA) INC.

UPDATE TO SURFACE WATER QUALITY MODELING

FINAL

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1 INTRODUCTION

WSP Canada have engaged WSP USA to update the geochemical models for the Galaxy Lithium James Bay Pegmatite Project in Quebec Canada. WSP Canada and WSP UK previously updated the models in 2018 (WSP report 171-02562-00_GC_R1, 2018) and 2019 (Technical Memorandum), and the original study was used to support the engineering design and environmental assessment of the project. Galaxy has completed a Value Engineering Exercise for the project. As a result of value engineering, several project components were relocated or modified, necessitating updates to the geochemical models.

This document addresses the James Bay Lithium Project site (the site) as described in the 2021 Preliminary Economic Assessment (PEA) prepared by G Mining Services Inc. (G Mining Services) and Golder. This report includes an update to the water balance (water balance developed by Stantec and updated by Golder) and an updated mine plan (including final pit shell and waste dumps (completed by G Mining Services and Golder)). This information was used to update the geochemical models to predict the discharge from the north water management pond (NWMP) and the water quality of the pit lake.

2 DATA REVIEW

The mine plan was updated following the Value Engineering Exercise. Changes include an increase in the number of the waste rock and tailings storage facilities (WRTSFs), updates to the final pit layout, and now includes the plan for waste rock disposal into the pit during the later portion of the mine life. The general site plan is shown on Figure 1, and Figure 2 shows the layout of the WRTSFs, showing both without in-pit filling and with in-pit filling.

The life of mine (LOM) has increased from 17 years to 18.5 years, and the final operational year base elevation of the pit was deepened from -39 mRL to -48 mRL. The final total waste and tailings amounts have increased by approximately 14,500,000 tonnes from those modeled in 2019. The cumulative tonnage of ore, waste rock, and tailings over the life of mine (LOM) are presented in Figure 3. Tailings and waste rock will be co-disposed within the WRTSFs, with the filtered tailings placed and compacted into cells contained within the waste rock embankments.

Previously, the mine plan included stacking the waste rock and tailings within one WRTSF beside the retention basin northwest of the pit (without any barriers between both facilities), the mine plan now includes four separate WRTSFs that will ultimately drain to the NWMP. The four WRTSFs are as follows:

- West WRTSF;
- South West WRTSF;
- North East WRTSF; and
- East WRTSF.

The East WRTSF is located east of the pit and once the east pit (JB3) is mined out in 2035, this WRTSF will extend into the pit for in-pit filling (East Dump Extension).

The proportion (total) of waste rock and tailings going to the WRTSFs are shown on Figure 4. The distribution of waste rock and tailings into the WRTSFs are shown on Figure 5. The ratio of waste rock to tailings varies over LOM; the waste rock averages 81 percent and the tailings averages 19 percent. It is important to note that the tailings tonnages in Figures 3 through 5 are estimated as 85 percent of the ore material that was mined.

The WRTSFs drain to water management ponds (WMPs). The development and operation of the WRTSFs and WMPs are summarized in the PEA.

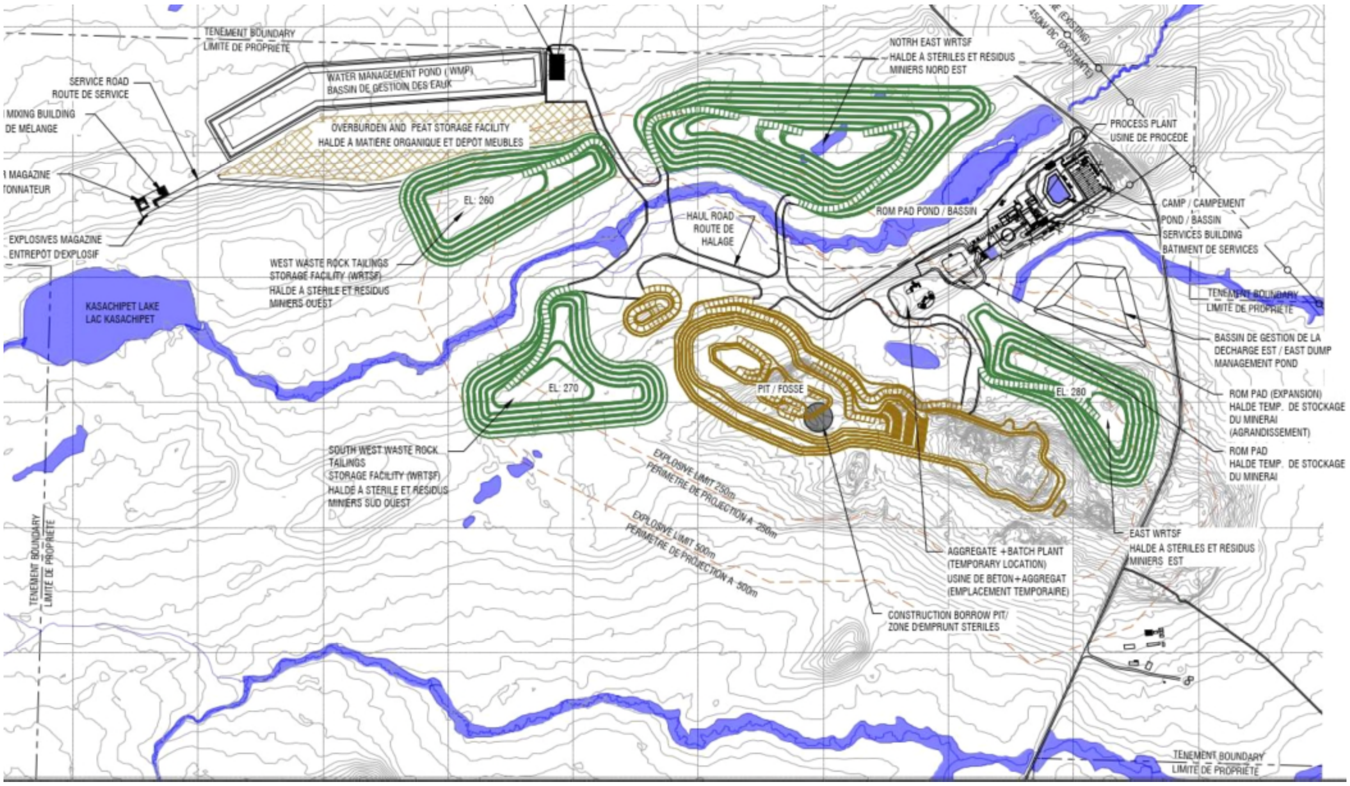

Figure 1: General Site Plan (G Mining Services, 2021)

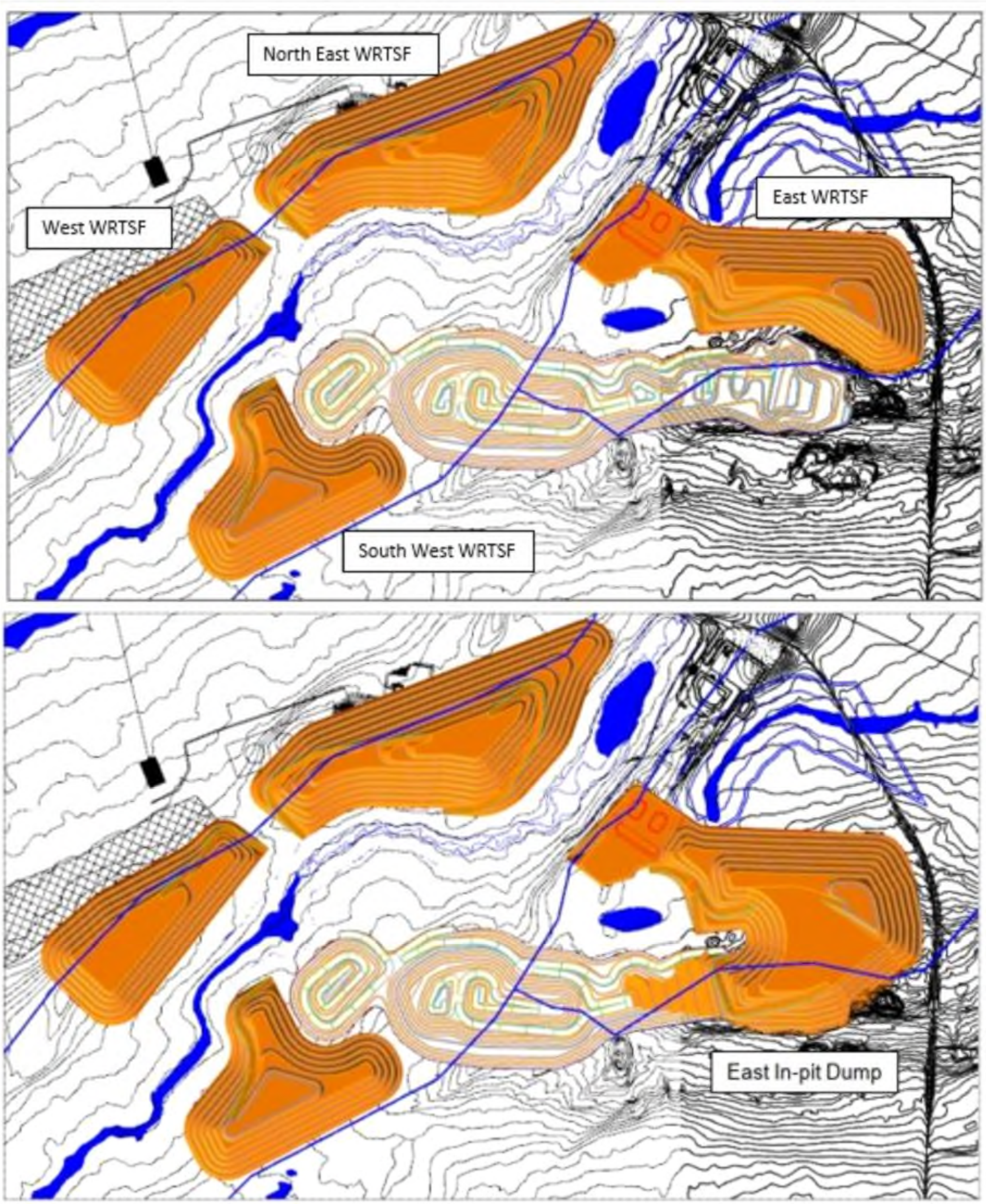

Figure 2: WRTSF Layout (G Mining Services, 2021)

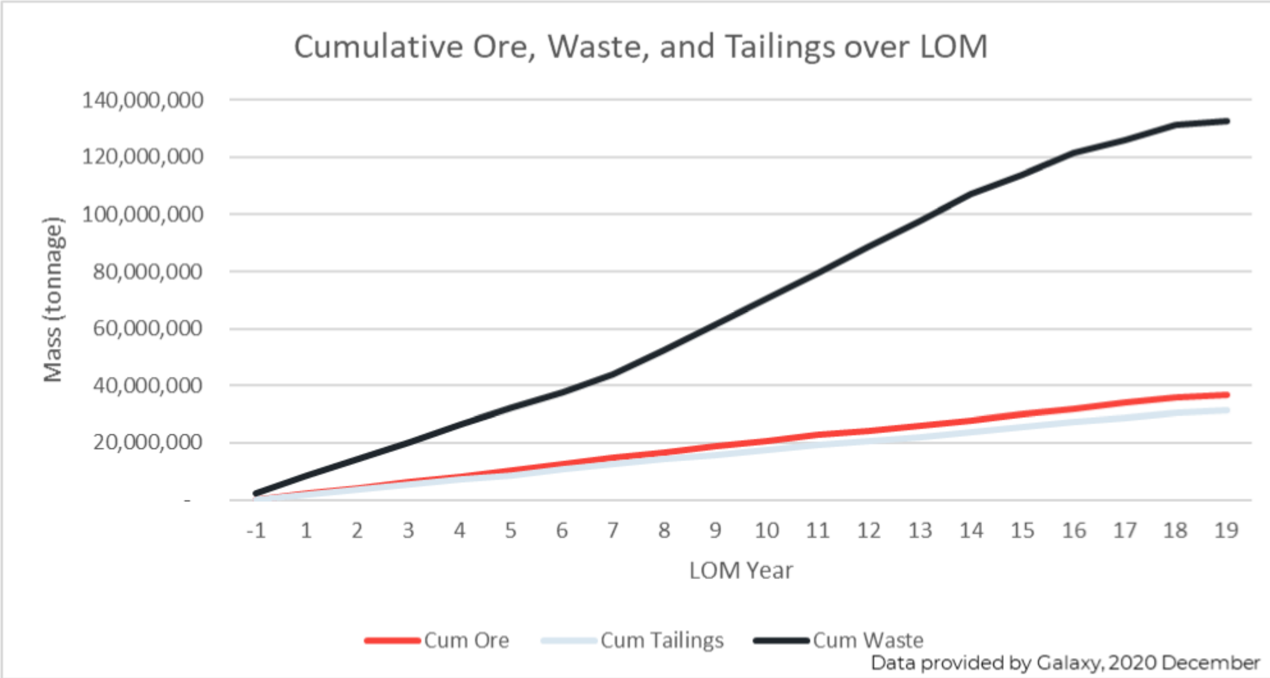

Figure 3: Cumulative Ore, Waste, and Tailings over LOM

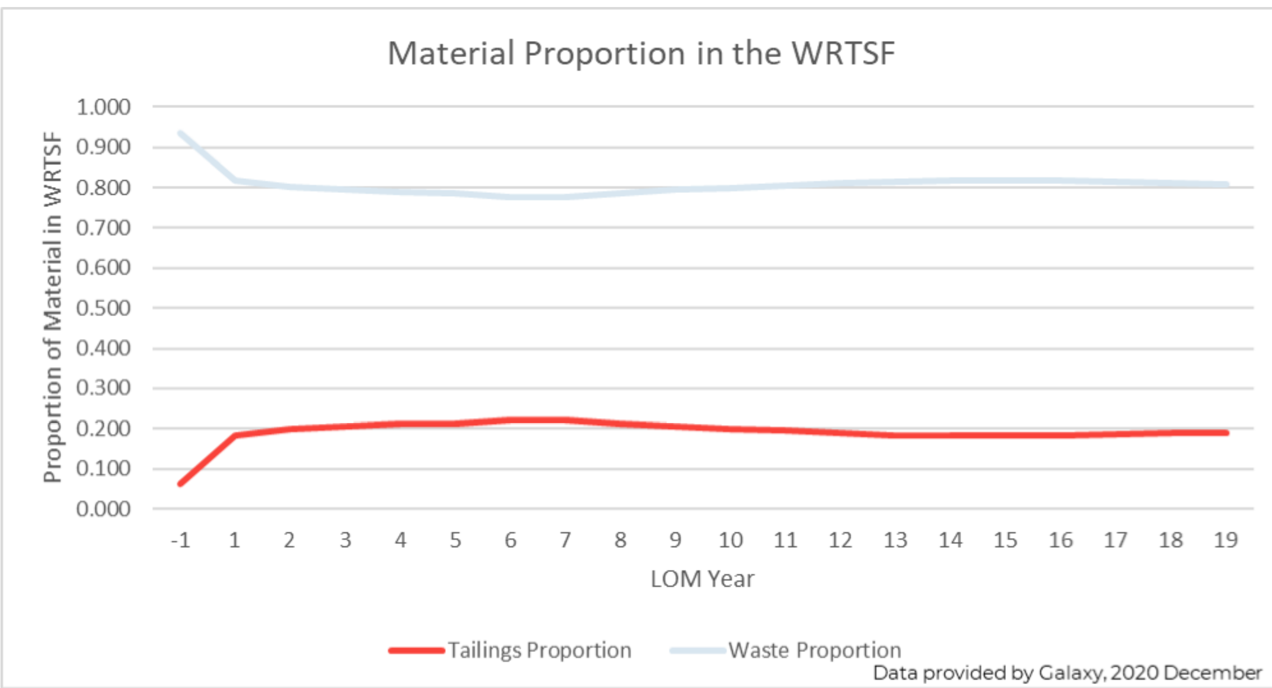

Figure 4: Proportion of Waste and tailings in WRTSFs

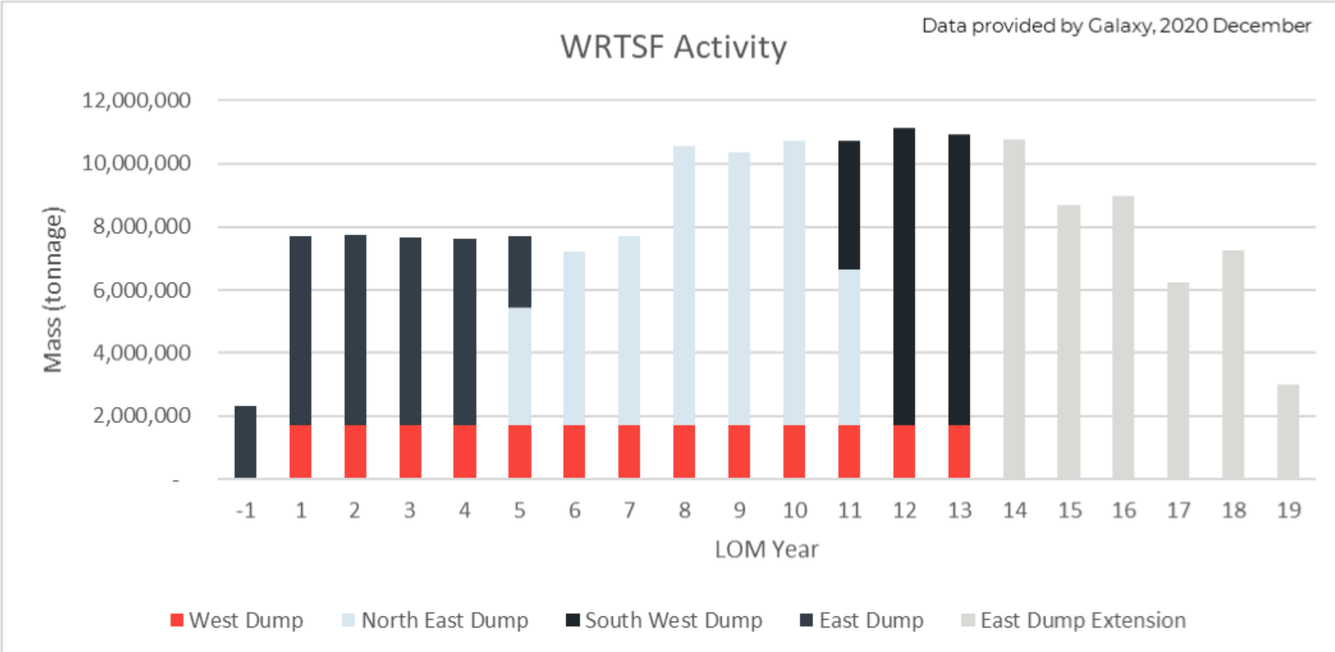

Figure 5: Distribution of waste rock and tailings in WRTSF over LOM

3 WATER MANAGEMENT POND MODELS

3.1 CONCEPTUALIZATION

The models for the NWMP are updated from the models conceptualized for the 2018 Geochemical Modeling report (WSP report 171-02562-00_GC_R1, 2018) and the 2019 technical memorandum. All site runoff will be managed at the NWMP. The water quality in the NWMP will depend on the chemistries and volumes of the different water types that mix in the NWMP, and the geochemical reactions that occur in the NWMP.

The main water types that flow into the NWMP are:

— Runoff from the Overburden and Peat Storage Facility (OPSF) – Overburden from pit stripping and site development;
— Water pumped from the East WMP (EWMP) containing runoff from the East WRTSF;
— Runoff from the West WRTSF;
— Runoff from North East WRTSF; and
— Pumped runoff from pit/South West WRTSF.

The water pumped from the pit into the basin is a mixture of

— Pit wall run-off;
— Groundwater inflow; and
— Direct precipitation to the pit, including snow-melt.

Figure 1 shows the distribution of waste rock and tailings for LOM and the information is summarized in Table 1, including the collection of runoff and seepage from each WRTSF. Because of the variations in placement of waste rock and tailings, water quality in the NWMP was modeled throughout LOM for both wet and dry climate scenarios to provide a range of results for the mine plan.

3.2 UPDATED MINE PLAN AND WATER BALANCE

The changes incorporated into the NWMP models include the following:

— Changes to the mine plan (G Mining Services);
— Updated waste rock, overburden, and water management facility design (Golder); and
— Updated site-wide water balance model completed by Golder.

Updates to the mine plan and water management facility design are generally summarized above. One major update is that waste rock will no longer be stored where it will be partially saturated.

The water balance for the new updated mine plan is similar to the water balance reviewed for the previous models (Golder 2021). As before, all runoff and seepage from area facilities reports to the NWMP. However, runoff and seepage from the East WRTSF is captured in the EWMP prior to being pumped to the NWMP. The component of the water balance can be broken down to correspond to a specific chemistry within the geochemical model, those components are listed in Table 2 and proportions of each component are shown in Table 3 for three of the years included in the model. The model addresses two climate scenarios presented in the water balance, 25 year wet and 25 year dry. The water balance also evaluated a scenario accounting for potential climate change impact on the average climate conditions, but that scenario was not evaluated as part of the surface water chemistry models. For geochemistry and water quality, it is assumed that the drier years will produce poorer water quality, and the wetter years will produce potentially better water quality based on increased dilution.

Table 1 Waste rock and tailings distribution for LOM

Management Area	Year				
	-1	1-4	5-10	11-13	14-18.5
North Water Management Pond (NWMP)	— Construction — Runoff from OPSF	— Runoff from OPSF — Runoff from West WRTSF — Pumped water from EWMP	— Runoff from OPSF — Runoff from West WRTSF — Runoff from North East WRTSF — Pumped water from EWMP	— Runoff from OPSF — Runoff from West WRTSF — Runoff from North East WRTSF — Pumped water from EWMP — Pumped runoff from pit/South West WRTSF	— Runoff from OPSF — Runoff from West WRTSF — Runoff from North East WRTSF — Pumped water from EWMP — Pumped runoff from pit/South West WRTSF
East Water Management Pond (EWMP)	— Construction	— Runoff from East WRTSF — Runoff pumped to NWMP	— Runoff from East WRTSF — Runoff pumped to NWMP	— Runoff from East WRTSF — Runoff pumped to NWMP	— Runoff from East WRTSF — Runoff pumped to NWMP
OPSF	— Placing overburden from pit striping and site development — Runoff to NWMP	— Runoff to NWMP	— Runoff to NWMP	— Runoff to NWMP	— Runoff to NWMP
East WRTSF	--	— Waste rock placement — Tailings placement in cells — Contact water draining to EWMP and pumped to NWMP	— Waste rock placement — Runoff to EWMP and pumped to NWMP	— Runoff to EWMP and pumped to NWMP	— Runoff to EWMP and pumped to NWMP — Waste rock placement in mined pit (East WRTSF extension)

Table 1 Waste rock and tailings distribution for LOM

Management Area	Year				
	-1	1-4	5-10	11-13	14-18.5
West WRTSF	--	— Waste rock placement — Runoff to NWMP	— Waste rock placement — Tailings placement in cells — Runoff to NWMP	— Waste rock placement — Runoff to NWMP	— Runoff to NWMP
North East WRTSF	--	--	— Waste rock placement — Runoff to NWMP	— Waste rock placement — Runoff to NWMP	— Tailings placement — Waste rock placement — Runoff to NWMP
South West WRTSF	--	--	--	— Waste rock placement — Tailings placement — Runoff to pit and then pumped to NWMP	— Runoff to pit and then pumped to NWMP

Information from Golder. 2021. *Tailings, Waste, Rock, Overburden, and Water Management Facility Preliminary Engineering Design*. March.

Table 2 Water balance inflow components for north water management pond models

Water Balance Component	Chemical Input for Model
WRTSF Runoff	Proportional waste rock and tailings contact water
WRTSF Seepage	Proportional waste rock and tailings contact water
OPSF Runoff	Median surface water
OPSF Seepage	Median surface water
Process Plant Runoff	Median surface water
Concrete Batch Plant Area Runoff	Median surface water
North Haul Road Runoff	Waste rock contact water
South Haul Road Runoff	Waste rock contact water
Explosives Magazine Runoff	Median surface water chemistry
Open Pit Runoff	Waste rock contact water
Open Pit Ground Water	Groundwater near the pit
Direct Precipitation to WMP	Pure water

Table 3 Water balance components for north water management pond models

Water Balance Component	Dry			Wet		
	Year 3	Year 9	Year 19	Year 3	Year 9	Year 19
Waste rock contact runoff and seepage	54%	62%	63%	54%	61%	63%
Tailings contact runoff and seepage	8%	8%	7%	7%	8%	7%
Median surface water	19%	8%	8%	18%	8%	8%
Groundwater near pit	6%	11%	8%	7%	12%	8%
Direct precipitation	12%	11%	14%	14%	11%	14%
Evaporation	4%	4%	5%	4%	4%	5%

The input chemistry used in the models was based on humidity cell column tests described in the 2018 modeling report and 2019 technical memorandum and monitoring data collected in previous studies. The chemical inputs are described in the 2018 modeling report, unless described below. The PHREEQC model requires dissolved concentrations as inputs, therefore the chemistry from earlier in the humidity cell tests was used rather than the total concentrations, representative of long-term steady state conditions, measured later in the evolution of the humidity cell tests. This also acts as a more conservative assessment, as the water chemistry of the leachates produced in the tests improved as the humidity cell tests progressed. The chemistry inputs used within the models are presented in Table 4 and Table 5 for dry and wet conditions, respectively.

A change included in the modeling update is water quality entering and mixing in the NWMP was calculated in monthly timesteps throughout LOM based on monthly water balance data. The previous models calculated the water quality by mixing the discreet components for three specific years but did not evaluate the changing water quality in the NWMP as water from the mine entered the NWMP. This update provides a more robust calculation of evolving water quality within the NWMP. A second update from the 2019 models is to the chemistry used to represent the contact water of waste rock and tailings in the WRTSFs. The waste rock is unsaturated (vs. the 2019 model when it was a mix of unsaturated and saturated waste rock), and the unsaturated waste rock uses the chemistry for the unsaturated waste rock humidity cell from weeks 1-4. Scaling of the waste rock, tailings, and pit runoff chemistry is analogous to the models completed previously with a scaling factor of 5.5 used for waste rock, tailings, and pit wall runoff.

Direct precipitation and evaporation are assumed to have no mass load and a pH of 5.5 (to mimic the natural chemistry of rainfall). Evaporation is the removal of pure water and does not remove solute load from the model.

Table 4 Estimated inflow chemistry for water management pond model for dry conditions

Parameter	Units	Waste Rock HCT first flush unsaturated	Tailings HCT first flush unsaturated	Median surface water chemistry	Groundwater near pit
pH	S.U.	7.6	7.65	4.23	7.38
Alkalinity	mg/L as CaCO3	28	31	0.75	49.2
pe	pe units	8.5	8.4	6.0	4.0
EC		24.8	35.7	1.4	10.3
Ca	mg/L	45.4	47.5	0.5	1.9
Mg	mg/L	8.1	5.1	0.3	2.1
K	mg/L	55.6	21.0	1.5	16.3
Na	mg/L	34.6	2.5	1.4	1.3
Cl	mg/L	n/a	n/a	0.3	12
SO4	mg/L	50	50	0.20	0.08
Al	mg/L	0.63	0.92	0.000004	0.00039
Sb	mg/L	0.010175	0.009533	0.000002	0.00001
Ag	mg/L	0.000138	0.000138	0.0009	0.0934
As	mg/L	0.8003	0.9442	0.004	0.013
Ba	mg/L	0.065	0.033	0.00001	0.00004
Be	mg/L	0.00003	0.00002	1.8E-05	9.2E-06
Cd	mg/L	3.5E-05	8.3E-06	0.0010	0.0005
Cr	mg/L	0.0011	0.0006	0.0002	0.0004
Co	mg/L	0.0028	0.0011	0.00032	0.00162
Cu	mg/L	0.00169	0.00491	n/a	0.0011
Sn	mg/L	0.1591	0.0464	1.615	0.087
Fe	mg/L	0.336	0.105	1.0E-06	1.0E-06
Hg	mg/L	2.8E-05	1.5E-04	0.0008	0.58
Li	mg/L	2.2633	0.4851	0.025	0.125
Mn	mg/L	0.143	0.116	0.00004	0.00158
Mo	mg/L	0.0126	0.0023	0.00043	0.00300
Ni	mg/L	0.0180	0.0035	0.00041	0.00007
Pb	mg/L	0.00030	0.00193	0.00012	0.00037
Se	mg/L	0.00187	0.00057	0.016	0.126
Sr	mg/L	0.566	0.379	0.00001	0.00065
U	mg/L	0.03839	0.02438	0.00001	0.00035
V	mg/L	0.00792	0.00875	0.005	0.004
Zn	mg/L	0.006	0.006	4.23	7.38

Table 5 Estimated inflow chemistry for water management pond model for wet conditions

Parameter	Units	Waste Rock HCT first flush unsaturated	Tailings HCT first flush unsaturated	Median surface water chemistry	Groundwater near pit
pH	S.U.	7.6	7.65	4.23	7.38
Alkalinity	mg/L as CaCO3	28	31	0.75	49.2
pe	pe units	8.5	8.4	6.0	4.0
EC		24.8	35.7	1.4	10.3
Ca	mg/L	4.4	6.93	0.5	1.9
Mg	mg/L	30.3	33.3	0.3	2.1
K	mg/L	18.8	42	1.5	16.3
Na	mg/L	n/a	n/a	1.4	1.3
Cl	mg/L	50	50	0.3	12
SO4	mg/L	0.34	82.5	0.20	0.08
Al	mg/L	0.00555	0.0024	0.000004	0.00039
Sb	mg/L	0.00008	0.00147	0.000002	0.00001
Ag	mg/L	0.4365	0.948	0.0009	0.0934
As	mg/L	0.036	0.2826	0.004	0.013
Ba	mg/L	0.00002	0.0555	0.00001	0.00004
Be	mg/L	1.9E-05	0.002007	1.8E-05	9.2E-06
Cd	mg/L	0.0006	0.0729	0.0010	0.0005
Cr	mg/L	0.0015	0.02667	0.0002	0.0004
Co	mg/L	0.00092	0.1335	0.00032	0.00162
Cu	mg/L	0.0868	0.2043	n/a	0.0011
Sn	mg/L	0.183	57.6	1.615	0.087
Fe	mg/L	1.5E-05	0.00081	1.0E-06	1.0E-06
Hg	mg/L	1.23	3.69	0.0008	0.58
Li	mg/L	0.078	9.27	0.025	0.125
Mn	mg/L	0.00686	0.01407	0.00004	0.00158
Mo	mg/L	0.00983	0.0873	0.00043	0.00300
Ni	mg/L	0.00017	0.2124	0.00041	0.00007
Pb	mg/L	0.00102	0.00036	0.00012	0.00037
Se	mg/L	0.309	0.423	0.016	0.126
Sr	mg/L	0.02094	0.2673	0.00001	0.00065
U	mg/L	0.00432	0.0345	0.00001	0.00035
V	mg/L	0.003	1.098	0.005	0.004
Zn	mg/L	7.6	7.65	4.23	7.38

3.3 RESULTS

The NWMP modeling results for wet and dry conditions are presented in Tables 6 through 8 for select months in LOM years, 3, 9, and 19 and are compared with applicable effluent limits defined by Directive 019 (D019) and MMER. The months were selected to represent summer/fall conditions as the water balance model is not as robust for winter months.

Similar to previous models, solute loads in the dry climate scenarios are typically around double those of the wet climate scenarios, as there is less dilution for the released mass load from the waste, tailings, and pit wall rock in the dry climate scenario. The results are similar to those produced by previous models with the exception that arsenic concentrations for the dry conditions exceed the applicable effluent limits. Concentrations of all other solutes are simulated to be compliant with regulations. Monthly arsenic concentrations for dry conditions are shown on Figure 6. Arsenic concentrations in May and June generally do not exceed D019 limits, but in later months, when there is a decrease in direct precipitation, arsenic concentrations increase and begin to exceed the D019 limit around Year 8. While the arsenic concentrations in previous models did not exceed the D019 limits, the Year 10 models did indicate arsenic concentrations may be up to 0.15 mg/L. The different results from the models is likely due to the 2021 model addressing the ongoing NWMP water quality compared to the 2019 model that evaluated it at specific time steps.

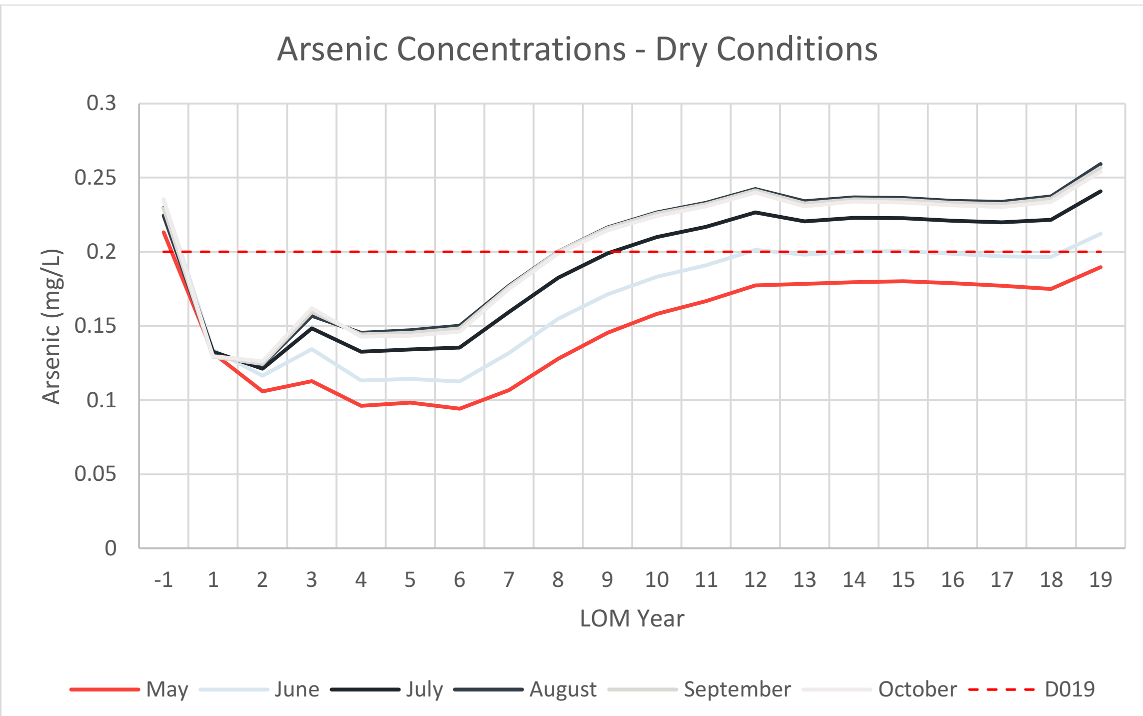

Figure 6: Arsenic Concentrations in North Water Management Pond

These modelling results are based on a simplified conceptualization, commensurate with the limited geochemical data available to date and the level of current understanding of water flow dynamics in the pit and water management pond. For instance, single chemistries have been assigned to a compound of runoff and seepage generated from waste rock or tailings, while runoff and seepage are expected to have markedly different degrees of interaction with the waste materials and resulting chemical signatures.

It is likely that the simulated parameter values are subject to a degree of uncertainty and are also likely to fluctuate significantly over time during a single year and over different years due to changing climatic conditions. The model simplifies actual mine scenarios by combining seepage and runoff water and making assigning the chemistry to the various components based on past studies. The PHREEQC model was set up to simulate sorption of arsenic and other trace metals onto iron precipitates, assuming a good contact between the percolating water and the iron precipitates in the waste pile prior to mixing of runoff and seepage in the NWMP. At field scale, due to the kinetics and location of precipitates, this process may be less efficient, and arsenic in the waste pile contact water may be more elevated than predicted. Due to the arsenic concentration exceeding the D019 limit, the design of water treatment infrastructure should assume that removal of arsenic will be necessary at least during part of each year to ensure compliance with D019 and MMER limits. A more detailed study of the waste and tailings, combined with the current geochemistry dataset, could be completed should a more detailed prediction be required.

Table 6 Water management pond geochemical modeling results – LOM Year 3 - summer

Parameters	Unit	Year 3 Dry			Year 3 Wet			D019 Average Monthly Concentration	MMER Monthly Mean Concentration
Physical-chemical		July	August	Sept	July	August	Sept		
pH	--	7.6	7.6	7.6	7.4				
Alkalinity (as CaCO3)	mg/L	18.3	17.9	17.4	10.8	10.7	10.4		
Major ions									
Calcium	mg/L	34.1	33.6	33.1	18.9	18.6	18.2		
Chloride	mg/L	0.3	0.4	0.4	0.3	0.4	0.4		
Magnesium	mg/L	6.1	6.0	5.9	3.5	3.4	3.3		
Potassium	mg/L	39.2	38.6	38.0	21.3	20.9	20.4		
Sodium	mg/L	29.1	28.7	28.2	16.4	16.1	15.8		
Sulphate	mg/L	35.4	35.0	34.5	35.3	34.7	34.0		
Trace Metals									
Aluminum	mg/L	0.005	0.005	0.005	0.003	0.003	0.003		
Antimony	mg/L	0.007	0.006	0.006	0.004	0.004	0.003		
Silver	mg/L	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002		
Arsenic	mg/L	0.148	0.157	0.159	0.106	0.113	0.112	0.2	0.5
Barium	mg/L	0.08	0.08	0.08	0.05	0.04	0.04		
Beryllium	mg/L	1.11E-06	1.10E-06	1.10E-06	1.12E-06	1.11E-06	1.14E-06		
Cadmium	mg/L	0.00016	0.00016	0.00016	0.00013	0.00012	0.00012		
Chromium	mg/L	0.013	0.012	0.012	0.006	0.006	0.006		
Cobalt	mg/L	0.004	0.004	0.004	0.003	0.003	0.002		
Copper	mg/L	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.3	0.3
Iron	mg/L	0.00008	0.00008	0.00008	0.00011	0.00011	0.00012	3	
Lithium	mg/L	2.0	2.0	1.9	1.1	1.1	1.0		
Manganese	mg/L	0.00019	0.00020	0.00021	0.00049	0.00050	0.00052		
Mercury	mg/L	4.71E-05	4.56E-05	4.46E-05	2.88E-05	2.77E-05	2.74E-05		
Molybdenum	mg/L	0.0100	0.0098	0.0097	0.0054	0.0053	0.0052		
Nickel	mg/L	0.008	0.008	0.008	0.008	0.008	0.008	0.5	0.5
Lead	mg/L	2.15E-05	2.12E-05	2.12E-05	1.54E-05	1.51E-05	1.52E-05	0.2	0.2
Selenium	mg/L	0.0012	0.0012	0.0012	0.0007	0.0007	0.0007		
Strontium	mg/L	0.42	0.42	0.41	0.23	0.23	0.23		
Uranium	mg/L	0.068	0.065	0.063	0.034	0.033	0.032		
Vanadium	mg/L	0.0054	0.0055	0.0056	0.0038	0.0038	0.0038		
Zinc	mg/L	0.021	0.021	0.022	0.027	0.026	0.027	0.5	0.5

Table 7 Water management pond geochemical modeling results – LOM Year 9 - summer

Parameters	Unit	Year 9 Dry			Year 9 Wet			D019 Average Monthly Concentration	MMER Monthly Mean Concentration
Physical-chemical		July	August	Sept	July	August	Sept		
pH	--	7.7	7.7	7.7	7.5	7.5	7.5		
Alkalinity (as CaCO3)	mg/L	20.9	20.5	20.2	13.8	13.7	13.4		
Major ions									
Calcium	mg/L	37.1	36.7	36.4	20.8	20.5	20.2		
Chloride	mg/L	0.3	0.3	0.3	0.3	0.3	0.3		
Magnesium	mg/L	6.6	6.6	6.5	3.8	3.7	3.7		
Potassium	mg/L	42.4	42.0	41.6	23.1	22.8	22.4		
Sodium	mg/L	31.7	31.4	31.1	18.2	18.0	17.7		
Sulphate	mg/L	38.9	38.6	38.3	38.8	38.3	37.8		
Trace Metals									
Aluminum	mg/L	0.006	0.006	0.006	0.004	0.004	0.004		
Antimony	mg/L	0.007	0.007	0.007	0.004	0.004	0.004		
Silver	mg/L	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002		
Arsenic	mg/L	0.199	0.216	0.216	0.137	0.150	0.147	0.2	0.5
Barium	mg/L	0.07	0.07	0.07	0.05	0.05	0.05		
Beryllium	mg/L	1.13E-06	1.11E-06	1.12E-06	1.04E-06	1.03E-06	1.05E-06		
Cadmium	mg/L	0.00015	0.00015	0.00015	0.00012	0.00011	0.00011		
Chromium	mg/L	0.012	0.012	0.012	0.006	0.006	0.006		
Cobalt	mg/L	0.004	0.003	0.003	0.003	0.002	0.002		
Copper	mg/L	0.00005	0.00004	0.00004	0.00004	0.00004	0.00004	0.3	0.3
Iron	mg/L	0.00007	0.00007	0.00007	0.00010	0.00010	0.00010	3	
Lithium	mg/L	2.2	2.1	2.1	1.2	1.2	1.2		
Manganese	mg/L	0.00015	0.00016	0.00016	0.00031	0.00031	0.00032		
Mercury	mg/L	5.08E-05	4.89E-05	4.84E-05	3.12E-05	2.95E-05	2.97E-05		
Molybdenum	mg/L	0.0108	0.0106	0.0105	0.0059	0.0058	0.0057		
Nickel	mg/L	0.008	0.008	0.008	0.007	0.007	0.007	0.5	0.5
Lead	mg/L	2.38E-05	2.36E-05	2.37E-05	1.62E-05	1.59E-05	1.61E-05	0.2	0.2
Selenium	mg/L	0.0014	0.0013	0.0013	0.0008	0.0008	0.0007		
Strontium	mg/L	0.46	0.46	0.45	0.26	0.25	0.25		
Uranium	mg/L	0.068	0.066	0.065	0.036	0.034	0.033		
Vanadium	mg/L	0.0063	0.0063	0.0064	0.0042	0.0041	0.0041		
Zinc	mg/L	0.019	0.019	0.020	0.022	0.021	0.022	0.5	0.5

Table 8 Water management pond geochemical modeling results – LOM Year 19 - summer

Parameters	Unit	Year 19 Dry			Year 19 Wet			D019 Average Monthly Concentration	MMER Monthly Mean Concentration
Physical-chemical		July	August	Sept	July	August	Sept		
pH	--	7.6	7.6	7.6	7.4	7.4	7.4		
Alkalinity (as CaCO3)	mg/L	18.2	17.6	17.3	11.4	11.1	10.9		
Major ions									
Calcium	mg/L	38.0	37.7	37.2	21.1	20.9	20.6		
Chloride	mg/L	0.2	0.2	0.2	0.2	0.2	0.2		
Magnesium	mg/L	6.8	6.7	6.7	3.8	3.8	3.7		
Potassium	mg/L	44.1	43.7	43.2	24.0	23.8	23.4		
Sodium	mg/L	31.9	31.6	31.2	18.0	17.8	17.5		
Sulphate	mg/L	40.1	39.8	39.3	39.9	39.5	38.9		
Trace Metals									
Aluminum	mg/L	0.005	0.005	0.005	0.003	0.003	0.003		
Antimony	mg/L	0.008	0.007	0.007	0.004	0.004	0.004		
Silver	mg/L	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002		
Arsenic	mg/L	0.241	0.259	0.257	0.149	0.161	0.157	0.2	0.5
Barium	mg/L	0.07	0.07	0.07	0.05	0.05	0.05		
Beryllium	mg/L	1.10E-06	1.09E-06	1.11E-06	1.10E-06	1.10E-06	1.14E-06		
Cadmium	mg/L	0.00016	0.00015	0.00015	0.00012	0.00012	0.00012		
Chromium	mg/L	0.012	0.011	0.011	0.006	0.006	0.006		
Cobalt	mg/L	0.004	0.004	0.004	0.003	0.003	0.003		
Copper	mg/L	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.3	0.3
Iron	mg/L	0.00008	0.00008	0.00008	0.00011	0.00011	0.00011	3	
Lithium	mg/L	2.2	2.1	2.1	1.2	1.2	1.2		
Manganese	mg/L	0.00020	0.00021	0.00022	0.00046	0.00048	0.00049		
Mercury	mg/L	4.67E-05	4.48E-05	4.42E-05	2.96E-05	2.81E-05	2.81E-05		
Molybdenum	mg/L	0.0110	0.0109	0.0108	0.0060	0.0059	0.0058		
Nickel	mg/L	0.009	0.009	0.009	0.008	0.008	0.008	0.5	0.5
Lead	mg/L	2.31E-05	2.29E-05	2.33E-05	1.63E-05	1.60E-05	1.65E-05	0.2	0.2
Selenium	mg/L	0.0014	0.0014	0.0014	0.0008	0.0008	0.0008		
Strontium	mg/L	0.47	0.47	0.46	0.26	0.26	0.25		
Uranium	mg/L	0.067	0.064	0.063	0.036	0.034	0.033		
Vanadium	mg/L	0.0071	0.0071	0.0071	0.0045	0.0044	0.0044		
Zinc	mg/L	0.021	0.021	0.022	0.026	0.025	0.026	0.5	0.5

4 PIT LAKE MODEL

4.1 CONCEPTUALIZATION

The model for the pit lake in closure is conceptualized as per the original model described in the Geochemical Modelling report (WSP report 171-02562-00_GC_R1, 2018). Any changes to inputs and set-up are described in this report, otherwise inputs and set-up can be assumed to match the previous description.

Similar to the previous 2018 and 2019 modeling studies, the pit lake model water chemistry results are presented as the water chemistry at the point of discharge following the completion of pit lake filling up to the spill point elevation in the open pit. The chemistry of the pit lake discharge point is presented in this report along with an estimation of how the chemistry may evolve as the lake is forming (only under the lower flow scenario).

4.2 UPDATED MINE PLAN AND WATER BALANCE AND GEOCHEMICAL DATA

4.2.1 MINE PLAN

The final pit shell for the planned mine has changed following updates to the mine plan. Changes are described earlier in this report and major changes include the following:

— The pit was deepened from -38 mRL to -48 mRL;

— Waste rock will be placed in the pit in the East Dump Extension; and

— The final pit layout is updated from the 2019 pit layout.

The new final pit shell is shown in the schematic in Figure 7. The stage vs. volume curve and stage vs. lake surface area curve were derived from the final pit shell (Figure 8). The spill point is 209 mRL and may occur at anywhere along the pink line along the pit rim on Figure 7.

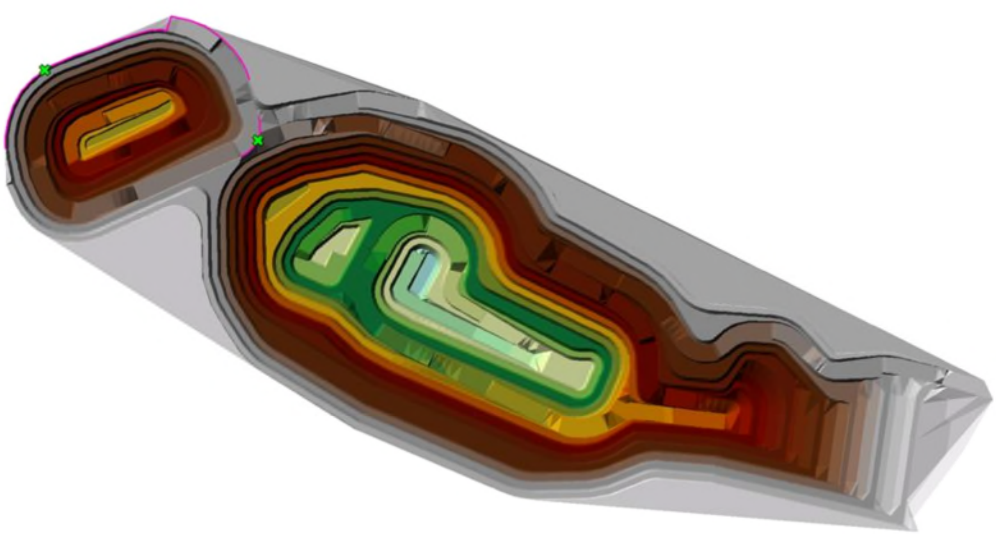

Figure 7: Schematic of Final Pit Shell Used in Pit Lake Filling Model

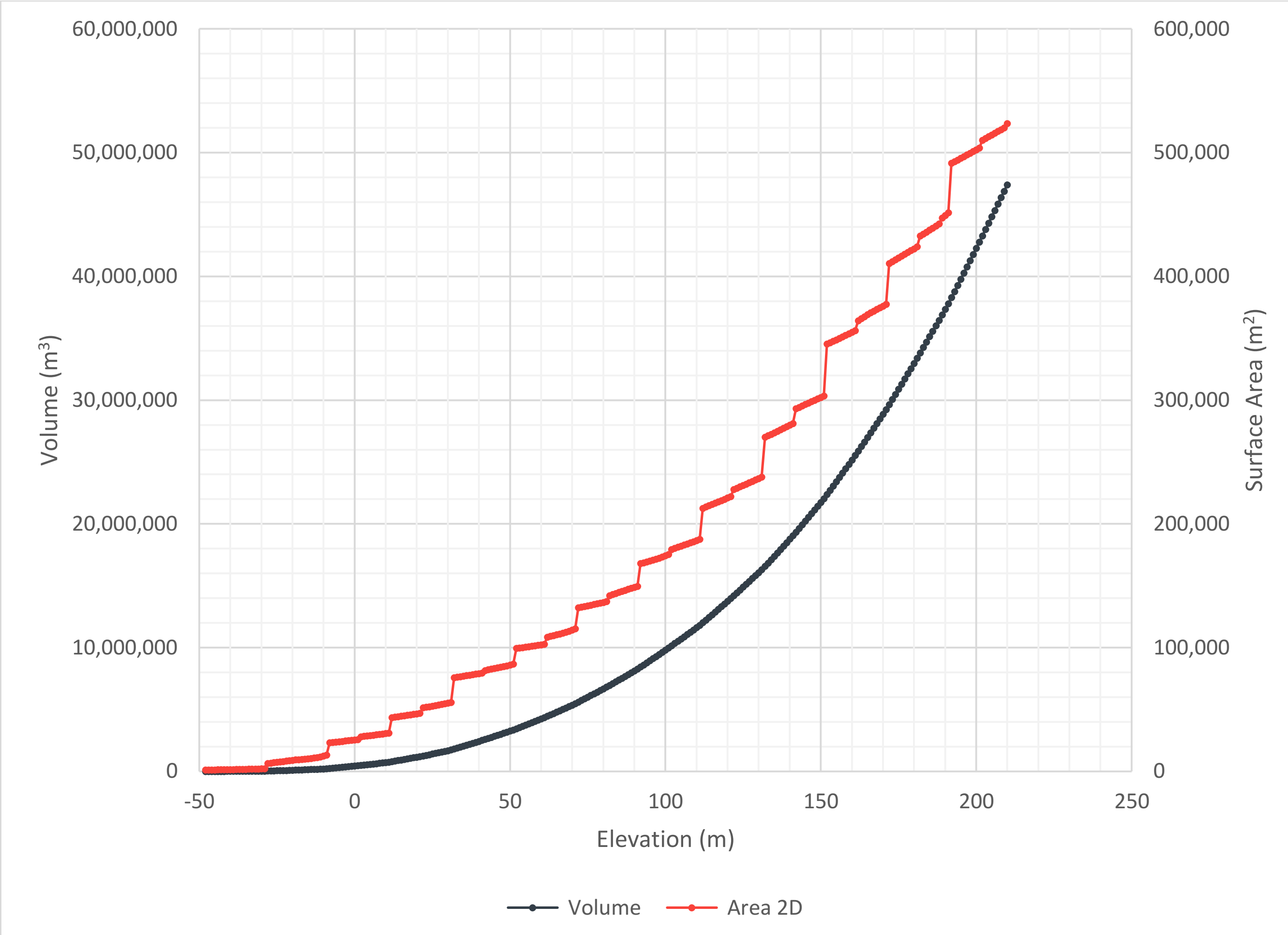

Figure 8: Stage-Volume and Stage-Surface Area Curves for the Final Pit Lake Filling Model

4.2.2 GROUNDWATER INFLOWS AND WATER BALANCE

The groundwater inflows for the pit lake water balance were derived from the FEFLOW groundwater model for the Galaxy project area, updated in 2021. The pit lake model included two scenarios originally to estimate the likely range of groundwater inflow values after mine closure. The updated groundwater modelling has provided new inflow values for Scenario 1 (low groundwater flow), based on the calibrated model where the rocks surrounding the pit have a very low permeability and for Scenario 2 (high groundwater flow) assume that the pit is connected to the more permeable paragneiss unit at some point. The groundwater inflow rate for the two scenarios are shown in Table 9.

Runoff and seepage from the South West WRTSF will drain to the pit. The model was updated to incorporate the runoff/seepage from the South West WRTSF. The model incorporates the volume of runoff/seepage from year 19 of the water balance during the 25-year dry conditions to provide a conservative estimate of the impact of the runoff/seepage on the lake.

All other elements of the water balance, such as climate data, are the same as the 2018 and 2019 models. The lake forms over 138 years for the low groundwater inflow scenario, and year 98 for the high groundwater inflow scenario. A summary of the water balance, provided in 10-year intervals, is shown for both scenarios in Table 10 and Table 11.

Table 9 Estimated groundwater inflows to the final pit under two flow scenarios

Model	Elevation	Groundwater Inflow (m^3/d)
SC 1: Calibrated model (very low permeability)	-48 m	365
	50 m	340
	150 m	280
	209 m	3
SC 2: Connected with the paragneiss unit at some point	-48 m	1125
	50 m	1078
	150 m	864
	209 m	4

Table 10 Summary of pit lake water balance for Scenario 1 (low permeability)

Year	Pit Lake Water Level (mRL)	Pit Lake Volume (m^3)	Pit Lake Surface Area (m^2)	Groundwater Inflow (m^3)	Rainfall+Snow on lake (m^3)	Pit wall runoff (m^3)	WRTSF Runoff/Seepage (m^3)	Waste Rock Flushing water (m^3)	Evaporation (m^3)
10	59	4,155,521	101,977	1,370,671	456,149	1,697,898	834,929	-	-204,126
20	88	7,827,859	147,191	1,164,839	788,281	1,318,570	751,776	2,944	-354,072
30	109	11,439,197	185,671	1,109,762	988,880	1,165,214	750,000	72,406	-474,924
40	126	15,128,246	232,165	1,104,646	1,308,370	1,045,833	774,833	73,958	-618,590
50	140	18,772,012	279,927	1,067,075	1,583,033	889,186	772,520	73,043	-741,092
60	152	22,374,035	345,414	1,031,847	1,826,559	750,554	770,567	72,177	-849,682
70	161	25,529,609	356,261	823,061	1,944,482	523,942	699,313	63,220	-898,444
80	170	28,856,219	376,059	752,686	2,269,855	511,300	771,691	66,670	-1,045,592
90	178	32,132,851	419,407	624,048	2,604,431	382,087	795,274	65,650	-1,194,858
100	185	35,134,977	437,417	468,961	2,607,431	299,854	759,471	60,146	-1,193,738
110	191	37,799,295	451,519	330,527	2,491,781	227,879	699,697	53,400	-1,138,965
120	197	40,764,075	498,166	272,999	3,204,281	81,580	807,026	59,376	-1,460,482
130	202	43,277,168	510,088	152,350	2,861,387	44,237	707,777	50,332	-1,302,991
140	207	45,845,537	517,220	77,223	3,087,249	10,434	746,584	51,439	-1,404,559

Table 11 Summary of pit lake water balance for Scenario 2 (high permeability)

Year	Pit Lake Water Level (mRL)	Pit Lake Volume (m^3)	Pit Lake Surface Area (m^2)	Groundwater Inflow (m^3)	Rainfall+Snow on lake (m^3)	Pit wall runoff (m^3)	WRTSF Runoff/Seepage (m^3)	Waste Rock Flushing water (m^3)	Evaporation (m^3)
10	82	6,959,732	142,169	4,197,372	610,573	1,596,831	828,186	-	-273,231
20	117	13,101,015	217,896	3,564,845	1,130,912	1,179,163	772,445	108,669	-506,082
30	140	18,772,012	279,927	3,202,366	1,508,874	894,853	740,123	113,683	-675,219
40	158	24,466,881	352,324	3,099,566	2,033,493	693,695	778,101	114,103	-909,986
50	171	29,232,918	377,333	2,280,712	2,239,857	502,674	745,128	95,511	-1,002,333
60	181	33,397,709	423,882	1,685,889	2,535,343	334,920	743,202	83,445	-1,134,563
70	190	37,349,042	449,130	1,285,703	2,874,513	278,272	799,185	79,174	-1,286,341
80	197	40,764,075	498,166	819,999	3,111,962	97,651	778,020	68,406	-1,392,599
90	203	43,787,979	511,533	464,378	3,166,204	42,820	767,374	60,563	-1,416,872
100	207	45,845,537	517,220	148,945	2,407,875	6,317	571,942	41,208	-1,077,521

4.2.3 GEOCHEMICAL DATA

The water quality for the source terms was derived on the same basis as for the NWMP model, and for the previous 2018 & 2019 models with the exception that it now incorporates runoff/seepage from the South West WRTSF and waste rock placed in the pit. The source term water chemistries are shown in Table 12. The groundwater quality used within the model is the same monitoring data as per the previous model. The water quality of the pit wall runoff and the runoff/seepage from the South West WRTSF was estimated using the week 1 – 4 data from the unsaturated waste rock humidity cell test, using a scaling factor of 2, which is the same scaling factor used in the 2018 and 2019 models. Rainfall and snowmelt onto the lake water table, and evaporation from the lake were represented as pure water with a pH of 5.5. The base depth of waste rock within the pit was estimated to be at 88.5 mRL based on the site configuration shown on Figures 1 and 7. The waste rock was incorporated into the pit lake model with the assumption that for each meter of depth in the pit, pore space in the waste rock comprises two percent of the pit volume and two percent of the planar area. Therefore, beginning at 88.5 mRL, two percent of the planar area was estimated to contain water from flushing waste rock voids. The water quality of the waste rock flushing water was estimated using the week 0 data from the saturated waste rock humidity cell test. Because the waste rock is sitting in the pit unsaturated for a number of years before the pit lake reaches it (20 years in low flow scenario and 12 years in higher flow scenario), mineral salts are assumed to have formed in the waste rock that will be flushed out once it is saturated with pit lake water. A scaling factor of 10 was used to represent the accumulation and flushing of these salts.

Table 12 Estimated inflow chemistry for pit lake

Parameter	Units	Waste Rock HCT week 1-4 unsat.	Waste Rock HCT first flush sat.	Groundwater near pit	Rainfall/ snowmelt & evaporation
pH	S.U.	7.6	7.66	7.38	5.5
Alkalinity	mg/L as CaCO3	28	35	49.2	0
Redox potential	mV	289.5	258	--	--
pe	pe units	8.5	8	4	4.0
Ca	mg/L	16.5	74.9	10.3	0
Mg	mg/L	2.9	38	1.9	0
K	mg/L	20.2	163	2.1	0
Na	mg/L	12.6	105	16.3	0
Cl	mg/L	n/a	n/a	1.3	0
SO4	mg/L	14	14	12	0
Al	mg/L	0.23	118	0.08	0
Sb	mg/L	0.003700	0.009	0.00039	0
Ag	mg/L	0.000050	0.0009	0.00001	0
As	mg/L	0.2910	1.31	0.0934	0
Ba	mg/L	0.024	1.21	0.013	0
Be	mg/L	0.00001	0.00952	0.00004	0
Cd	mg/L	1.3E-05	3.8E-04	9.2E-06	0
Cr	mg/L	0.0004	0.266	0.0005	0
Co	mg/L	0.0010	0.0498	0.0004	0
Cu	mg/L	0.00062	0.083	0.00162	0
Sn	mg/L	0.0579	0.515	0.0011	0
Fe	mg/L	0.122	75.7	0.087	0
Hg	mg/L	1.0E-05	5.0E-05	1.0E-06	0
Li	mg/L	0.8230	6.14	0.58	0
Mn	mg/L	0.052	1.48	0.125	0
Mo	mg/L	0.0046	0.0199	0.00158	0
Ni	mg/L	0.0066	0.187	0.00300	0
Pb	mg/L	0.00011	0.0443	0.00007	0
Se	mg/L	0.00068	0.0057	0.00037	0
Sr	mg/L	0.206	1.01	0.126	0
U	mg/L	0.01396	0.0403	0.00065	0
V	mg/L	0.00288	0.194	0.00035	0
Zn	mg/L	0.002	0.23	0.004	0

4.3 MODELING METHODOLOGY

The modeling methodology was the same as used for the 2018 report and 2019 technical memorandum. For each of the two scenarios, using the proportions shown in Tables 10 and 11, the four inflow water types were mixed in PHREEQC and evaporated water was removed from the mixture. As the residence time in the lake water is long, precipitation of supersaturated mineral phases including ferrihydrite and amorphous aluminum hydroxide was again permitted. The partial pressure of carbon dioxide (CO_2) was adjusted to equilibrium with atmospheric CO_2 levels. As most of the lake water body is expected to be anoxic, no equilibrium with atmospheric oxygen was specified. Also, for conservatism, as most of the water in the lake will not be in close contact to the pit walls and bottom, no sorption of trace elements onto iron hydroxides was simulated.

4.4 RESULTS

The results for the water quality at the end of the pit lake filling time, at the point of discharge from the lake, are tabulated in Table 13. This includes both the low groundwater inflow scenario (post-closure year 138), and the high groundwater inflow scenario (post-closure year 98).

Solute concentrations for the low flow scenario are more concentrated than those for the higher flow scenario. The simulated pH for both the low inflow and high inflow scenarios is pH 8.0, compliant with D019 and MMER average monthly limits. Dissolved As in both scenarios is greater than 0.1 mg/L, compliant with both Directive 019 and MMER, but relatively close to the Directive 019 limit of 0.2 mg/L. All other parameters are also compliant with both Directive 019 and MMER average monthly limits.

A separate model was created to evaluate the progression of the water quality throughout the period of the filling of the pit for scenario 1 (low flow) and this model returned similar results to the static model run for the end of the pit lake filling time. The pH was between 8.0 and 8.1 throughout filling of the pit lake. The final static filled mix for the pit lake has a dissolved arsenic concentration of 0.168 mg/L, less than both the D019 and MMER average monthly limits. However, Figure 10 shows that the initial estimated concentration for arsenic at the beginning of the pit lake filling mix has an arsenic concentration of 0.223 mg/L, elevated above the D019 limit. The arsenic concentration continues to exceed the D019 limit for the first 62 years of pit filling. Following ongoing dilution, the arsenic concentration drops over time.

The incorporation of the waste rock in the pit at 88.5 mRL is visible at the 20 year mark when the pit lake encounters the base of the waste rock in Figures 9 and 10. However, the impact on the chemistry of the pit lake is limited. This is to be expected as pore space in the waste rock was assumed to comprise only two percent of the pit volume.

While the pit lake model does account for the presence of waste rock in the pit, a more robust model may be developed with the actual volume of waste rock present. In addition, the model provides a conservative estimate of the potential impact of runoff/seepage from the South West WRTSF into the pit. The estimate is conservative as the source term chemistry for the runoff/seepage utilizes humidity cell data from weeks 1-4 when the average arsenic concentrations were generally more elevated than the other periods during humidity cell testing. While the arsenic may flush faster from the South West WRTSF, it is still anticipated that arsenic concentrations will initially exceed the D019 limit.

Table 13 Modeling results of the final water quality in the pit lake

Parameters	Unit	Scenario 1 Low Inflow	Scenario 2 High Inflow	D019 Average Monthly Concentration	MMER Monthly Mean Concentration
Physical-chemical					
pH	--	8.0	8.0		
Alkalinity (as CaCO3)	mg/L	41.8	45.4		
Major ions					
Calcium	mg/L	10.6	10.9		
Chloride	mg/L	0.3	0.6		
Magnesium	mg/L	2.3	2.4		
Potassium	mg/L	11.8	9.7		
Sodium	mg/L	10.8	13.0		
Sulphate	mg/L	17.0	16.1		
Trace Metals					
Aluminum	mg/L	0.012	0.013		
Antimony	mg/L	0.00182	0.00142		
Silver	mg/L	0.00004	0.00004		
Arsenic	mg/L	0.167	0.151	0.2	0.5
Barium	mg/L	0.033	0.034		
Beryllium	mg/L	0.0002	0.0002		
Cadmium	mg/L	0.00001	0.00001		
Chromium	mg/L	0.005	0.005		
Cobalt	mg/L	0.001	0.001		
Copper	mg/L	0.00202	0.00234	0.3	0.3
Iron	mg/L	0.02	0.0085	3	
Lithium	mg/L	0.59	0.62		
Manganese	mg/L	0.075	0.098		
Mercury	mg/L	0.00000533	0.00000424		
Molybdenum	mg/L	0.00264	0.00241		
Nickel	mg/L	0.007	0.006	0.5	0.5
Lead	mg/L	0.001	0.001	0.2	0.2
Selenium	mg/L	0.00047	0.00047		
Strontium	mg/L	0.13	0.14		
Uranium	mg/L	0.007	0.005		
Vanadium	mg/L	0.005	0.004		
Zinc	mg/L	0.006	0.006	0.5	0.5

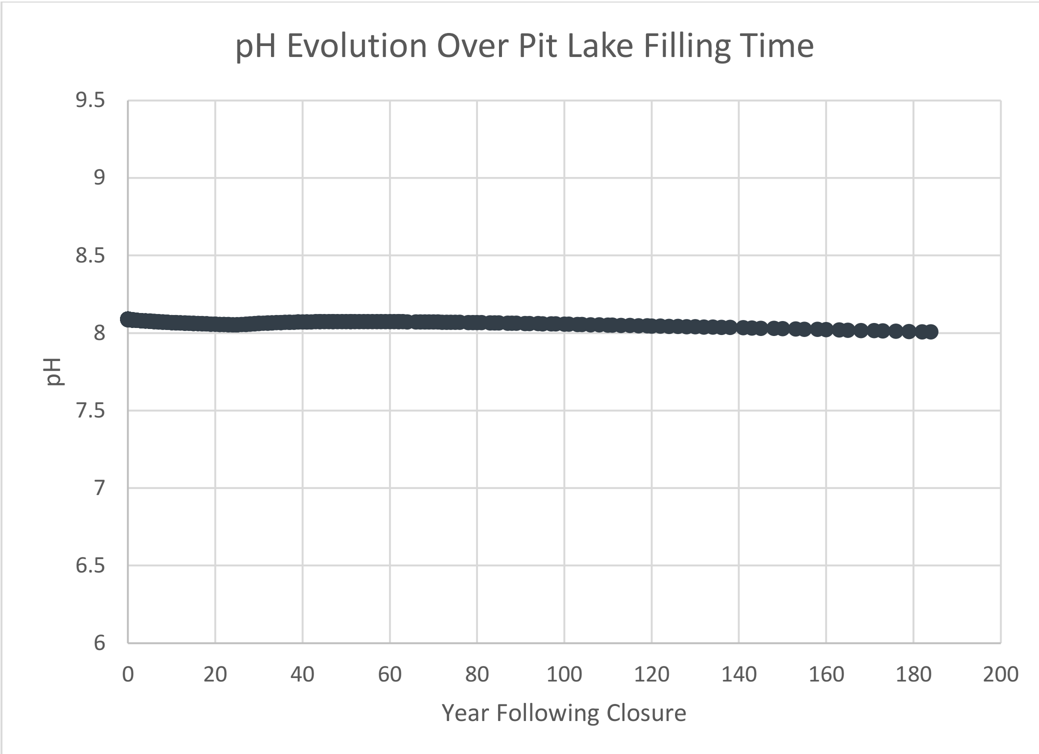

Figure 9: pH Evolution Over Pit Lake Filling Time

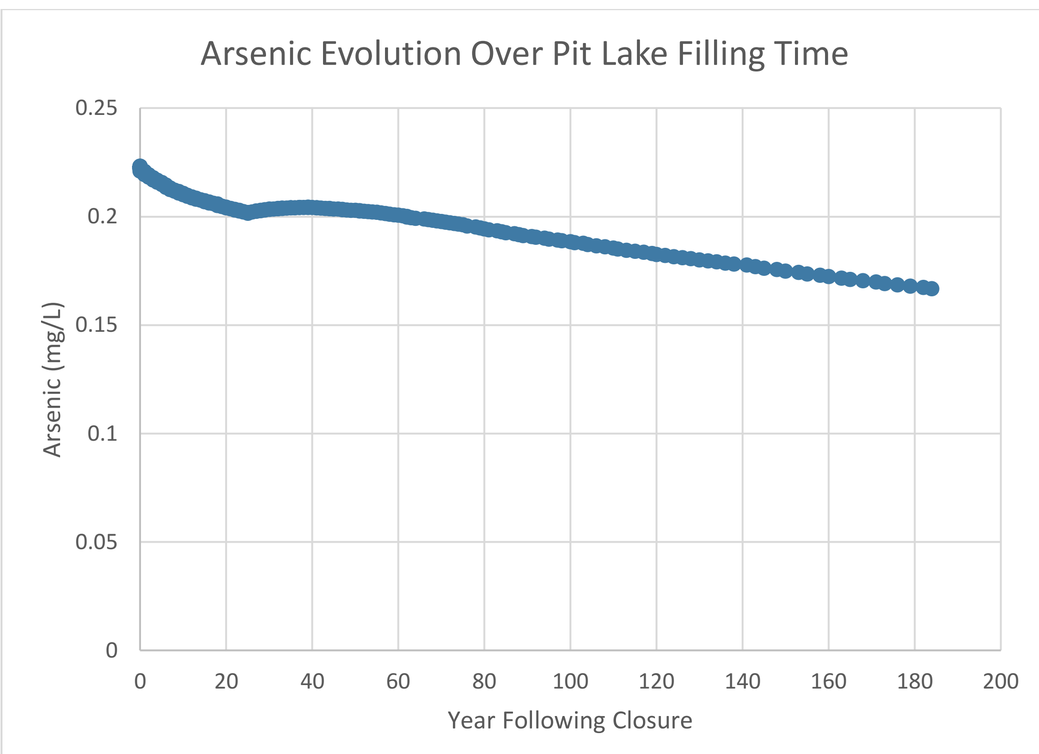

Figure 10: Arsenic Evolution Over Pit Lake Filling Time

5 SUMMARY AND CONCLUSIONS

The geochemical models for the NWMP and the final pit lake filling model were updated using similar conceptualizations as the 2018 and 2019 models. Updates included changes to the mine plan, including in-pit disposal of waste rock.

The water management pond model was updated to address the changing water chemistry in the NWMP throughout LOM for both 25-year dry conditions and 25-year wet conditions. Results of the model indicate that arsenic concentrations in the dry scenario will begin to exceed D019 average monthly limits in approximately Year 8 and concentrations will continue to increase over time. Based on these results, design for any water treatment infrastructure for the NWMP discharge should assume that removal of arsenic may be necessary during parts of the year. Because of the elevated arsenic concentrations during LOM, we recommend that the geochemical models are refined to address additional changes to the mine plan.

For the geochemical model of the final pit lake, two water qualities were simulated for low and high groundwater inflow values. Dissolved arsenic in both scenarios is near 0.15 mg/L, compliant with both Directive 019 and MMER, but relatively close to the Directive 019 limit of 0.2 mg/L. All other parameters are also compliant with both Directive 019 and MMER average monthly limits. However, arsenic concentrations exceeded the D019 limit for the first 62 years of the pit filling model. This is a conservative estimate. As for the NWMP model, a degree of uncertainty remains regarding the likely solute concentrations in the final pit lake (particularly regarding arsenic), due to the limited current knowledge about the future pit lake dynamics. Should further information become available we would recommend refining the pit lake filling model and chemistry prediction.

The geochemical modelling results presented herein are based on limited geochemical data and therefore represent high-level estimates. It is recommended to carry out additional geochemical sampling, laboratory testing and more detailed modelling to reduce the inherent uncertainties. It is good practice to increase the amount of geochemical information and sample numbers commensurate with project stage.

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