GOLDER

TECHNICAL MEMORANDUM

DATE 6 May 2019 **Project No.** 18108905-291-TM-Rev0

TO Michel Groleau
Agnico Eagle Mines Limited - Meadowbank Division

CC Jennifer Range

FROM Jennifer Levenick, Don Chorley **EMAIL jlevenick@golder.com**

UPDATED HYDROGEOLOGICAL ASSESSMENT, WHALE TAIL PIT, EXPANSION PROJECT

1.0 INTRODUCTION

Agnico Eagle Mines Limited: Meadowbank Division (Agnico Eagle) is proposing to develop the Whale Tail Pit, IVR Pit and Underground operations on the Amaruq property (Expansion Project), in continuation of mine operations and milling of the Meadowbank Mine. The Approved Project supports mining ore from one open pit, the Whale Tail Pit, processed over a three to four-year mine life. The Expansion Project proposes mining additional ore from the expanded Whale Tail Pit, the IVR Pit, and Underground operations.

This report presents the results of updated hydrogeological modelling completed for the Expansion Project since submission of the FEIS addendum in December 2018. The model was updated based on results of monitoring at the Westbay system in November 2018, supplemental packer testing in December 2018, and additional thermal analysis in 2019. The updated hydrogeological model was then used to provide revised predictions of groundwater inflow and total dissolved solids (TDS) concentrations during dewatering, mining, pit and underground flooding, and long-term post-closure (reflooded) conditions.

The technical memorandum is organized as follows:

- Section 2.0 provides a summary of hydrogeological data and thermal modelling results available since last hydrogeological assessment completed for the Expansion Project (Golder 2018).
- Section 3.0 and 4.0 provides a description of the changes made to the conceptual and numerical model based on the additional data collected.
- Section 5.0 provides a summary of the updated groundwater model predictions during dewatering, mining and filling phases of the Expansion Project.
- Section 6.0 provides a summary of the updated groundwater model predictions after the pits are fully flooded.

2.0 DATA REVIEW

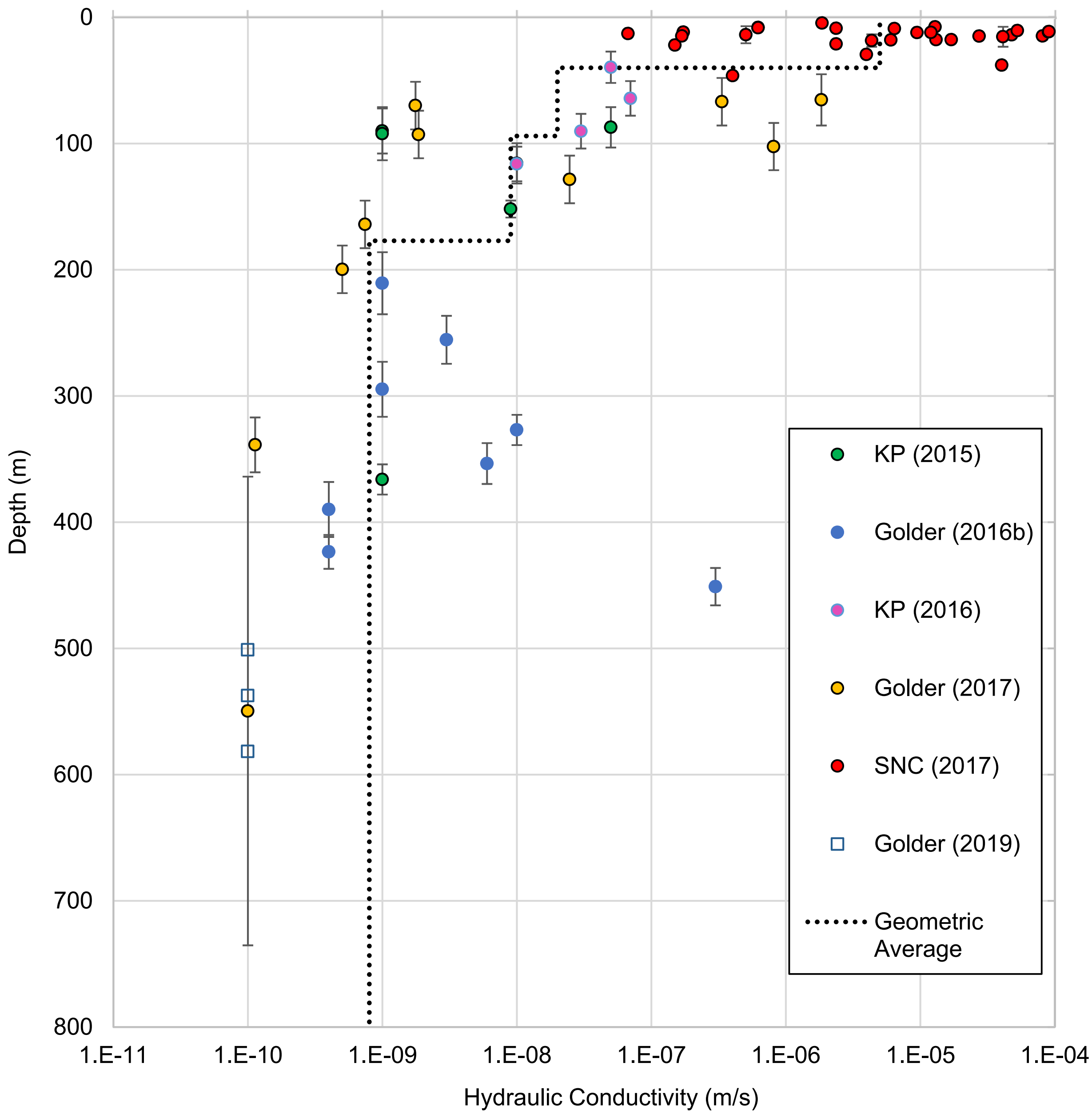
Since the completion of the FEIS hydrogeological assessment for the Expansion Project (Golder 2018), investigations have been carried out to collect additional site-specific data, as requested in the Project Certificate No. 008, Term and Condition No. 15 for the Approved Project. A summary of the results of these investigations is presented below.

2.1 Hydrogeological Testing

A hydrogeological testing program was conducted between 7 and 9 of December 2018 (Golder 2019b) to collect data near the underground below IVR pit. The testing was conducted in deep bedrock in the sub-permafrost zone over a depth interval of about 375 to 626 metres below ground surface (mbgs). Each of the three tests conducted within this interval resulted in estimated hydraulic conductivities of less than 1 x 10^{-10} m/s (due to limitations of the testing equipment, hydraulic conductivities of less than 1 x 10^{-10} m/s could not be quantified).

With the addition of these tests to historical measurements of bedrock hydraulic conductivity (Figure 1), the hydraulic conductivity of the deep bedrock is inferred to be slightly lower than what was assumed in the previous hydrogeologic modelling. These packer test data also provide a higher level of confidence that the one high value of hydraulic conductivity over a 30 m zone from a depth of about 436 m to 466 m in deep bedrock that was measured during the drilling of the borehole for the Westbay multi-level well is likely an isolated zone of jointing near the test interval and is not a large-scale enhanced permeability zone.

Figure 1 presents an updated summary of the hydraulic conductivity measurements completed for the area of the two pits and Underground, including the 2018 measurements and historical data. Figure 2 presents the location of the borehole locations tested. With the additional measurements from December 2018, the calculated geometric average of the test data below 200 mbgs decreased from 1 x 10^{-9} m/s to 8 x 10^{-10} m/s.



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AGNICO EAGLE MINES LIMITED

PROJECT
AMARUQ PROPERTY – EXPANSION PROJECT

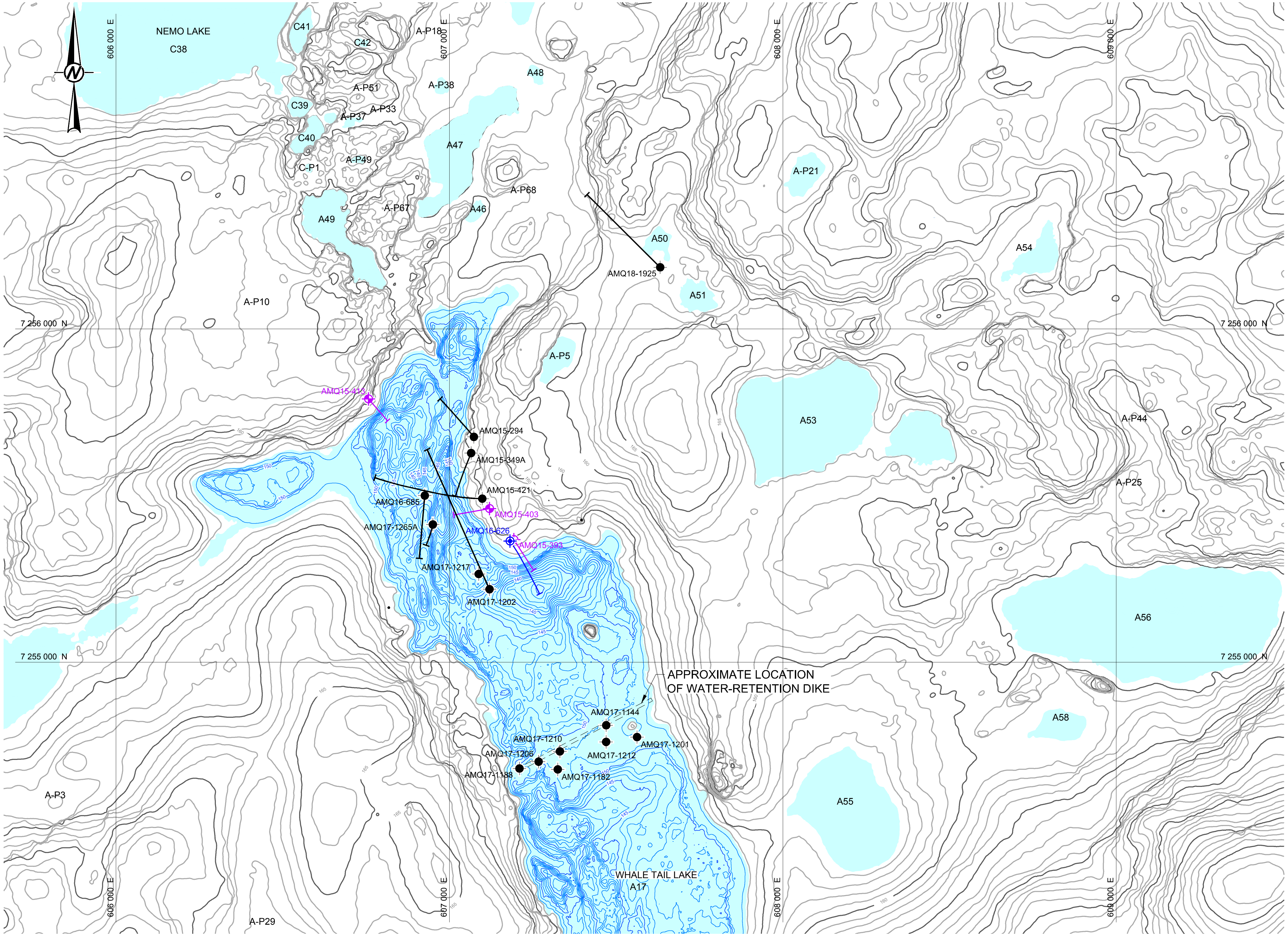
CONSULTANT

GOLDER

YYYY-MM-DD	2019-05-01
PREPARED	JL
DESIGN	JL
REVIEW	DC
APPROVED	JL

TITLE
SUMMARY OF HYDRAULIC CONDUCTIVITY TEST RESULTS

PROJECT No.	Rev.	FIGURE
18108905	**0**	**1**



LEGEND

- EXISTING GROUND SURVEY
- EXISTING BATHYMETRY
- WATER BODY
- WESTBAY SYSTEM
- BOREHOLE
- MONITORING WELL

NOTE(S)

1. ALL UNITS ARE IN METERS UNLESS NOTED OTHERWISE.
2. CONTOUR INTERVAL 1m MINOR AND 5m MAJOR.

REFERENCE

BASE PLAN AND BATHYMETRY DATA RECEIVED FROM AGNICO EAGLE MINES LTD. DATE RECEIVED NOVEMBER 25, 2016.
CAD FILE: COURBESZM_AMARUQ_GLOBAL_UTM14_20150929.DWG
CAD FILE: 1665858-2100B-CM-0002.DWG
CAD FILE: 61-000-142-001_R0BLOC.DWG

0 250 500
1:12,500 METRES

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PROJECT
AMARUQ PROJECT PROPERTY - EXPANSION PROJECT

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YYYY-MM-DD	2019-02-12
DESIGNED	CM
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REVIEWED	JL
APPROVED	DH

TITLE
LOCATION OF PACKER TEST BOREHOLES AND INSTALLED MONITORING WELLS

PROJECT NO.	CONTROL	REV.	FIGURE
18108905	291	0	2

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2.2 Permafrost Assessment

Golder was recently retained to carry out an updated thermal assessment for the Project to:

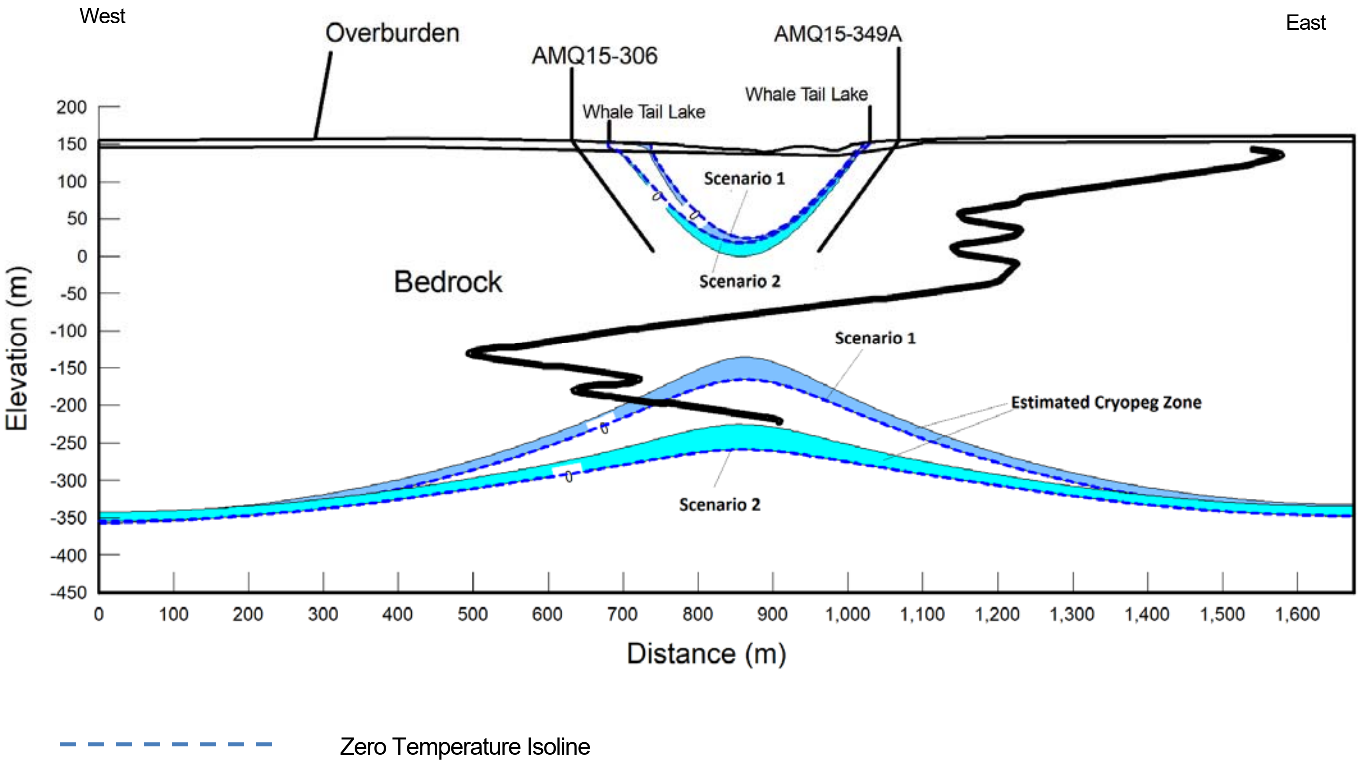
- Evaluate existing permafrost characteristics in the Whale Tail Lake and Project area.
- Evaluate existing talik conditions under the Whale Tail Lake adjacent to the Project site.

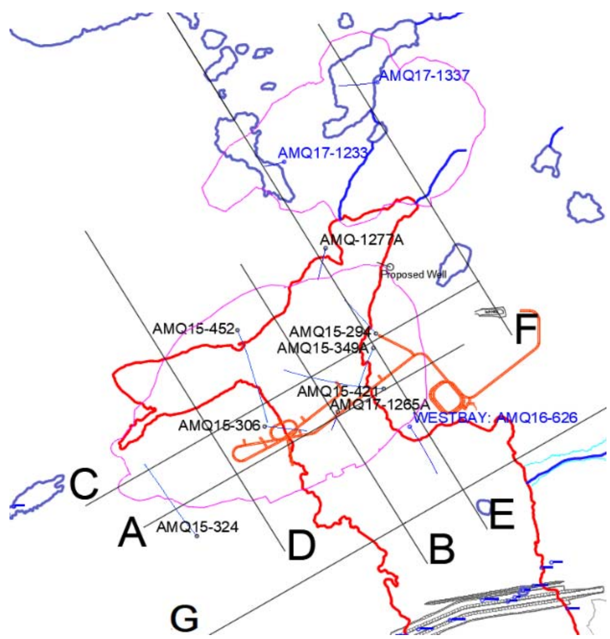
The results of this work are documented in Golder (2019c). The report presents a review and summary of estimated permafrost condition based on available thermistor data to date, as well as the results of a thermal modelling exercise prepared to assess permafrost conditions and the extent of talik formations beneath the Whale Tail Lake. Results from the thermal modelling were used to develop a 3D representation of the permafrost in the Whale Tail Lake area.

Based on the thermal modelling and the available thermistor data, the permafrost characteristics in the Project area are summarized below:

- The depth of permafrost outside of the influence of lakes is estimated to be between 452 m and 522 m based on thermal gradients and ground temperatures at the lowest portions of the thermistor strings. The depth of permafrost increases with increasing distance from lakes with talik.
- Considering the 2D thermal modelling and 3D block model, the assessment indicated that:
  - Under the northern portion of the lake below Whale Tail Pit, there is likely a closed talik formation (Section C of the thermal modelling report, reproduced on Figure 3 of this report).
  - Open talik conditions are probable in the southern portion of the lake where the Whale Tail Lake becomes wider (Section G of the thermal modelling report, reproduced on Figure 4 of this report).
  - Permafrost depth is between 480 m and 550 m for ground away from the Whale Tail Lake, and between 350 m and 450 m below surface in portions beneath the Whale Tail Lake where a closed talik is present.
  - The cryopeg thickness is likely between 20 m to 30 m.

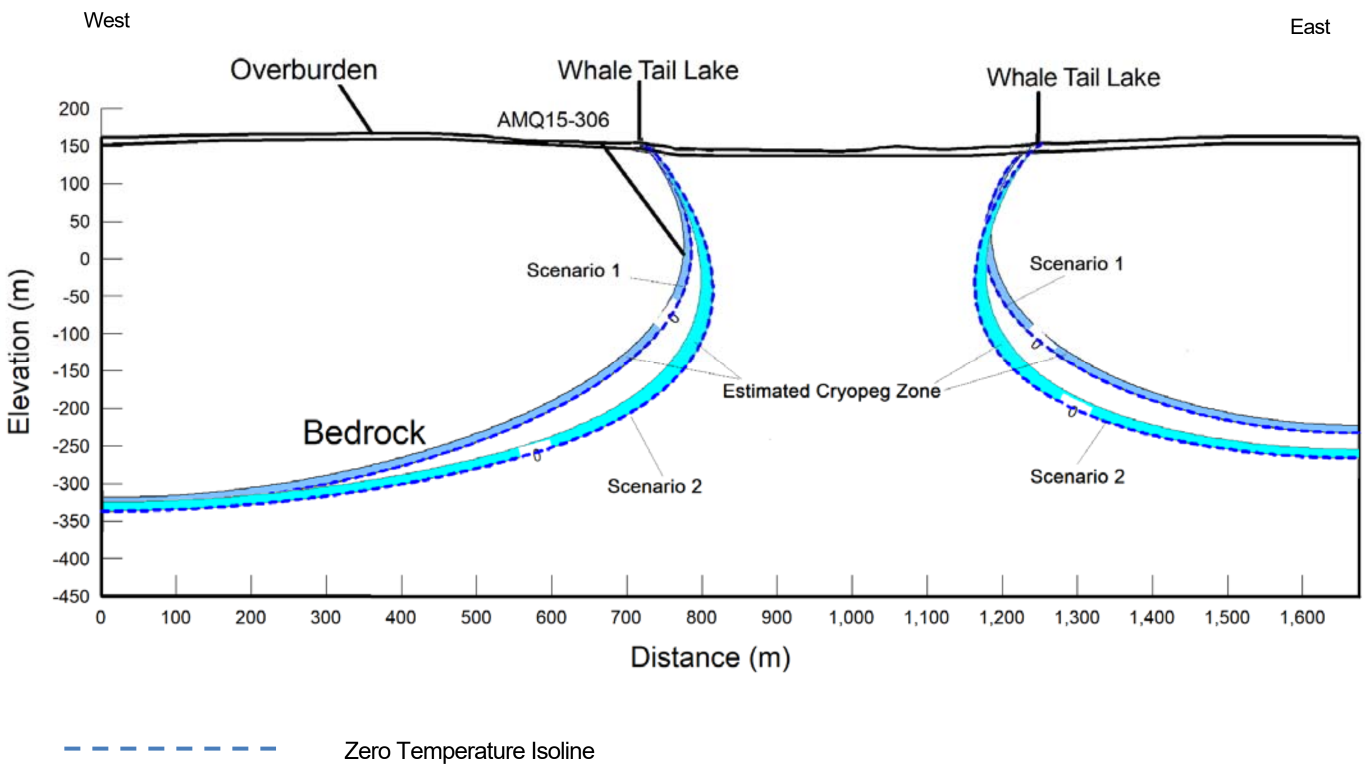
Review of the 2D thermal analysis and 3D block model indicates that the predicted closed and open talik is consistent with the conceptual hydrogeological conditions adopted in the FEIS Addendum.

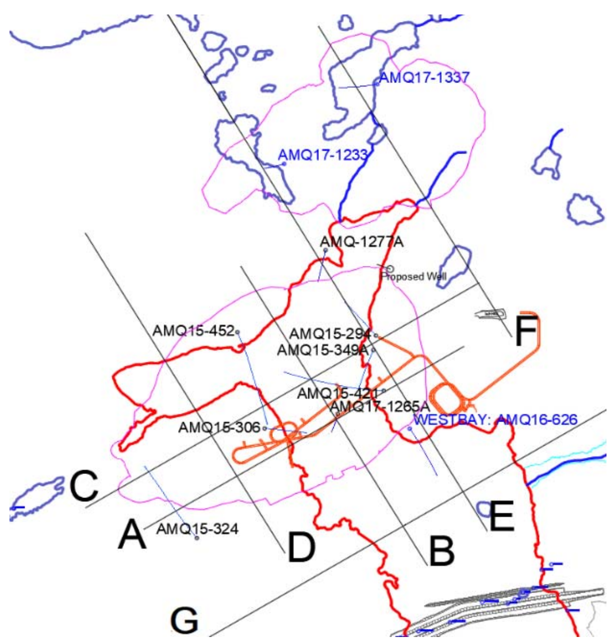




From Golder 2019.

CLIENT AGNICO EAGLE MINES LIMITED		PROJECT AMARUQ PROPERTY – EXPANSION PROJECT	
CONSULTANT GOLDER	YYYY-MM-DD: 2019-05-01	TITLE **THERMAL MODEL CALIBRATION RESULTS – SECTION C**	
	PREPARED: JL		
	DESIGN: JL		
	REVIEW: DC	PROJECT No. **18108905**	Rev. **0**
	APPROVED: JL	FIGURE **3**	





From Golder 2019.

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CONSULTANT

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DESIGN	JL
REVIEW	DC
APPROVED	JL

TITLE
THERMAL MODEL CALIBRATION RESULTS – SECTION G

PROJECT No. **18108905** Rev. **0** FIGURE **4**

2.3 Westbay Sampling and Hydraulic Head Measurements

Groundwater sampling and hydraulic head measurements of the Westbay multi-level system was undertaken in November 2018 (Golder 2019a) and are described below. The 2018 sampling data supplements previous data collected from the Westbay multi-level system in 2016.

Groundwater samples were collected from ports 2, 3, 4, and 6 of the Westbay multi-level well in November 2018. During drilling and installation of the Westbay, the drilling fluid was tagged with fluorescein. During collection of the water samples, the fluorescein concentration was measured to estimate the proportion of the sample that could be attributed to drilling fluid.

Groundwater quality of each water sample was estimated using a mass balance calculation to remove the proportion of residual drill fluid from the collected samples. The 2018 program estimated groundwater quality at Ports 6, 4, and 3 are in the same range as previously estimated. The calculated groundwater TDS were slightly higher in 2018 relative to 2016. The variation is attributed to the higher proportion of residual drilling water in the sample, which produces greater uncertainty in the TDS of the formation water. Therefore, the 2018 values are not considered to represent an actual increase in groundwater TDS and the assumptions for the FEIS Addendum conceptual model, which are based on the more reliable and applicable 2016 data, are still considered to be appropriate.

The concentrations of metals and arsenic were low. The maximum calculated arsenic concentration remains similar to what was calculated for Port 6 in 2016. Given that the arsenic concentrations are similar to assumptions adopted in the geochemical models for the FEIS (low arsenic in Formation groundwater), groundwater arsenic content is still not likely to have a significant effect on mine surface water quality.

Hydraulic heads measurements were recorded at the sampling ports prior to any sampling or development. The measurements indicate a downward hydraulic gradient was present (magnitude of 0.008 m/m), which is consistent with the conceptual understanding of pre-development groundwater flow directions and predicted conditions post-closure following the formation of the Whale Tail Pit Lake (Golder 2018). Gradients measured pre-development are considered a reasonable interpretation of what long-term gradients could be post-closure following the formation of the pit lake.

Considering the approximate area of Whale Tail Pit (0.5 km^2), the updated geometric average of the deep sub-permafrost bedrock (8×10^{-10} m/s), and the measured downward gradient (0.008 m/m), the data would indicate long term groundwater flux from the pit lake would be approximately 0.3 m^3/day. This value is lower than discharge measurements predicted in the FEIS addendum for the Environmental Assessment (EA) Scenario of 1.5 m^3/day (Golder 2018).

3.0 CONCEPTUAL MODEL AND REFINEMENT OF BEDROCK HYDRAULIC CONDUCTIVITY

Except for the refinement of the hydraulic conductivity for the deep sub-permafrost bedrock, field data collected in 2018 is consistent with the conceptual model presented in the FEIS Addendum and no changes were made to the interpreted flow conditions. The conceptual model is presented in Appendix 6-B of the FEIS Addendum (Golder 2018).

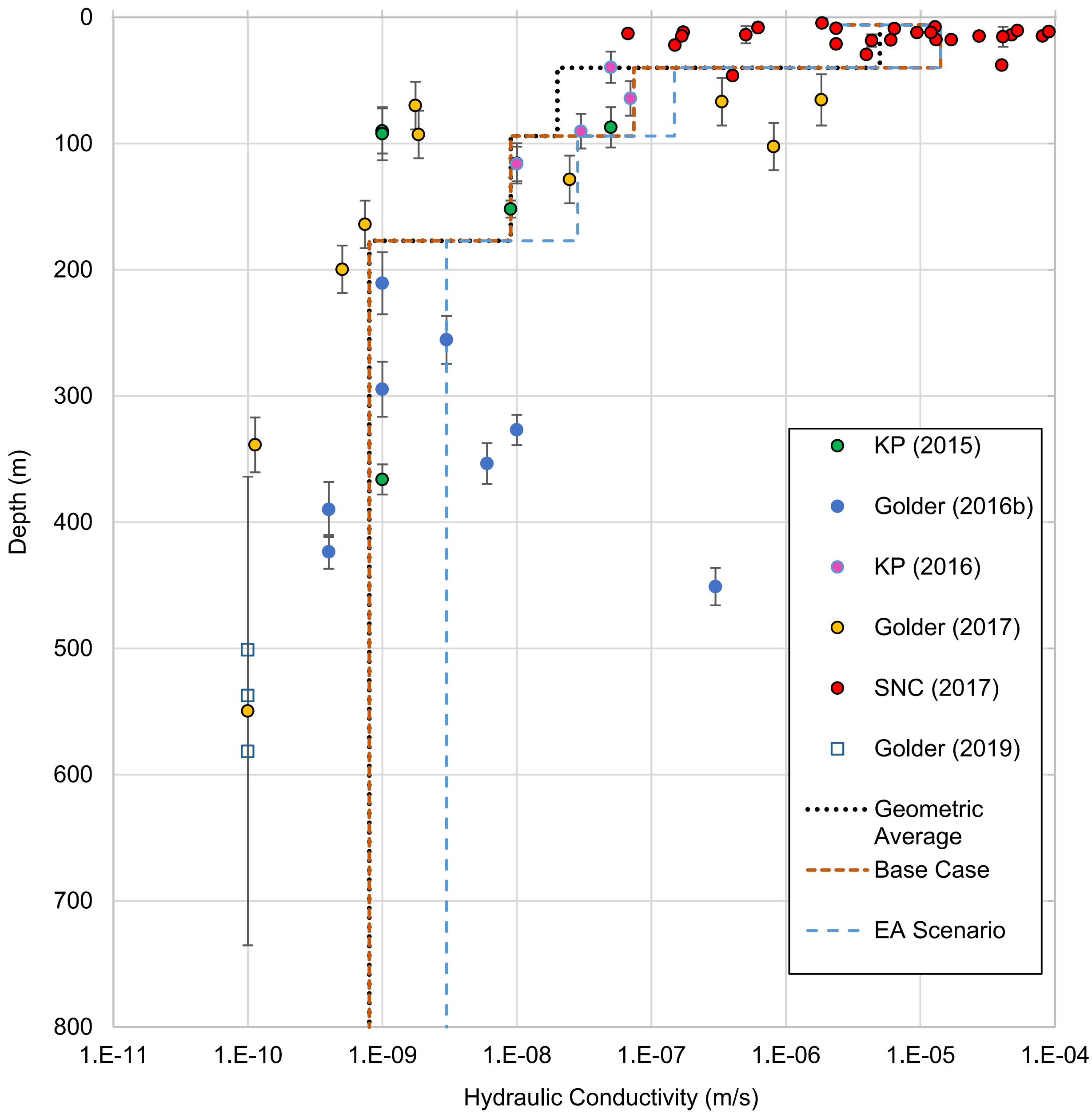
Hydraulic head monitoring conducted in November 2018 confirmed the downward direction of the vertical hydraulic gradient predicted by the model below Whale Tail Lake. Review of the 2D thermal analysis and 3D block model indicates that predicted closed and open taliks are consistent with the conceptual hydrogeological conditions adopted in the FEIS Addendum (closed talik in the northern portion of Whale Tail lake and open talik in the southern portion). The 3D block model was compared to the permafrost in the numerical model, and minor adjustments were made in the simulated permafrost depth along the margins of Whale Tail Lake (slightly smaller in extent).

Considering the packer test results, the hydraulic conductivity of the deep sub-permafrost bedrock was lowered from what was used in the FEIS addendum. For the Base Case, the hydraulic conductivity was decreased from 1×10^{-9} m/s to 8×10^{-10} m/s, which is equivalent to the geometric average of the test values. For the EA Scenario, the hydraulic conductivity was decreased from 4×10^{-9} m/s to 3×10^{-9} m/s, which is approximately 3 times higher than the geometric average of the data values. As described in the FEIS modelling report (Golder 2018), the Base Case Scenario represents reasonable estimates of hydraulic conductivity based on measured data; whereas, the EA Scenario incorporates conservatively higher estimates of hydraulic conductivity. Figure 5 presents the updated hydraulic conductivity profile for the bedrock that was assigned in this assessment of groundwater inflows and quality for the EA and Base Case Scenarios. Table 1 presents a tabular summary of the bedrock hydraulic conductivity used in the EA Scenario for the FEIS Addendum compared to the bedrock hydraulic conductivity used in this updated assessment.

Table 1: Hydraulic Conductivity of the Hydrostratigraphic Units

Hydrostratigraphic Unit	Depth Interval (m)	Hydraulic Conductivity (m/s)		Hydraulic Conductivity (m/s)	
		FEIS Base Case Scenario	2019 Updated Base Case Scenario	FEIS EA Scenario	2019 Updated EA Scenario
Overburden	0 to 6	2×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}
Weathered bedrock	6 to 40	1×10^{-5}	1×10^{-5}	1×10^{-5}	1×10^{-5}
Competent bedrock	40 to 100	7×10^{-8}	7×10^{-8}	1×10^{-7}	1×10^{-7}
Competent bedrock	100 to 200	9×10^{-9}	9×10^{-9}	3×10^{-8}	3×10^{-8}
Competent bedrock	>200	1×10^{-9}	<u>**8×10^{-10}**</u>	4×10^{-9}	<u>**3×10^{-9}**</u>

Note: Parameters which have changed since the FEIS Addendum are shown in bold and underlined.



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YYYY-MM-DD	2019-05-01
PREPARED	JL
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REVIEW	DC
APPROVED	JL

TITLE
UPDATED HYDRAULIC CONDUCTIVITY VALUES – BASE CASE AND EA SCENARIO

PROJECT No.	Rev.	FIGURE
18108905	0	5

4.0 3D NUMERICAL HYDROGEOLOGICAL MODEL

To complete the updated hydrogeological assessment for the Expansion Project, the numerical hydrogeological model developed for the Expansion Project in FEFLOW was updated to incorporate the minor changes in hydraulic conductivity at depth and permafrost extent identified in Sections 2.0 and 3.0:

- The 3D block model was compared to the permafrost in the numerical model, and minor adjustments were made in the permafrost depth along the margins of Whale Tail Lake. Overall, changes to the permafrost extent were minor and did not conceptually alter the interpretation of where open and closed talik were present in Whale Tail Lake.
- The hydraulic conductivity of the competent bedrock below a depth of 200 m was decreased based on the updated packer test data collected in December 2018 (Table 1).

Except for the above two changes, no other modifications were made to the numerical model prior to predicting updated groundwater inflow quantity and quality for the Base Case and EA Scenarios. The development and construction of the numerical model is presented in Appendix 6-B of the FEIS Addendum (Golder 2018).

5.0 UPDATED MODEL PREDICTIONS – PRE-DEVELOPMENT, DEWATERING, MINING AND FILLING PHASES

The following section of the report provides updated predictions for dewatering of Whale Tail Lake and the mining and reflooding of the pits and underground for the Expansion Project. As discussed in Section 4.0, this model incorporates a reduction in deep bedrock hydraulic conductivity based on additional packer testing in December 2018, and the results of the thermal modelling, which overall support the permafrost interpretation in the FEIS Addendum. Minor adjustments were made in the permafrost depth along the margins of Whale Tail Lake but overall, changes to the permafrost extent were minor and did not conceptually alter the interpretation of where open and closed talik were present in Whale Tail Lake.

Updated predictions of groundwater inflow (quantity and TDS quality[1]) are provided for the Base Case and EA Scenario. The Base Case Scenario represents the best estimate of groundwater inflow and groundwater TDS based on the measured data. The EA Scenario is designed to be a reasonable, yet more conservative, assessment of potential groundwater inflow quantity and TDS quality than values that might be adopted for mine operation planning (i.e., Base Case Scenario). Results from the more conservative EA Scenario are used in the Updated Site-Wide Water Balance and Water Quality model.

[1] Consistent with previous modelling in the FEIS Addendum, TDS concentrations do not account for loading from lakes and Whale Tail Attenuation Pond. TDS from these sources accounted for in Site Wide Water Quality analysis.

5.1 Base Case Scenario

5.1.1 Dewatering

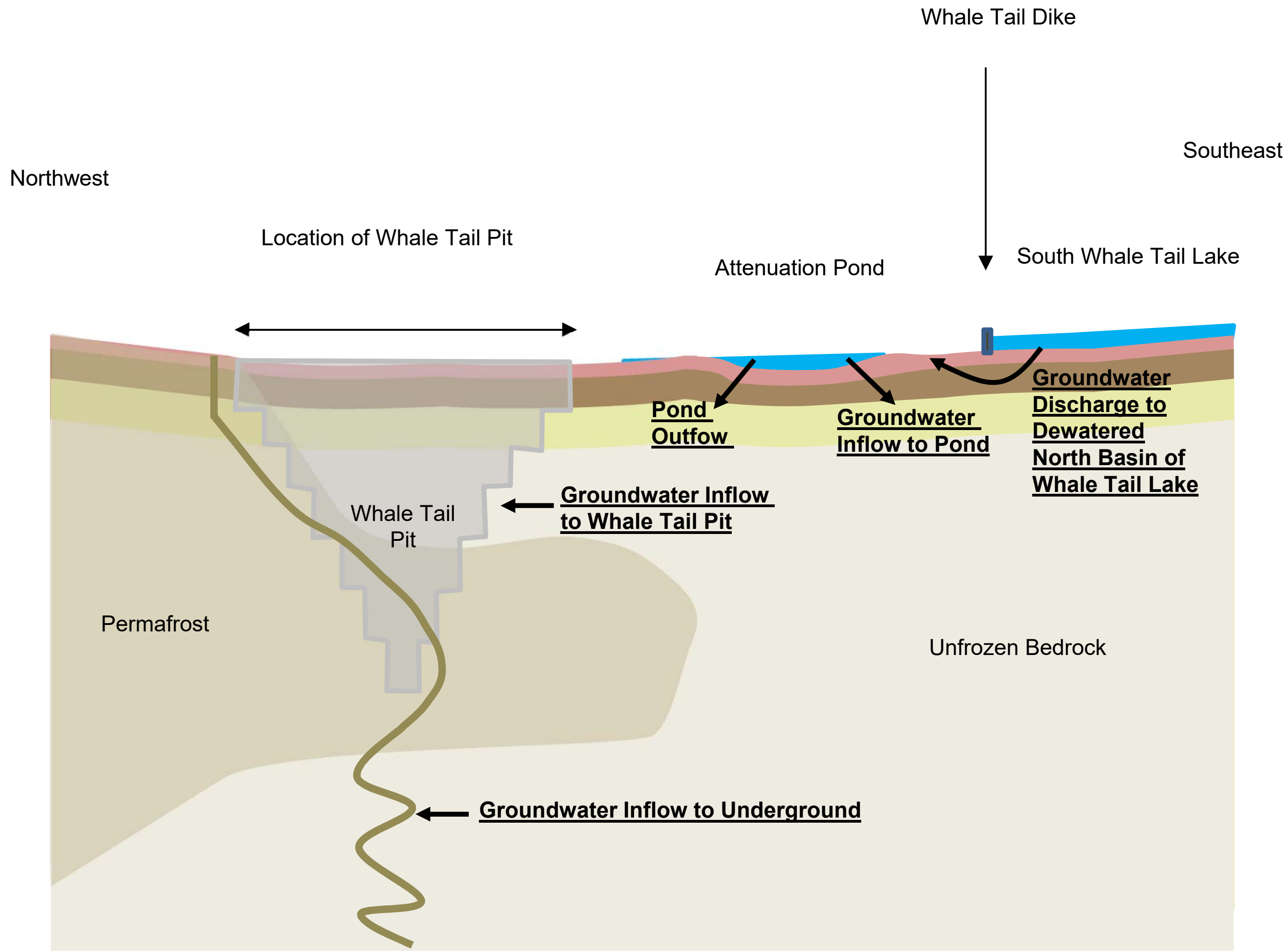
Table 2 presents a summary of the predicted discharge to the North Basin of Whale Tail lake during dewatering. The predicted discharge of 1320 m^3/day is within 20 m^3/day of the FEIS predictions (1340 m^3/day) and no change in TDS concentration was predicted. The minor variation in predicted discharge from the FEIS reflects the small adjustments made to permafrost extent along the margins of Whale Tail Lake.

Table 2: Predicted Groundwater Discharge to North Basin of Whale Tail Lake during Dewatering – Base Case Scenario

Phase	Base Case Scenario	
	Groundwater Discharge (m^3/day)	TDS Concentration (mg/L)
Lake Dewatering (Q1-Q3 2019)	1320	80

5.1.2 Mining

Table 3 presents a summary of the updated predicted groundwater flow rates and groundwater TDS concentrations to the mine development areas for the Base Case Scenario during mining of the open pits and underground. The predictions presented on these tables are conceptually shown on Figure 6 and include: predicted groundwater inflow to Whale Tail Pit, predicted groundwater inflow to the Underground, predicted flow to and from the Whale Tail Attenuation Pond, and predicted discharge to the dewatered North Base of Whale Tail Lake (i.e., the flow of water below the Whale Tail Lake Dike to the dewatered lake bottom). Groundwater inflow to the IVR Pit during mining is not included as the pit is in permafrost (groundwater inflow will be negligible). Some interception of surface water runoff and direct precipitation by the IVR Pit is excepted, but this is not a flow component derived from the groundwater modelling. It is addressed in the Updated Site-Wide Water Balance and Water Quality Model (Golder 2019d).



Legend

- Flow Component with predictions of Water Quantity and TDS Water Quality
- Waterbody
- Permafrost
- Overburden (0 to 6 m below ground surface)
- Weathered Bedrock (6 to 40 m below ground surface)
- Competent Bedrock (40 to 100 m below ground surface)
- Competent Bedrock (>100 m below ground surface)

NOTES:
Conceptual Only. Not to Scale.

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YYYY-MM-DD	2019-05-01
PREPARED	JL
DESIGN	JL
REVIEW	DC
APPROVED	JL

TITLE
CONCEPTUAL SCHEMATIC SHOWING LOCATION OF FLOW COMPONENTS WITH PREDICTIONS OF GROUNDWATER INFLOW

PROJECT No.	Rev.	FIGURE
18108905	0	6

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Table 3: Predicted Groundwater Inflow and Groundwater Quality during Mining – Base Case Scenario – Whale Tail Pit and Underground

Phase	Time Period	Whale Tail Pit		Underground		Whale Tail Attenuation Pond			North Basin of Whale Tail Lake (within the diked area) [3]	
		Groundwater Inflow (m^3/day)	TDS Concentration[2] (mg/L)	Groundwater Inflow (m^3/day)	TDS Concentration[2] (mg/L)	Groundwater Inflow (m^3/day)	Inflow TDS Concentration (mg/L)	Surface Water Outflow (m^3/day)	Groundwater Discharge to Surface (m^3/day)	Inflow TDS Concentration (mg/L)
Mining	August-December 2019[1]	970	120	NA	NA	350	110	180	650	70
	2020	1160	50	20	3880	120	170	860	720	30
	2021	1310	20	30	4080	90	150	1040	730	20
	2022	1340	20	110	5630	90	130	1080	720	10
	2023	1340	10	180	6890	90	110	1080	720	10
	2024	1340	10	170	7430	90	80	1080	720	10
	2025	1340	10	130	7760	90	40	1080	720	10

Notes:
Pictorial representation of Flow Locations Components shown on Figure 6.
IVR Pit is located in permafrost and was therefore not modelled. Interception of runoff / direct precipitation accounted for in Site Wide Water Balance.
[1] Mining prior to Q4 2019 is within permafrost and groundwater inflow will be negligible.
[2] TDS concentrations do not account for loading from lakes and Whale Tail Attenuation Pond. TDS from these sources to be accounted for in Site Wide Water Quality analysis.
NA = not applicable; TDS = total dissolved solids; m^3/day = cubic metres per day; mg/L = milligrams per litre; % = percent.

Whale Tail Open Pit

In the last quarter of 2019, following dewatering of the North Basin of Whale Tail Lake, mining is expected to intersect unfrozen rock, and groundwater inflow to the pit is predicted to be 970 m^3/day. The groundwater inflow to the open pit was predicted to increase from 970 m^3/day in 2019 to 1,340 m^3/day in 2022 to 2025. The overall inflow to the pit does not increase significantly as the pit deepens because the flow of water is primary through the permeable shallow (weathered) bedrock and the lower portion of the pit is in permafrost. The predicted quantity of groundwater inflow into the open pit during mining for the Base Case Scenario is close to what was predicted in the FEIS Addendum as no changes were made to the shallow bedrock hydraulic conductivity based on the recent packer test data.

Groundwater inflow predictions during mining conservatively assumes that no freeze-back will occur in the pit walls. This assumption was adopted for Whale Tail Pit to be conservative and because during the first few years of mining, the pit will be both widened and deepened, resulting in the continual exposure of unfrozen bedrock. During the later years of mining; however, the pit development will be entirely within the permafrost and significant freeze back in the pit walls is considered possible and has been observed at Meadowbank. Although not simulated, if freeze back does occur as is the case at Meadowbank, actual groundwater inflow to the pit could be substantively lower than the predicted values in Table 3 and Table 4 (i.e., reduce to zero during periods of full freeze back).

TDS concentration in the groundwater inflow to the pit was predicted to decrease during mining from approximately 120 mg/L (2019) to 10 mg/L (2023 to 2025). These TDS concentrations are identical to the predicted TDS concentrations in the FEIS Addendum. The relatively low TDS concentration and decrease in TDS over time reflects the minimal upwelling of higher salinity waters at depth due to the presence of the permafrost at the base of the pit and the high contribution of lake water from the South Base of Whale Lake and from the Whale Tail Attenuation Pond water. Consistent with the FEIS Addendum, the predicted TDS concentrations in this model only account for TDS loading from groundwater. TDS loading from the Whale Tail Attenuation Pond and South Basin of Whale Tail Lake is accounted for in the water quality model (Golder 2019d).

Underground

For the Underground, groundwater inflow was predicted to increase from 20 m^3/day in 2020, which is the first year the Underground development will be within unfrozen bedrock, up to 180 m^3/day in 2023, which is when the underground reaches its maximum depth of -505 masl. By the final year of mining, the groundwater inflow decreases to 130 m^3/day. This decrease reflects that the underground is no longer being deepened and flow to the underground is likely near steady state conditions (reduced drainage from storage). The predicted flows based on the updated model is approximately 13% lower than the predicted values in the FEIS Addendum at the end of mining (150 m^3/day). The reduction in groundwater inflow reflects the small decrease in hydraulic conductivity in the deep sub-permafrost bedrock due to the additional packer testing data.

TDS concentrations in the groundwater inflow to the Underground were predicted to increase from 3,880 mg/L in 2020 to 7,760 mg/l in 2025. The predicted increase in TDS concentration is the result of the interception of higher salinity groundwater as the mine is deepened, and the upwelling of higher TDS water from beneath the Underground. The predicted TDS concentrations are within 30 mg/L of the predicted values in the FEIS Addendum for the Base Case Scenario.

5.1.3 Reflooding of Pits and Underground

Table 4 and Table 5 respectively presents a summary of the predicted groundwater inflow rates and groundwater TDS concentration to the mine development areas for the Base Case Scenario during reflooding of the pits and underground. The predictions presented in Table 4 and Table 5 include: predicted groundwater inflow to Whale Tail Pit Lake, predicted groundwater flow to the Underground, predicted flow to and from the Whale Tail Attenuation Pond, and predicted discharge to the dewatered North Base of Whale Tail Lake (i.e., the flow of water below the Whale Tail Lake Dike to the dewatered lake bottom surface). Groundwater inflow to the IVR Pit during refilling was not included as the pit is in permafrost (groundwater inflow will be negligible).

The predictions presented for the reflooding phase utilize a conceptual filling schedule for the Whale Tail Pit and the Underground, based on initial water balance predictions. Fine tuning of the flooding sequence was conducted after the conceptual filing schedule was developed; however, these adjustments will not have a significant impact on the predicted flow rates and salinity for a given elevation range.

For the prediction of pit reflooding, the pit walls were assumed to be frozen at the start of closure / end of mining, which restricted the inflow of groundwater to the pit lake until the pit lake rises and thaws the pit walls. This is considered reasonable as during the later years of mining, the pit development is limited to within the permafrost below Whale Tail Lake. If the pit walls do not remain frozen or melts seasonally, higher inflows than what is predicted could occur resulting in a shorter pit-filling period.

Considering the assumption of freeze-back in the pit walls, groundwater inflow to the Whale Tail Pit was not predicted to occur until 2030, when the pit lake level rises above the top of permafrost elevation near the pit (approximately 40 masl). When the water elevation in the pit lake rises above the permafrost, the freeze back is assumed to dissipate below the lake level and groundwater inflow to the pit was predicted to resume. The groundwater inflow to the pit lake was predicted to increase from 10 m^3/day in 2030 to approximately 1,160 m^3/day in 2036 as the pit walls progressively become unfrozen and connected to the permeable weathered bedrock. As the pit lake rises further in elevation, the groundwater inflows decrease and eventually the pit lake switches to a groundwater recharge boundary (i.e., the pit lake starts to recharge the sub-permafrost groundwater flow system). These groundwater inflow rates are similar to predictions in the FEIS Addendum and reflect that no changes were made to the shallow bedrock hydraulic conductivity.

The refilling of the Underground is expected to occur over a very short period (i.e. the bottom 500 m will be refilled in the first year). The water level in the Underground is therefore almost immediately higher then the hydraulic heads in bedrock near the Underground, resulting in a small but generally consistent flux of water from the Underground to bedrock. At the end of the reflooding period (2041) the Underground remains a source of groundwater recharge. with a predicted discharge of -10 m^3/day. These flow rates are slightly lower (by 0 to 5 m^3/day) of the predicted groundwater recharge rates predicted in the FEIS Addendum.

Table 4: Predicted Groundwater Inflow and Groundwater Salinity during Reflooding - Base Case Scenario – Whale Tail Pit, Whale Tail Attenuation Pond, North Basin of Whale Tail Lake

Phase	Approximate Time Period	Water Level in Pit (masl)		Whale Tail Pit		Whale Tail Attenuation Pond			Dewatered North Basin of Whale Tail Lake (within the diked area)	
		From	To	Net Groundwater Inflow/Outflow[1] (m^3/day)	TDS Concentration[2] (mg/L)	Groundwater Inflow (m^3/day)	Inflow TDS Concentration (mg/L)[2]	Surface Water Outflow (m^3/day)	Net Groundwater Discharge to Surface[1] (m^3/day)	Inflow TDS Concentration[2] (mg/L)
Flooding	2026	-130	-76	NA	NA	145	30	<5	340	<10
	2027	-76	-39	NA	NA	170	24	<5	340	<10
	2028	-39	3	NA	NA	180	21	<5	345	<10
	2029	3	26	NA	NA	185	19	<5	345	<10
	2030	26	43	10	24	190	18	<5	345	<10
	2031	43	61	60	24	180	17	10	345	<10
	2032	61	73	90	21	170	17	30	345	<10
	2033	73	87	120	19	160	17	45	340	<10
	2034	87	101	130	17	155	17	50	340	<10
	2035	101	111	700	<10	125	25	505	330	<10
	2036	111	124	1160	<10	85	29	940	300	<10
	2037	124	133	910	<10	90	22	740	300	<10
	2038	133	142	360	<10	115	16	315	315	<10
	2039	142	149	-30	NA	70	22	135	370	<10
	2040	149	153.5	-10	NA	0	NA	5	155	<10
	2041	153.5	153.5	0	NA	0	NA	0	-10	<10

Notes:
Pictorial representation of Flow Locations Components shown on Figure 6.
IVR Pit is located in permafrost and was therefore not modelled. Interception of runoff / direct precipitation accounted for in Site Wide Water Balance.
[1] Positive values indicate flow to the pit/pond and negative values indicate flow to bedrock.
[2] TDS concentrations do not account for loading from lakes and Whale Tail Attenuation Pond. TDS from these sources to be accounted for in Site Wide Water Quality analysis.
NA = not applicable; TDS = total dissolved solids; m^3/day = cubic metres per day; mg/L = milligrams per litre; % = percent.

Table 5: Predicted Groundwater Inflow and Groundwater Salinity during Refilling – Base Case Scenario – Underground

Phase	Approximate Time Period	Water Level in Underground (masl)		Underground	
		From	To	Net Groundwater Inflow/Outflow[1] (m^3/day)	TDS Concentration[2] (mg/L)
Flooding	2026	-505	-76	-30	NA
	2027	-76	-39	<-5	NA
	2028	-39	3	<-5	NA
	2029	3	26	<-5	NA
	2030	26	43	<-5	NA
	2031	43	61	<-5	NA
	2032	61	73	<-5	NA
	2033	73	87	-5	NA
	2034	87	101	-10	NA
	2035	101	111	-10	NA
	2036	111	124	-10	NA
	2037	124	133	-10	NA
	2038	133	142	-25	NA
	2039	142	149	-15	NA
	2040	149	152.5	-10	NA
	2041	153	152.5	-10	NA

Notes:
Pictorial representation of Flow Locations Components shown on Figure 6.
[1] Positive values indicate flow to the underground and negative values indicate flow to bedrock.
[2] TDS concentrations do not account for loading from lakes and Whale Tail Attenuation Pond. TDS from these sources to be accounted for in Site Wide Water Quality analysis.
NA = not applicable; TDS = total dissolved solids; m^3/day = cubic metres per day; mg/L = milligrams per litre; % = percent.

5.2 EA Scenario

The Base Case predictions discussed in the preceding section provides the most likely estimates of groundwater inflow quantity and quality for the Expansion Project based on the available hydraulic conductivity data (Section 2 Table 1). Considering the number of tests; however, and in consideration of the sensitivity analysis conducted in the FEIS Addendum, an EA Scenario was developed as part of the FEIS Addendum. This scenario provides a reasonable yet conservative estimate of groundwater inflow such that there is a high level of confidence that the potential effects of the Expansion Project on groundwater inflow quantity and salinity have not been underestimated. Results from the EA Scenario are used in the Site-Wide Water Balance and Water Quality Models for the Expansion Project. Hydraulic conductivity values adopted in the EA Scenario relative to the Base Case are presented in Section 3.0 and take in to account the recent packer testing data collected in December 2018.

5.2.1 Dewatering

Table 6 presents a summary of the predicted discharge to the North Basin of Whale Tail lake during dewatering. The predicted discharge of 1330 m^3/day is within 20 m^3/day of the FEIS Addendum predictions (1350 m^3/day) and no change in TDS concentration was predicted. The minor variation in predicted discharge from the FEIS reflects the small adjustments made to permafrost extent along the margins of Whale Tail Lake.

Table 6: Predicted Groundwater Discharge to North Basin of Whale Tail Lake during Dewatering – EA Scenario

Phase	EA Scenario	
	Groundwater Discharge (m^3/day)	TDS Concentration (mg/L)
Lake Dewatering (Q1-Q3 2019)	1330	80

5.2.2 Mining

Table 7 and Table 8 presents a summary of the updated predicted groundwater flow rates and groundwater TDS concentrations to the mine development areas for the EA Scenario during mining of the open pits and underground. The predictions presented on these tables are conceptually shown on Figure 5 and include: predicted groundwater inflow to Whale Tail Pit, predicted groundwater inflow to the Underground, predicted flow to and from the Whale Tail Attenuation Pond, and predicted discharge to the dewatered North Base of Whale Tail Lake (i.e., the flow of water below the Whale Tail Lake Dike to the dewatered lake bottom). Groundwater inflow to the IVR Pit during mining is not included as the pit is in permafrost (groundwater inflow will be negligible). Some interception of surface water runoff and direct precipitation by the IVR Pit is excepted, but this is not a flow component derived from the groundwater modelling. It is addressed in the Updated Site-Wide Water Balance and Water Quality Model (Golder 2019d).

Whale Tail Open Pit

The predicted quantity and TDS concentration of groundwater inflow into the open pit during mining for the EA Scenario is similar to what was predicted in the Base Case and assumes no freeze-back in the pit walls. For the EA Scenario, the groundwater inflow to the open pit was predicted to increase from 970 m^3/day in 2019 to 1,350 m^3/day in 2025 and the TDS concentration was predicted to decrease from 120 mg/L in 2019 to 10 mg/L in 2025. Groundwater inflow is controlled by the shallow bedrock hydraulic conductivity, which was not modified between the Base Case and EA Scenario due to the high number of tests in this unit and the conservatism used in the Base Case Scenario. The shallow bedrock hydraulic conductivity is also unchanged from the FEIS Addendum; therefore, predicted inflows to the open pit are similar to the predictions in the FEIS Addendum.

Underground

For the EA Scenario, the updated groundwater inflow to the Underground was predicted to increase from 60 m^3/day in 2020 to a maximum of 420 m^3/day in 2023. In the final year of mining, the groundwater inflow decreases slightly to 340 m^3/day. These groundwater inflows are approximately 2 to 3 times higher than the Base Case values for the same period of mining. Predicted TDS concentrations for the EA scenario are 30% higher than the Base Case at the end of mining and reflect more upwelling of deeper more saline groundwater beneath the Underground.

The predicted inflows based on the updated model is approximately 20% lower than the predicted values at the end of mining in the FEIS Addendum (430 m^3/day). The reduction in groundwater inflow reflects the small decrease in hydraulic conductivity in the deep sub-permafrost bedrock due to the additional packer testing data. The predicted TDS concentrations are approximately 2 to 9 % lower than the predicted values in the FEIS Addendum.

Contributions to the inflow to the Whale Tail Pit and the Underground from the Whale Tail Attenuation Pond and the South Basin of Whale Tail Lake were evaluated for the EA Scenario to support the update to the Site-Wide Water Quality Model. TDS concentrations from these sources are accounted for in the Site-wide Water Quality model through a feedback loop. The quantity contributions predicted by the hydrogeological model are presented in Table 7 and Table 8. In 2020, approximately 64% of groundwater inflow to the pit is originating from the Whale Tail Attenuation Pond. The pond represents the major contributor to groundwater inflow to the pit due to its connection to the pit through the permeable shallow bedrock. The contribution from the pond was predicted to increase to 82% at the end of mining. The contribution from the South Basin of Whale Tail Lake is also predicted to increase from 3% in 2021 to 15% at the end of mining in 2025. In the Underground, the source of groundwater inflow is attributed only to water from the deep bedrock flow system.

Table 7: Predicted Groundwater Inflow and Groundwater Quality during Mining - EA Scenario – Whale Tail Pit and Underground

Phase	Time Period	Whale Tail Pit				Underground			
		Groundwater Inflow (m^3/day)[3]	Inflow TDS Concentration (mg/L)[2]	Portion of Inflow from Attenuation Pond (%)	Portion of Inflow from South Basin of Whale Tail Lake (%)	Net Groundwater Inflow (m^3/day)	Inflow TDS Concentration (mg/L)[2]	Portion of Inflow from Attenuation Pond (%)	Portion of Inflow from South Basin of Whale Tail Lake (%)
Mining	August-December 2019[1]	970	120	1%	<1%	NA	NA	NA	NA
	2020	1170	50	64%	<1%	60	4120	<1%	<1%
	2021	1320	30	79%	3%	70	4580	<1%	<1%
	2022	1360	20	81%	9%	250	6230	<1%	<1%
	2023	1360	20	82%	12%	420	7850	<1%	<1%
	2024	1350	10	82%	14%	410	9090	<1%	<1%
	2025	1350	10	82%	15%	340	10180	<1%	<1%

Notes:
Pictorial representation of Flow Locations Components shown on Figure 5.
IVR Pit is located in permafrost and was therefore not modelled. Interception of runoff / direct precipitation accounted for in Site Wide Water Balance.
[1] Mining prior to Q4 2019 is within permafrost and groundwater inflow will be negligible.
[2] TDS concentrations do not account for loading from lakes and Whale Tail Attenuation Pond. TDS from these sources to be accounted for in Site Wide Water Quality analysis.
NA = not applicable; TDS = total dissolved solids; m^3/day = cubic metres per day; mg/L = milligrams per litre; % = percent.

Table 8: Predicted Groundwater Inflow and Groundwater Salinity during Dewatering and Mining - EA Scenario – Whale Tail Attenuation Pond and Whale Tail Lake (North Basin)

Phase	Time Period	Whale Tail Attenuation Pond				North Basin of Whale Tail Lake (within the diked area)[1]		
		Groundwater Inflow (m^3/day)	Inflow TDS Concentration (mg/L)[2]	Portion of Inflow from South Basin of Whale Tail Lake (%)	Pond Outflow (m^3/day)	Net Groundwater Inflow (m^3/day)[3]	TDS Concentration (mg/L)[2]	Portion of Inflow from South Basin of Whale Tail Lake (%)
Mining	August-December 2019	350	110	<1%	180	650	70	39%
	2020	120	170	<1%	860	720	30	85%
	2021	90	160	5%	1050	730	20	98%
	2022	90	140	23%	1090	720	10	99%
	2023	90	110	49%	1090	720	10	99%
	2024	90	90	74%	1090	720	10	>99%
	2025	90	70	94%	1090	720	10	>99%

Notes:

Pictorial representation of Flow Locations Components shown on Figure 5.

IVR Pit is located in permafrost and was therefore not modelled. Interception of runoff / direct precipitation accounted for in Site Wide Water Balance.

[1] Predictions of groundwater inflow to North Basin of Whale Tail lake represents the discharge of groundwater to the lake basin during dewatering and mining. This excludes discharges to the pit and Whale Tail Attenuation Pond, which are within the North Basin of Whale Tail Lake.

[2] TDS concentrations do not account for loading from lakes and Whale Tail Attenuation Pond. TDS from these sources are accounted for in the Site Wide Water Quality model.

NA = not applicable; TDS = total dissolved solids; m3/day = cubic metres per day; mg/L = milligrams per litre; % = percent.

5.2.3 Reflooding of Pits and Underground

Table 9 and Table 10 respectively presents a summary of the predicted groundwater inflow rates and groundwater TDS concentration to the mine development areas for the EA Scenario during reflooding of the pits and underground. The predictions presented in Table 9 and Table 10 include: predicted groundwater inflow to Whale Tail Pit Lake, predicted groundwater flow to the Underground, predicted flow to and from the Whale Tail Attenuation Pond, and predicted discharge to the dewatered North Base of Whale Tail Lake (i.e., the flow of water below the Whale Tail Lake Dike to the dewatered lake bottom surface). Again, it should be noted that TDS concentrations do not account for loading from nearby lakes and the Whale Tail Attenuation Pond. TDS from these sources are taken in to account by a feedback loop in the Site Wide Water Quality model. Groundwater inflow to the IVR Pit during refilling was not included as the pit is in permafrost (groundwater inflow will be negligible).

The predictions presented for the reflooding phase utilize a conceptual filling schedule for the Whale Tail Pit and the Underground, based on initial water balance predictions. Fine tuning of the flooding sequence was conducted after the conceptual filing schedule was developed; however, these adjustments will not have a significant impact on the predicted flow rates and salinity for a given elevation range.

Similar to the Base Case, the pit walls were assumed to be frozen at the start of closure / end of mining, which restricted the inflow of groundwater to the pit lake until the pit lake rises and thaws the pit walls. Considering the assumption of freeze-back in the pit walls, groundwater inflow to the Whale Tail Pit was not predicted to occur until 2030, when the pit lake level rises above the top of permafrost elevation near the pit (approximately 40 masl). When the water elevation in the pit lake rises above the permafrost, the freeze back is assumed to dissipate below the lake level and groundwater inflow to the pit was predicted to resume. The groundwater inflow to the pit lake was predicted to increase from 20 m^3/day in 2030 to approximately 1,170 m^3/day in 2036 as the pit walls progressively become unfrozen and connected to the permeable weathered bedrock. As the pit lake rises further in elevation, the groundwater inflows decrease and eventually the pit lake switches to a groundwater recharge boundary (i.e., the pit lake starts to recharge the sub-permafrost groundwater flow system). These groundwater inflow rates are similar to predictions in the FEIS Addendum and reflect that no changes were made to the shallow bedrock hydraulic conductivity.

At the start of reflooding, a small flux of groundwater inflow (10 m^3/day) is predicted to discharge to the Underground. Over time, as hydraulic gradients near the Underground dissipate, the Underground switches to a groundwater recharge boundary. At the end of the filling period (2041) the Underground remains a source of groundwater recharge (-20 m^3/day) to the sub-permafrost groundwater regime. These predicted inflows are similar to or lower than those predicted in the FEIS Addendum, which ranged from 50 m^3/day inflow at the start of reflooding to -25 m^3/day (positive values indicate flow to the pit/pond; negative values indicate flow to bedrock) discharge at the end of reflooding (0 to 70 % lower than the FEIS values depending on the pit lake elevation).

Table 9: Predicted Groundwater Inflow and Groundwater Salinity during Reflooding - EA Scenario – Whale Tail Pit, Whale Tail Attenuation Pond, North Basin of Whale Tail Lake

Phase	Approximate Time Period	Water Level in Pit (masl)		Whale Tail Pit				Whale Tail Attenuation Pond				North Basin of Whale Tail Lake (within the diked area)		
		From	To	Net Groundwater Inflow/Outflow[1] (m^3/day)	Inflow TDS Concentration [2] (mg/L)	Portion of Inflow from Attenuation Pond (%)	Portion of Inflow from South Basin of Whale Tail Lake (%)	Groundwater Inflow (m^3/day)	Inflow TDS Concentration (mg/L) [2]	Portion of Inflow from South Basin of Whale Tail Lake (%)	Pond Outflow (m^3/day)	Net Groundwater Inflow/Outflow[1] (m^3/day)	TDS Concentration (mg/L) [2]	Portion of Inflow from South Basin of Whale Tail Lake (%)
Flooding	2026	-130	-76	NA	NA	NA	NA	150	35	76%	<5	345	<10	>99%
	2027	-76	-39	NA	NA	NA	NA	170	30	84%	<5	345	<10	>99%
	2028	-39	3	NA	NA	NA	NA	180	25	89%	<5	345	<10	>99%
	2029	3	26	NA	NA	NA	NA	180	25	91%	<5	345	<10	>99%
	2030	26	43	20	24	47%	41%	185	20	93%	<5	345	<10	>99%
	2031	43	61	90	24	47%	41%	170	20	96%	25	345	<10	>99%
	2032	61	73	130	19	44%	50%	160	20	97%	55	340	<10	>99%
	2033	73	87	170	15	46%	53%	150	20	98%	80	340	<10	>99%
	2034	87	101	170	13	50%	50%	145	20	98%	90	335	<10	>99%
	2035	101	111	730	<10	71%	29%	120	25	99%	530	330	<10	>99%
	2036	111	124	1170	<10	81%	19%	85	30	99%	950	300	<10	>99%
	2037	124	133	910	<10	82%	18%	90	20	99%	745	300	<10	>99%
	2038	133	142	360	<10	82%	18%	115	15	99%	315	315	<10	>99%
	2039	142	149	-30	NA	NA	NA	70	20	98%	140	370	<10	>99%
	2040	149	153.5	-10	NA	NA	NA	0	NA	NA	10	155	<10	>99%
	2041	153.5	153.5	0 to -5	NA	NA	NA	0	NA	NA	5	-10	NA	NA

Notes:
Pictorial representation of Flow Locations Components shown on Figure 5.
IVR Pit is located in permafrost and was therefore not modelled. Interception of runoff / direct precipitation accounted for in Site Wide Water Balance.
[1] Positive values indicate flow to the pit/pond and negative values indicate flow to bedrock.
[2] TDS concentrations do not account for loading from lakes and Whale Tail Attenuation Pond. TDS from these sources to be accounted for in Site Wide Water Quality analysis.
NA = not applicable; TDS = total dissolved solids; m^3/day = cubic metres per day; mg/L = milligrams per litre; % = percent.

Table 10: Predicted Groundwater Inflow and Groundwater Salinity during Refilling - EA Scenario – Underground

Phase	Time Period	Water Level in Underground (masl)		Underground			
		From	To	Net Groundwater Inflow/Outflow[1] (m^3/day)	Inflow TDS Concentration[2] (mg/L)	Portion of Inflow from Attenuation Pond (%)	Portion of Inflow from South Basin of Whale Tail Lake (%)
Flooding	2026	-505	-76	10	9800	<1%	<1%
	2027	-76	-39	30	12100	<1%	<1%
	2028	-39	3	20	12700	<1%	<1%
	2029	3	26	10	13200	<1%	<1%
	2030	26	43	10	13600	<1%	<1%
	2031	43	61	5	13800	<1%	<1%
	2032	61	73	5	14000	<1%	<1%
	2033	73	87	-5	NA	<1%	<1%
	2034	87	101	-5	NA	NA	NA
	2035	101	111	-10	NA	NA	NA
	2036	111	124	-15	NA	NA	NA
	2037	124	133	-20	NA	NA	NA
	2038	133	142	-35	NA	NA	NA
	2039	142	149	-25	NA	NA	NA
	2040	149	152.5	-25	NA	NA	NA
	2041	153	152.5	-20	NA	NA	NA

Notes:
Pictorial representation of Flow Locations Components shown on Figure 5.
IVR Pit is located in permafrost and was therefore not modelled. Interception of runoff / direct precipitation accounted for in Site Wide Water Balance.
[1] Positive values indicate flow to the underground and negative values indicate flow to bedrock.
[2] TDS concentrations do not account for loading from lakes and Whale Tail Attenuation Pond. TDS from these sources to be accounted for in Site Wide Water Quality analysis.
NA = not applicable; TDS = total dissolved solids; m^3/day = cubic metres per day; mg/L = milligrams per litre; % = percent.

6.0 MODEL PREDICTIONS - FULLY FLOODED OPEN PITS

The following section provides updated groundwater model predictions for the IVR Pit and Whale Tail pit following flooding of the mine development and North Basin of Whale Tail Lake. This data may be used in the future to support updated hydrodynamic modelling of the pit lakes, if required, to evaluate long-term pit lake water quality. Updated predictions are provided for the pit lakes to evaluate if the changes made to the model (estimated hydraulic conductivity of the deep sub-permafrost bedrock) affect previous predictions in the FEIS addendum.

The model predictions were provided for the EA Scenario, and utilizes the same model as the dewatering, mining and reflooding phases. As discussed in the modelling report of the FEIS Addendum (Golder 2018), density-dependent transport of solutes was not considered for the assessment of groundwater conditions as the buoyancy effects were considered negligible in relation to the regional hydraulic head gradient.

Although the two pit lakes are connected following filling, the groundwater flow conditions surrounding the pit lakes are initially very different. As presented in the FEIS Addendum, the Whale Tail Pit lake is predicted by thermal analysis to be connected to the deep sub-permafrost groundwater 11 years into filling and for the permafrost below the pit lake to fully degrade over 50 years. The IVR Pit lake is predicted to be within permafrost during mining and flooding and the permafrost below the pit lake to fully degrade over 1000 years.

6.1 Whale Tail Pit

Table 11 presents predicted outflow from the Whale Tail Pit lake following full reflooding of the pit. The pit lake was predicted to recharge the regional sub-permafrost groundwater system from the first year after full flooding and over the following 300 years. Over time, as the groundwater flow system near the flooded mine workings re-equilibrates and the shallow bedrock re-saturates and/or re-pressurizes, the amount of recharge to the sub-permafrost flow system decreases from 3.3 m^3/day in Year 1 to 1.4 m^3/day after 200 years. The long-term predicted pit lake discharge to the sub-permafrost groundwater flow system is predicted to be 1.2 m^3/day, which is 20% less than the long-term pit lake discharge in the FEIS Addendum (1.5 m^3/day) as a result of the slight reduction in deep bedrock hydraulic conductivity. No significant groundwater inflows to the pit lake were predicted.

Table 11: Predicted Whale Tail Pit Lake outflow following Flooding of the Mine Development

Time (Years after Reflooding)	Pit Lake Outflow to Groundwater (m^3/day)
1	3.3
50	2.1
100	1.8
200	1.4
300	1.2

Considering the hydraulic conductivity assigned to the deep bedrock for the FEIS scenario (3×10^{-9} m/s) based on packer testing data, the approximate area of the pit (0.5 km^2), and the measured pre-development downward hydraulic gradient at the Westbay Well (0.008 m/m), the calculated steady-state discharge from the pit is 1 m^3/day. This value is in good agreement with the predicted value from the model after 300 years (1.2 m^3/day).

6.2 IVR Pit

The IVR Pit is in an area of regional permafrost; therefore, during mining and flooding, groundwater inflows to the pit were assumed to be negligible. Following flooding and the formation of the IVR Pit lake, the permafrost is expected to melt and connect the IVR Pit lake to the sub-permafrost groundwater flow system.

In consideration of the long timeline associated with the melting of the permafrost, the fully flooded analysis of the IVR Pit was limited to a prediction of the long-term steady-state groundwater flow environment that would develop near the pit lake following the full melting of permafrost below the pit footprint. Model results confirmed the assumption that the IVR Pit lake would act as recharge boundary to the regional groundwater system once the permafrost layer beneath the lake melts. The long-term predicted discharge from the IVR Pit lake to the sub-permafrost groundwater flow system was approximately 0.5 m^3/day, which is 30% lower than the predicted discharge in the FEIS Addendum (0.7 m^3/day) as result of the slight reduction in the deep bedrock hydraulic conductivity.

Because the IVR Pit Lake and Whale Pit lakes will be maintained at the same elevation and directly connected following reflooding of the pit lakes and the North Basin of Whale Tail Lake, lateral movement between the two pit lakes is expected to be negligible.

7.0 SUMMARY AND CONCLUSIONS

Field data collected in November and December 2018, and the updated thermal analysis, supports the conceptual and numerical models developed for the FEIS Addendum for the Expansion Project. This work supports that:

- A downward vertical hydraulic gradient is present in the area of Whale Tail pit. This indicates that the prediction of the Whale Tail Pit and IVR Pit lakes being a groundwater recharge boundary is reasonable.
- That a closed talik is present in the northern portion of Whale Tail Lake and open talik is present in the southern portion of Whale Tail Lake.
- The hydraulic conductivity adopted in the Expansion Project FEIS for the EA Scenario was conservative for the prediction of groundwater effects. Subsequent packer testing indicates the deep sub-permafrost bedrock is lower than what was assumed in the FEIS, which resulted in updated predicted inflows and TDS quality in the underground being lower than what was previously predicted in the FEIS.

Considering the supplemental data collection and thermal modelling, updated predictions of groundwater inflow quantity and TDS were provided for two scenarios:

- Base Case – Most likely estimate of hydrogeological parameters based on hydraulic testing. These predictions represent the best estimate of groundwater inflow and groundwater salinity based on the measured data. The Base Case is used to understand what groundwater conditions are likely to be but is not carried forward in the Site Wide Water Balance Model as it is not conservative for the assessment of environmental effects.

- EA Scenario – Hydraulic conductivity values adopted in the EA Scenario consider the available field measurements of hydraulic conductivity and sensitivity analyses that consider uncertainties in these parameters. The EA Scenario is designed to be a reasonable, yet more conservative, assessment of potential groundwater inflow quantity and quantity such that the potential effects of the Expansion Project on groundwater flow can be assessed. Results from the EA Scenario are used in the Water Balance and Water Quality model for the Expansion Project.

Mining

Groundwater inflow predictions during mining conservatively assumes that no freeze-back will occur in the pit walls. This assumption was adopted for Whale Tail Pit because during the first few years of mining, the pit will be both widened and deepened, resulting in the continual exposure of unfrozen bedrock. During the later years of mining; however, the pit development will be entirely within the permafrost and significant freeze back in the pit walls is considered possible and has been observed at Meadowbank. Although not simulated, if freeze back does occur as is the case at Meadowbank, actual groundwater inflow to the pit could be substantively lower than the predicted values.

For the Base Case Scenario, groundwater inflow to the Whale Tail Pit is predicted to increase from an average of 970 m^3/day in 2019 to 1,340 m^3/day in 2022 to 2025 and the TDS concentration of the inflow is predicted to decrease from 120 mg/L in 2019 to 10 mg/L in 2025[2]. The groundwater inflow to the Underground is predicted to increase from 20 m^3/day in 2020 to 180 m^3/day in 2023 and then decrease to 130 m^3/day in 2025. The predicted TDS concentration in the Underground inflow is predicted to increase from 3,880 mg/L in 2020 to 7,760 mg/L near the end of mining.

For the EA Scenario, groundwater inflow to the Whale Tail Pit is predicted to increase from an average of 970 m^3/day in 2019 to 1,350 m^3/day in 2025 and the TDS concentration in the inflow is predicted to decrease from 120 mg/L in Q4 of 2019 to 10 mg/L in 2025[1]. The groundwater inflow to the Underground is predicted to increase from 60 m^3/day in 2020 to 4200 m^3/day in 2023 and then decrease to 340 m^3/day in 2025. The predicted TDS concentration in the Underground inflow is predicted to increase from 4,120 mg/L in 2020 to 10,180 mg/l in 2025.

The groundwater inflow to the Whale Tail Pit is similar for both the EA and Base Case Scenarios as a conservatively high estimate of hydraulic conductivity in the shallow weathered bedrock was adopted for both scenarios. Because the shallow bedrock is unchanged from the values used in the FEIS Addendum modelling, the predicted inflows to Whale Tail pit is unchanged from the FEIS addendum.

For the deeper bedrock, where a smaller data set were available, a conservatively higher hydraulic conductivity was assumed in the EA Scenario relative to the Base Case (See Table 1). The predicted groundwater inflows and predicted TDS concentration to the Underground are therefore higher in the EA Scenario. The higher TDS is associated with increased predicted upwelling of deeper more saline groundwater beneath the Underground.

[2] TDS predictions only account for TDS loading from groundwater and not loading from the Attenuation Pond and South Whale Tail lake. Loading from these sources was accounted for in the Site Wide Water Quality model.

Relative to the FEIS Addendum dataset, additional testing has been conducted that indicates that the deeper bedrock hydraulic conductivity is lower than was assumed in the FEIS addendum; predicted inflows to the Underground in this updated assessment are therefore 13 to 20% lower at the end of mining relative to the FEIS addendum modelling for the Base Case and EA Scenario respectively. TDS concentrations in the inflow to the underground were similar to the FEIS addendum modelling for the Base Case and between 2 to 9% lower than the FEIS addendum modelling for the EA Scenario.

Flooding

Following mining, reflooding of Whale Tail Pit and Underground will begin dissipating the steep hydraulic gradients that developed during mining around the mine workings. By the end of refilling, both the Whale Tail Pit Lake and the Underground are predicted to be sources of groundwater recharge.

During pit-reflooding, the Whale Tail Pit walls were assumed to be frozen at the start of closure (end of mining), which restricts the inflow of groundwater to the pit lake until the pit lake water level rises and thaws the pit walls. This is considered reasonable as during the later years of mining, the pit development is limited to within the permafrost below Whale Tail Lake. If the pit walls do not remain frozen or melt seasonally, higher inflows than predicted could occur resulting in a shorter pit-filling period. Freeze-back was not assumed during mining to conservatively predict the potential inflows to the pit (groundwater inflows would substantively lower with freeze-back); freeze-back was assumed for reflooding to conservatively predict the length of time it could take to refill Whale Tail Pit (a shorter filling schedule would be predicted without freeze-back).

For the Base Case, the groundwater inflow to the pit lake is predicted to increase from 10 m^3/day in 2030 to approximately 1160 m^3/day in 2036 as the pit walls progressively thaw and connect to the permeable weathered bedrock. Similar flow rates are predicted for the EA Scenario, where groundwater inflow to the pit lake is predicted to increase from 20 m^3/day in 2030 to approximately 1,170 m^3/day in 2036 as the pit walls progressively thaw and connect to the permeable weathered bedrock. As the pit lake water level rises further in elevation, the groundwater inflows for both scenarios decrease and eventually the pit lake becomes a groundwater recharge boundary (i.e., the pit lake starts to recharge the regional groundwater flow system). Because the shallow bedrock is unchanged from the values used in the FEIS Addendum modelling, the predicted inflows to Whale Tail pit is unchanged from the FEIS addendum.

The reflooding of the Underground is expected to occur over a very short period (i.e. the bottom 500 m will be reflooded in the first year). At the start of reflooding, a small flux of groundwater inflow is predicted to discharge to the Underground. Over time, as hydraulic gradients near the Underground dissipate, the Underground switches to a groundwater recharge boundary. At the end of the flooding, the Underground is predicted to remain a source of groundwater recharge for both the Base Case and EA Scenarios. These predicted inflows are similar to or lower than those predicted in the FEIS Addendum (0 to 70 % lower than the FEIS values depending on the pit lake elevation).

Fully Flooded Mine

Although the Whale Tail Pit Lake and IVR Pit are connected following full flooding, the groundwater flow conditions surrounding the pit lakes are initially very different. The Whale Tail Pit lake is predicted by thermal analysis to be connected to the deep sub-permafrost groundwater flow system during refilling, and the permafrost below the pit lake to fully degrade over 50 years. The IVR Pit lake is predicted to be within permafrost during refilling and the permafrost below the pit lake to fully degrade over 1000 years. The long-term groundwater recharge from the Whale Tail and IVR Pit lakes is predicted to be minimal; 1.5 m^3/day and 0.5 m^3/day, respectively.

Because the IVR Pit Lake and Whale Pit lakes will be maintained at the same elevation and directly connected following reflooding of the pit lakes and the North Basin of Whale Tail Lake, lateral movement between the two pit lakes is expected to be negligible.

8.0 CLOSURE

We trust this document satisfies you current requirements. If you have any questions or require further assistance, please do not hesitate to contact the undersigned.

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https://golderassociates.sharepoint.com/sites/102527/technical work/02_hydrog-modelling/01_report/rev0/18108905-291-tm-updated-hydrogmodel_rev0.docx

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