TMI_908-GW(2)-01

Unique Identifier	Agency IR#	Annex	Agency Group Stakeholder	[illegible]	
TMI_908-GW(2)-01	GW(2)-01	1	CEA Agency	**Reference to EIS Guidelines:**	Part 2, Sections 9.1.1 and 9.1.2
				Reference to EIS / Appendix	n/a
				Cross-reference to Round 1 IRs	TMI_72-GW(1)-09, TMI_74-GW(1)-11, TMI_75-GW(1)-12, TMI_83-GW(1)-20, TMI_115-SW(1)-29

Context and Rationale

The groundwater model has a number of deficiencies, listed below, which raise uncertainties with the modelling exercise, the outputs of the model, and the effects assessments that incorporate those model outputs. These concerns are also tied with concerns raised in other IRs related to characterization of geochemistry on the site (see CEAA 31, 24 to 26 and 33), cover options for TSF and WRSAs (see CEAA 9 to 11 and 30), and TSF base and liner (see CEAA 14 and 29).

1) **Recharge for Overburden Aquifer**

Recharge was based on very limited field observations which were conducted during unusually dry years (Appendix M of the revised EIS, Section 3.2 and Figure 9). Recharge rates have important implications for modelling the quantity of seepage.

2) **Recharge for Waste Rock Storage Area (WRSA)**

As discussed in IR# GW(2)-02, low values were used for infiltration though the WRSA. Using these low values for infiltration will cause the groundwater model to output a lower amount of seepage.

3) **Hydraulic Conductivity Measurements**

The hydraulic conductivity measurements as described in Section 5.6.2.2 of the revised EIS do not allow for proper characterization of the overburden layers or the bedrock. In addition, the number of measurements, particularly in key geologic units such as weathered bedrock and the different types of overburden appear to be limited.

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Furthermore, the data in Table 5.6.2.2-1 of the same section, presenting the hydraulic conductivity values (K) of the overburden layers, indicates either an error in testing or misinterpretation of units

4) Thickness of the Overburden

It is stated in Appendix M, Section 5.1.1 of the revised EIS that "Model layer 3 corresponds to the weathered Shallow Bedrock unit. This zone was assumed to have a uniform thickness of 7 m". A rationale for this assumption was not provided in the revised EIS.

The thickness of the model layers, particularly the upper layers, will have an effect on seepage flow estimates. These layers are also likely to have the greatest potential for interaction with surface water bodies.

5) [illegible]

There is uncertainty with the assumed porosity of 1% for shallow bedrock in the groundwater model (See IR# GW(2)-03)

6) Particle Tracking

A particle tracking for the open pit zone of influence was not provided in the EIS and it is unclear how the clay layers that may exist between the tailings storage facility (TSF) and the pit lake may influence the rate of capture of seepage (See IR# GW(2)-04)

7) Sensitivity Analyses

A sensitivity analysis for the recharge and infiltration from WRSA is not provided in the revised EIS. A sensitivity

analysis for the hydraulic conductivity of key geologic units such as the overburden and weathered bedrock also needs to be factored into the groundwater model.

Due to the above deficiencies with the groundwater model, the Agency has uncertainty with the seepage assessment conducted for the Project. The seepage calculations should be based on an updated groundwater model that factors the design of the cover for the TSF and WRSA, TSF base and liner, and concerns raised in other IRs regarding characterization of geochemistry of mine rock and ore.

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				This is important for the Agency to understand as seepage from the Project can lead to contamination of surrounding waterbodies and affect the fish and fish habitat.
				Specific Question/Request [illegible] A. Provide an updated groundwater model that addresses all seven of the concerns raised in the “Context and Rationale” for this IR. Incorporate the findings from the IRs CEAA 26, 30, 38, and 34 in the revision of the model. B. Provide the potential range in seepage volumes (e.g. based on sensitivity analyses) from the TSF and WRSA. Also provide travel times for this seepage to various receptor locations. Include in this assessment, an explanation of how seepage volumes would be expected to flow through various geologic layers. C. Determine the capture efficiency of the seepage collection system, and assess the efficiency based on different ditch depths, and whether efficiency can be improved through the use of additional mitigation measures such as pump-back wells. D. Reassess the changes in water quality from seepage emanating from the TSF and WRSA and an updated groundwater model, taking the responses from Questions A to C into consideration. E. Revise the effects to fish and fish habitat taking the response from Question D into consideration. F. Describe additional mitigation measures to prevent adverse effects to fish and fish habitat, if necessary, taking into consideration the response to Question E. G. Characterize residual effects, if any, after the mitigation measures describes in Question F have been implemented. H. Update the follow-up program for potential effects to fish and fish habitat, including objectives and any monitoring measures that will be implemented to verify the predictions of effects and evaluate the effectiveness of the proposed mitigation measures. If follow-up is not required, provide a rationale. I. Incorporate the findings from this IR into the revision of seepage water quality assessment requested in IR# MW(2)-06.
				Response(s) A. This response has been superseded by TMI_951-GW(2)-01B Part A B. This response has been superseded by TMI_951-GW(2)-01B Part B C. This response has been superseded by TMI_951-GW(2)-01B Part C D. This response has been superseded by TMI_951-GW(2)-01B Part D E. This response has been superseded by TMI_951-GW(2)-01B Part E F. This response has been superseded by TMI_951-GW(2)-01B Part F

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				G. This response has been superseded by TMI_951-GW(2)-01B Part G H. This response has been superseded by TMI_951-GW(2)-01B Part H I. This response has been superseded by TMI_951-GW(2)-01B Part I
				Agency Comment on Draft Response: **No comment on Draft Response**
				Specific Response to the Agency Comment: **None required**
				Final Response: A. This response has been superseded by TMI_951-GW(2)-01B Part A B. This response has been superseded by TMI_951-GW(2)-01B Part B C. This response has been superseded by TMI_951-GW(2)-01B Part C D. This response has been superseded by TMI_951-GW(2)-01B Part D E. This response has been superseded by TMI_951-GW(2)-01B Part E F. This response has been superseded by TMI_951-GW(2)-01B Part F G. This response has been superseded by TMI_951-GW(2)-01B Part G H. This response has been superseded by TMI_951-GW(2)-01B Part H I. This response has been superseded by TMI_951-GW(2)-01B Part I

TMI_909-GW(2)-02

Unique Identifier	Agency IR #	Annex	Agency Group or Stakeholder	[illegible]	
TMI_909-GW(2)-02	GW(2)-02	1	CEA Agency	**Reference to EIS Guidelines:**	Part 2, Sections 9.1.2 and 10
				Reference to EIS / Appendix	Section 2.5.3.2 Table 3.15-1 Appendix M
				Cross-reference to Round 1 IRs	n/a

Context and Rationale

Insufficient information is provided to substantiate the effects from the uncapped and capped waste rock storage area (WRSA) options provided in the revised EIS.

1) **Uncapped WRSA**
   - Appendix M, Section 5.3.5 mentions that only 100- 200 mm/yr of infiltration was assumed for the uncapped WRSA scenario. Considering the high porosity of mine rock (See IR# GW(2)-03) that is uncapped, infiltration rates should be much higher than the assumed rate of 100-200 mm/yr, since most precipitation is capable of infiltration. Seepage will be proportional to infiltration once the waste rock mass is sufficiently saturated to induce flow.

2) **Capped WRSA**
   - There is insufficient information to evaluate the degree of acid rock drainage (ARD) that can be generated after capping the WRSA, and the resulting effects upon surface water quality. Assumptions about ARD generation need to be carefully substantiated. In addition to geochemical factors, the ability of the cap to reduce infiltration needs to be substantiated based on the design and materials that will be used for construction (See IR# MW(2)-04).
   - An infiltration rate of 30 mm/yr was assumed for the capped WRSA scenario, based on an assumed hydraulic conductivity of 1x10-9 m/s for the cap. This value of 1x10-9 m/s is unlikely for disturbed clays that are likely to be mixed with silts and sands and that are not proposed to be compacted (See IR# MW(2)-04).
   - Calculations of the length of time for waste rock to become saturated to induce flow are important as they will inform the timing of effects, and inform the design of Follow-Up Monitoring Programs to verify predictions associated with the WRSA.

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- Table 3.15-1 of the revised EIS states "Further technical information received from EcoMetrix has identified that a greater percentage of the waste rock may be PAG". It is unclear whether this has been incorporated into the water quality assessment, as this information can have important implications for the WRSA and the ARD calculations.
- It is important for the Agency to understand this issue as acidic water from the mine rock can enter the surface water bodies through seepage and affect fish and fish habitat.

Specific Question/ Request / Information Request:

A. Reassess the rate of infiltration assumed for uncapped WRSA scenario with consideration of high porosity of mine rock.

B. Substantiate the ability of the cap on WRSA to reduce ARD by providing an analysis of the conceptual design and materials that will be used for construction (see IR# MW(2)-04)

C. Provide detailed assumptions and calculations, with supporting data and rationale, regarding the rate of ARD generation, infiltration rates, and the amount of time for the WRSA to become sufficiently saturated such that seepage can begin to flow. Use data and information from similar caps that have been implemented in Canada in areas with similar climate and geography to support the assumptions and conclusions about the performance of the cap.

D. Describe how the assessment conducted for ARD has taken into consideration that a greater percentage of the mine rock may be PAG. Provide an updated assessment, if necessary.

E. Update the water quality assessment taking the responses from Questions A to D into consideration.

F. Describe the effects on fish and fish habitat, if any, taking the response from Question E into consideration.

G. Describe mitigation measures to prevent adverse effects to fish and fish habitat, if necessary;

H. Characterize residual effects, if any, after the mitigation measures have been implemented;

I. Update the follow-up program for potential effects to fish and fish habitat, including objectives and any monitoring measures that will be implemented to verify the predictions of effects and evaluate the effectiveness of the proposed mitigation measures. If follow-up is not required, provide a rationale.

J. Incorporate the findings of this IR, if applicable, into the revision of seepage water quality assessment requested in IR# MW(2)-06, and revision of groundwater model requested in IR# GW(2)-01.

Response:

Part A.

To clarify the assumed infiltration rate of 100-200 mm/year represents a conservative rate of infiltration from the uncapped WRSA into the underlying overburden and bedrock and not the infiltration rate into the WRSA itself. As the waste rock in the WRSA will have a large amount of connected void space, it is agreed that most of the precipitation

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				will infiltrate into the WRSA. The infiltration into the WRSA will either infiltrate into the underlying overburden and bedrock, or drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches. The amount of infiltration that either enters the underlying overburden and bedrock, or travels laterally to the perimeter of the WRSA depend on the relative hydraulic residences (where $c = \frac{flow\ length\ L}{hydraulic\ conductivity\ K}$). The hydraulic resistances are calculated as follows: • <u>Infiltration that enters underlying bedrock and overburden</u>: Based on the data collected from 2012–2014, the hydraulic conductivity of the shallow bedrock is 1×10^{-6} m/s (Section 5.6.5 of the revised EIS [April 2018]). Assuming 1 m of vertical saturated infiltration into the underlying bedrock, the hydraulic resistance is: $c = \frac{1\ m}{1\times10^{-6}\ m/s} = 1 \times 10^{6}\ s.$ • <u>Infiltration that travels laterally to the perimeter of WRSA</u>: The hydraulic conductivity of the waste rock is likely to be in the range of 1×10^{-2} m/s, given the large amount of connected void space in a WRSA. Freeze and Cherry (1979) give the hydraulic conductivity of a gravel in the range of 1×10^{-3} m/s to greater than 1×10^{-1} m/s. Assuming less than 300 m of lateral travel to the perimeter of the WRSA, the hydraulic resistance is: $c = \frac{300\ m}{1\times10^{-2}\ m/s} = 3 \times 10^{4}\ s.$ The hydraulic resistance for infiltration that enters the underlying overburden and bedrock is about two (2) orders of magnitude higher than the hydraulic resistance for the infiltration that travels laterally to the perimeter of the WRSA. Therefore, most of the infiltration into the WRSA is likely to travel laterally to the perimeter of the WRSA to be captured by the perimeter ditches. Vertical infiltration into the underlying bedrock and overburden would only become significant if there was a potential for water to pond (e.g., being trapped in a topographic basin). As the WRSA is located on a topographic high next to the open pit, the potential for ponding and the build-up of a significant water table within the WRSA is very limited. Consequently, the infiltration rate of 100-200 mm/year into the underlying overburden and bedrock is conservative and no changes are required to the modelled infiltration rate for the uncapped WRSA. The uncapped WRSA scenario will only exist during operations and for a short period of time during closure when a low-permeability dry cover will be constructed over the WSRA as described in Section 3.16.8. As detailed in the response to TMI_911-GW(2)-04), groundwater seepage from the uncapped WRSA during operations will be captured by the open pit, and will not reach the receiving environment. During closure, when the low permeability cover is being placed over the WRSA, the water level in the open pit will be low, and the groundwater levels will be in the early stages of recovery. Water seeping from the uncapped WRSA during the closure phase, will continue to be captured by the groundwater drawdown and will report to the open pit. Therefore, regardless of the assumed infiltration rate into the uncapped WRSA, and the rate of seepage from the uncapped WRSA, none of the seepage from the uncapped WRSA will reach the receiving environment and therefore

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				changing the rate of infiltration into the uncapped WRSA would not have an effect on the predicted surface water quality predictions (the Water Addendum) and thus fish and fish habitat (the Fish Addendum). Part B. The purpose of the multi-layer, low permeability dry cover over the WRSA is not to reduce ARD, but rather to reduce the rate of infiltration into the WRSA and thus the rate of seepage from the WRSA into the underlying overburden and bedrock. As described in Section 3.5.1 of the revised EIS (April 2018), waste rock from the mining operations will be placed in either the WRSA, or in the mined-out areas of the open pit. In the initial stages of mining, the only location suitable for the placement of waste rock is the WRSA. Therefore, much of the material present in the WRSA at closure will have been there since the early stages of mining activities (i.e., for longer than 10 years). Additionally, as stated in Section 5.4.3.4 of the revised EIS (April 2018), 93% of the material present in the WRSA is assumed to be PAG. Given that the rate of ARD onset for the Goliath Gold Project has conservatively been predicted to be 2 years (see TMI_904-MW(2)-08), the analysis of seepage from the WRSA is based upon the assumption that ARD has occurred, and will continue to occur, within the WRSA. The multi-layer, low permeability dry cover over the WRSA is intended to reduce the rate of infiltration into the WRSA and thus the rate of seepage from the WRSA into the underlying overburden and bedrock. The design and construction of low permeability covers on waste rock and landfills are well understood and covers that can achieve significant infiltration reductions (e.g., >95%) are well documented. The exact design of the cap for the WRSA will be determined during detailed design, but would likely include a compacted clay layer, which can reliably achieve hydraulic conductivities of less than 1×10-9 m/s (Hauser et al., 2001). If sufficient clay of suitable quality are not available on site, Treasury Metals will obtain the necessary materials from other sources to ensure the cap over the WSRA achieves the designed performance. Part C. Rate of ARD Generation To clarify, in the revised EIS (April 2018) the seepage from the capped WRSA was assumed to contain metals that had leached from the material in the WRSA. This assumption was carried forward and considered in the surface water quality predictions also relied on in determining the effects to fish and fish habitat. It was assumed that the capped WRSA would be ARD/ML given that the geochemical predictions indicated that the rate of ARD onset would be as early as 2 years, the material in the WRSA will have been in place for longer than 10 years, and that 93% of the material in the WRSA would be PAG. The cap on the WRSA is not intended to reduce ARD, only infiltration and subsequently the rate of seepage from the capped WRSA. Infiltration Rates

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				The exact design of multi-layer, low permeability dry cover over the WRSA will be determined during detailed design. However, it would likely include a compacted clay layer, which can reliably achieve hydraulic conductivities of less than 1×10-9 m/s (Hauser et al., 2001). Thus, the assumed infiltration rate for the capped WRSA of 30 mm/yr is consistent with the hydraulic conductivities that can be achieved (i.e., less than 1×10^{-9} m/s). <u>Time for WRSA to become saturated</u> The material in the WRSA will have large void spaces and high hydraulic conductivity (likely greater than 1×10^{-2} m/s). Because of this, and that it is topographically elevated relative to the open pit, it is highly unlikely that the WRSA will become saturated. Although the WRSA will not become saturated, it has been assumed that seepage from the uncapped WRSA will occur through operations and closure, and will continue to occur, at a diminished rate, following placement of the cap. As, described in Part A, the underlying overburden and bedrock has been conservatively estimated to have 100-200 mm/year of infiltration; however, with the placement of the multi layer, low permeability cap, only 30 mm/year of infiltration into the WRSA is predicted, and thus infiltration into the underlying overburden and bedrock would reduce to 30 mm/year. <u>Part D.</u> The assessment conducted for ARD in the revised EIS (April 2018) indicated that 93% of the material in the WRSA is PAG (Section 5.4.3.4 "Material Characterization for ARD/ML Potential"). To clarify, Table 3.15.1 of the revised EIS (April 2018) describes refinements from the initial Project description provided in December 2012 to initiate the Environmental Assessment for the Goliath Gold Project to the Project description used as the basis of the original EIS submitted in April 2015. Therefore, "a greater percentage of waste rock may be PAG" mentioned in Table 3.15-1 refers to the indication that 93% of the waste rock would be PAG and this was incorporated in the original EIS (April 2015) and in the revised EIS (April 2018). The 93% PAG indication was also relied on in the revised EIS (April 2018) for the surface water quality prediction as well as the effects of the Project on fish and fish habitat. Given that the revised EIS (April 2018) relied on the consideration that "a greater percentage of mine rock may be PAG", no reassessment is required. <u>Part E.</u> As described in the responses to Parts A through D, there are no changes expected in the WRSA seepage rates and qualities from that used in the revised EIS (April 2018). While the responses to Parts A through D do not lead to the requirement of updating the surface water quality model, the surface water quality assessment has been updated as part of the Round 2 process, to reflect other required changes and refinements. The information presented in this Round 2 response, has been incorporated into Section W6.3 and W6.5 of the Water Addendum. The Water Addendum presents the updated water quality assessment that consolidates all of the identified Round 2 changes and concerns including those changes to groundwater and mine waste that would affect surface water quality.

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				<u>Part F.</u> There will be no changes to the effects predicted to fish and fish habitat arising from the issues and concerns raised in Parts A through D of this information request because there are no changes to surface water quality arising from the issues and concerns raised in Parts A through D of this information request. <u>Part G.</u> As described in the responses to Parts A through F, there will be no changes to the effects predicted to fish and fish habitat arising from issues and concerns raised in this information request, therefore there are no additional mitigation measures required regarding seepage emanating from the WRSA. <u>Part H.</u> There are no changes to the characterization of residual adverse effects from those presented in the revised EIS (April 2018), as there are no changes to the predicted effects, or the required mitigation measures from Round 2 issues or concerns regarding seepage emanating from the WRSA. <u>Part I.</u> No specific modifications to the Follow-Up Program were identified as a result of changes in seepage emanating from the WRSA. An updated Follow-Up Program has been provided in support of the Round 2 process as the Goliath Gold Follow Up Program Addendum. <u>Part J.</u> The information presented in this Round 2 response, has been incorporated into Sections W6 (Quantity and Fate of Seepage from the Project) and W7 (Quality of Seepage from the Project) of the Goliath Gold Water Addendum. The Water Addendum presents the updated water quality assessment that consolidates all of the identified Round 2 changes and concerns including those changes to groundwater and mine waste that would affect surface water quality. References: Hauser, Victor L., Barron L. Weand, and Marc D. Gill. "Natural covers for landfills and buried waste." *Journal of Environmental Engineering* 127.9 (2001): 768-775.

Unique Identifier	Agency IR #	Annex	Agency Group / Stakeholder	Cross-Reference to Technical/ Information Request Response
				<u>Agency Comment on Draft Response</u> <u>A & B.</u> Please refer to the sufficiency review for TMI_951-GW(2)-01B in regards to seepage from the uncapped and capped WRSA. *<u>A. Uncapped WRSA:</u> The infiltration rate into the uncapped WRSA is presented as being conservative because they are estimating more infiltration than they feel warranted into the weathered bedrock and overburden. This does not take into account that it is the overall amount of infiltration into the WRSA that will generate the seepage that can affect surface water quality in the Pit Lake, which includes radial flow outward from the base of the WRSA, rather than just the component that passes through the bedrock and overburden. The overall amount of recharge into the WRSA, estimated by the Proponent to be 100-200 mm/year are low as compared to estimates made by proponents of other mines that feature waste rock piles.* *Confirm the assumptions for the volume of infiltration/ recharge into the WRSA.* *<u>B. Capped WRSA:</u> The response makes a non-conservative assumption that the multi-layer cap over the WRSA will achieve a hydraulic conductivity of less than $1X10^{-9}$ m/s. Although this might be achievable in the context of a landfill (the citation provided is in relation to landfills), this is not achievable on a sustained basis for the cap. A number of physical processes will degrade the performance of the cap; these include: settlement and slumping of the waste rock pile, freeze-thaw cycles, and the drying out of the clay that will irreversibly increase the hydraulic conductivity through the clay (regardless of the re-wetting of the clay). Thus, the infiltration of water and subsequent release of seepage are underestimated.* *Please clarify, for the capped WRSA scenario, the potential effects of higher seepage volumes from the ARD-generating WRSA on surface water quality.* <u>C & D.</u> In regards to the infiltration rates, please refer to the sufficiency review for TMI_951-GW(2)-01B in regards to seepage from the uncapped and capped WRSA. Regarding saturation of the WRSA, the issue is not whether or not the entire WRSA will become saturated, rather it is the time required for saturated flow to commence from the base of the WRSA. Since the waste rock is initially dry, and the waste rock volume is large, it may take many years for any seepage to commence flowing. Understanding the timing of that flow will be important to understanding when a monitoring program is likely to begin detecting the effects of seepage flow. **Clarify the timing of the seepage flow from the WRSA and linkage with the monitoring program.** E – J.

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				Specific Response [illegible] the Agency [illegible] Parts A To clarify the assumed infiltration rate of 100-200 mm/year represents a conservative rate of infiltration from the uncapped WRSA into the underlying overburden and bedrock and not the infiltration rate into the WRSA itself. As discussed in the draft response, infiltration into the uncapped WRSA would either infiltrate into the underlying overburden and bedrock or would drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches. The amount of infiltration that either enters the underlying overburden and bedrock, or travels laterally to the perimeter of the WRSA depend on the relative hydraulic residences (where $c = \frac{flow\ length\ L}{hydraulic\ conductivity\ K}$). The draft response also states that because the waste rock in the WRSA will have a large amount of connected void space, most of the precipitation that falls on the WRSA will infiltrate into the WRSA. Since 1969, annual rates of precipitation in the Dryden area have ranged from 883 to 392 mm/year, with an average value of about 658 mm/year. If 100–200 mm/year is assumed to infiltrate into the underlying overburden and bedrock, then 458–558 mm/year of infiltration into the WRSA would drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches. As discussed in both the December 18, 2018, and the January 10, 2019 meetings with the Agency and their technical reviewers, the infiltration into the WRSA that would drain laterally through the WRSA to the perimeter of the WRSA would be captured by the perimeter ditches and directed to segregated runoff collection pond (collection pond #3 on Figure 3.0.1A of the revised EIS [April 2018]). The water within the collection pond would be monitored, and if required, a caustic material would be added to the pond to treat the water prior to its incorporation into the overall water management system. It is important to remember that the uncapped WRSA scenario will only exist during operations and for a short period of time during closure when a low-permeability, multi-layer, dry cover will be constructed over the WSRA as described in Section 3.16.8. As detailed in the response to TMI_911-GW(2)-04), seepage from the uncapped WRSA to the underlying overburden and bedrock (groundwater) during operations will be captured by the open pit, and will not reach the receiving environment. During closure, when the low permeability cover is being placed over the WRSA, the water level in the open pit will be low, and the groundwater levels will be in the early stages of recovery. Water seeping from the uncapped WRSA into the underlying overburden and bedrock during the closure phase, will continue to be captured by the groundwater drawdown and will report to the open pit. The infiltration into the WRSA that would drain laterally through the WRSA to the perimeter of the WRSA would be captured by the perimeter ditches and directed to segregated runoff collection pond where it would be tested, and if required treated before being directed to the open pit. Part B

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				As discussed in both the December 18, 2018, and the January 10, 2019 meetings with the Agency and their technical reviewers, there were concerns raised regarding the ability of Treasury Metals to construct the multi-layer, low-permeability dry cover over the WRSA in a manner that can achieve the desired hydraulic conductivities to reduce infiltrations into the capped WRSA over the long-term. This has been addressed in the following two ways: I. Provision of additional details regarding the conceptual design and materials to be used for multi-layer, low-permeability dry cover over the WRSA, including a discussion of factors that can lead to increased permeability of the cap; and II. Inclusion of a sensitivity analysis in the Goliath Gold project Water Addendum that includes fully 50% infiltration rate through the cap over the WRSA. **Part I — WRSA Cap Details** Conceptual Design The development of a closure cover design generally follows the diagram below where the process is ideally started prior to construction as part of the MENDM regulation and is finalized ideally a minimum of 1 year prior to start of closure cover construction after the mine is no longer in operation. Many revisions follow the initial closure cover design as part of the Closure Plan revision as outlined in the MENDM regulations.

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				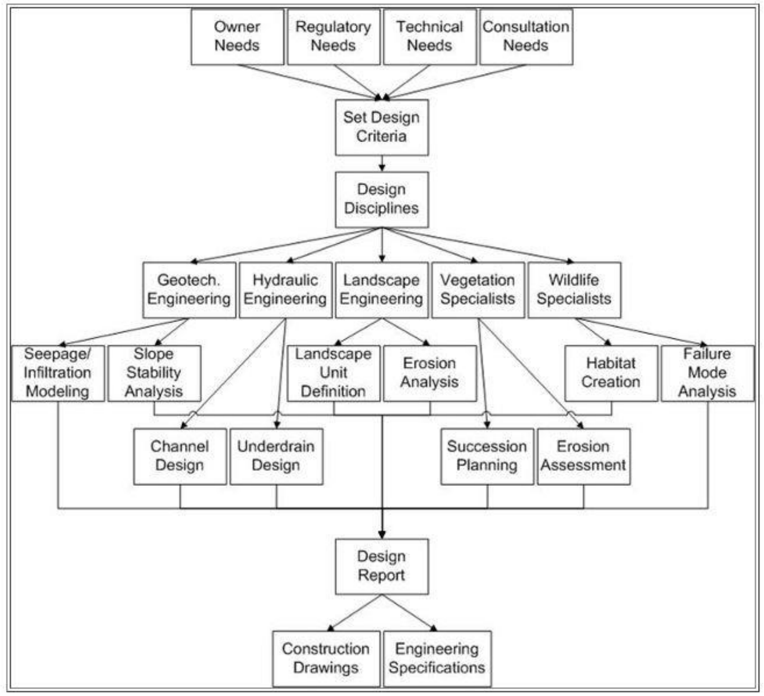 Diagram provided by Edumine online course: Covers for Mine Geowaste Facilities – 2: Design and Performance Analysis. At the request of the Agency's reviewer, a conceptual draft WRSA closure cover has been provided below. The WRSA closure cover has been designed to inhibit the failure modes described above and ensure encapsulation of the waste within the WRSA for an industry accepted functional lifetime using best available technologies. Every WRSA closure cover generally consists of the basic layers, from top to bottom are vegetation and rocky soil (1), water storage/frost protection layer (2), a hydraulic barrier (3) and finally material to separate the waste from the cover and prevent migration of the cover components into the waste (4). Layer 4 is a function of preventing migration only and is therefore not discussed further at this time. Layer 1 The WRSA closure cover design includes a top layer (1) of rocky soil and vegetation. The depth is minimal, 20 cm maximum, and usually consist of topsoil mixed with granular. The topsoil provides the vegetation with nutrients while the granular provides some erosion protection.

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				(continued below)

Layer 2

The water storage or frost protection layer (2) provides both water storage and growth medium for use by the vegetation as well as a frost protection layer for the deeper layers of the closure cover. In some cases, with a layer of thick soil and abundant vegetation, an evapotranspirative (ET) cover may be sufficient to limit infiltration. The purpose of the ET cover is that the water seeps into the soil and is stored in voids of the soil pending evapotranspiration by the vegetation.

The below diagram is a visual representation of three (3) different ET covers;

- Conventional ET cover with soil over the waste,
- ET cover with a lower permeability layer beneath the soil, likely a layer amended with bentonite or similar,
- ET cover with a lower permeability layer beneath the soil, in this case likely a compacted low permeability soil.

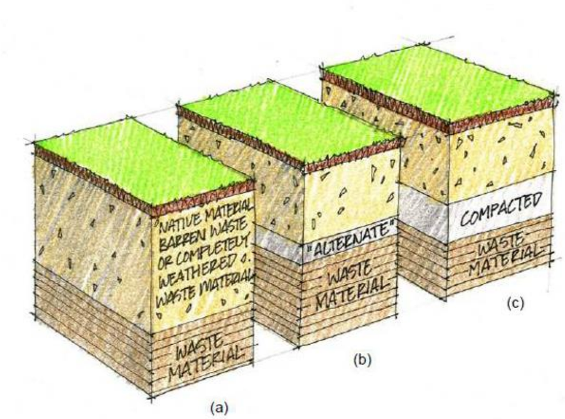

Diagram provided from O'Kane Consultants (ed.). (2012). Cold Regions Cover System Design Technical Guidance Document (MEND 1.61.5c). Prepared for MEND (Mine Environment Neutral Drainage) and funded by AANDC (Aboriginal Affairs and Northern Development Canada). Retrieved from: https://mvlwb.com/sites/default/files/mvlwb/documents/Cold%20Regions%20Cover%20System%20Design%20Technical%20Guidance%20Document%20(MEND%20Report%201.16.5c).pdf.

It is at this layer as well that should the top layer of the cover crack, the ET layer is of sufficient depth and material that to some degree is self healing and ensure the cover remains functional.

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				The ET layer has a major impact on the overall effective hydraulic conductivity of the closure cover as the ET layer in times outside of high intensity precipitation events, can effectively store all the water infiltration so no water makes it further into the cover. Layer 3 Sites, like the Goliath Gold Project, that experience highly variable climatic conditions could see the high -intensity precipitation overwhelm the storage capacity of the ET cover material which would cause infiltration. ET covers with this hydraulic barrier are generally called enhanced store-and-release covers (ESR cover). To minimize migration of the infiltration into the waste, as part of the closure cover design, a hydraulic barrier has been included in the design. There are several materials that the hydraulic barrier could be constructed from including compacted low permeability soil, biosolids and sludges amended for specific use, a geosynthetic clay liner, a layer of waste amended with bentonite and any combination of the previous materials listed. Generally, the design of the hydraulic barrier is designed to meet a design hydraulic conductivity of 10^{-9} m/s to inhibit infiltration This is industry standard practice and best available technology. In the case of the Goliath Gold Project ESR cover a number of different materials are being considered that would deliver a design hydraulic conductivity of 10^{-9} m/s. Each material option has design positives and negatives, most glaringly being the functional life of a compacted clay liner, which could see the hydraulic conductivity of the Layer 3 component drop over the age of the ESR cover to 10^{-6} m/s approximately. However, the overall effective hydraulic conductivity of the ESR cover would be designed to accommodate a drop in the Layer 3 hydraulic conductivity. Regardless of the material chosen for the final closure cover design, the final ESR cover will be designed to meet the functional needs and regulatory requirements of the site. Although it is expected that the various failure mechanisms could result in an increase in the overall hydraulic conductivity, ultimately only a small portion of the precipitation falling on the WRSA would infiltrate through the degraded closure cover. To address potential uncertainties associated with the long-term viability and performance of the WRSA closure cover, the Goliath Gold Project Water Addendum includes a sensitivity run, with an extremely high rate of infiltration through the WRSA cover and into the WRSA (i.e., 50% of annual precipitation is assumed to infiltrate into the WRSA as agreed to during January 10, 2019 technical meeting with the Agency, and their technical reviews from the provincial and federal governments including NRCan and ECCC). The sensitivity analysis did not consider the overall effective hydraulic conductivity of an ESR cover such as the description above as further detailed design would have to be conducted prior to the inputs to the analysis being valid. Failure Mechanisms The failure modes considered in the waste rock storage area (WRSA) included more than just slope failure however given the intrinsic nature of design and the minimal level of detail included in the draft design, slope failure was considered the greatest risk and therefore the only identified failure mode within the IR#2 responses and discussed within the revised EIS.

Unique Identifier	Agency IR #	Annex	Agency Group Stakeholder	[illegible] Reference [illegible] Request [illegible] Response
				Further to this, regarding the possible failure of the closure cover, there are several failure mechanisms and mitigations that can be done to enhance the design and extend the function life of a closure cover as discussed in the following table.

Failure / Force	Issue / Failure mechanism	Mitigation
Wind	Dust generation Wind erosion	- Vegetated soil cover - Upper Layer of rocky soil that provides wind breaks for vegetation and coverage should the vegetation die off and need a chance to grow back.
Freezing	Freeze thaw forces causing changes in permeability and decrease of functional life	- Use of geosynthetic clay liner or equivalent to prevent effect of compacted clay liner issues with freeze thaw - Frost protection layer (also doubles the function as moisture storage for vegetation layer)
Rain	Runoff causing erosion and increased infiltration	- Design for seepage and drainage appropriately including diversion channels, rocky upper layers, vigorous vegetation and swales that can impede water induced erosion - Terraces to decrease final slope grade and length
Heat	Evaporation causing cracking of upper layer	- Vegetated soil cover with frost protection/water storage layer
Fire	Vegetation removed causing erosion	- Erosion resistant cover with rocky soil to protect against erosion even without vegetation
Waste Deformation	Crack of top cover layers causing water ponding and increased infiltration	- Cover design allows for some self healing properties - Design for seepage and drainage appropriately including natural swales and water shedding designs
Gravity-Induced Creep	Slope creep pulls the cover downslope	- Bunding and terraces to decrease final slope grade and length to decrease strain

Unique Identifier	Agency IR #	Annex	Agency Group Stakeholder	[illegible]

Vegetation	Roots penetrate cover and increase infiltration	- Herbicide layer well underneath frost protection/ water storage layer - Thicker water storage layer - Geo or hydraulic barrier layer
Animals	Burrowing beneath rock cover, increase infiltration	- Thicker (1 m +) water storage layer, safe for animals to burrow
Humans	Assuming a 1,000 + year functional life, may become location for habitation, therefore may dig into the cover, increasing infiltration	- Thicker (1 m +) water storage layer, safe for minimal human disturbance

Part II — Sensitivity Analysis

In addition, a separate sensitivity run has been included in the Goliath Gold Project Water Addendum to address uncertainties associated with the assumed hydraulic conductivity of 1×10^{-9} m/s that models the effects on surface water quality due to an increased rate of infiltration into the capped WRSA during post-closure. Specifically, the total infiltration into the WRSA for this sensitivity run will be increased to 50% of the precipitation (i.e., 329 mm/year), 75 mm/year of which is assumed to infiltrate into the underlying overburden and bedrock, and the remaining 254 mm/year would drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches and ultimately report to the open pit. The surface water quality modelling continues to indicate that surface water quality will be largely unchanged as a result of the Project, with resulting water quality being the same as, or slightly improved from the existing condition for most parameters. The results of the surface water quality modelling with an increased infiltrations rate through the capped WRSA resulted in one (1) additional predicted residual adverse effects in Thunder Lake (residual adverse effects represent situations where the predicted concentrations for a parameter are higher than existing conditions). In the situation where the water quality is predicted to the higher than existing condition, the resulting water quality remains below the PWQO for the protection of aquatic life.

Parts C and D

An expanded discussion regarding the infiltrations rates to the uncapped and capped WRSA are provided in the specific responses to parts A and B, respectively. As discussed in the draft response to Part A, infiltration into the WRSA is far more likely to drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches, than it is to infiltrate into the underlying overburden and bedrock.

The uncapped WRSA will be constructed progressively over a period of one (1) to two (2) years and exposed to precipitation throughout that timeframe. Because the waste rock in the WRSA will have a large amount of connected void space, most of the precipitation that falls on the WRSA will infiltrate into the WRSA. Therefore, only material placed since the last precipitation event should be dry. Additionally, the WRSA will be relatively small during the early stages of construction, and infiltration into the WRSA will rapidly travel to the edge of the WSRA to be collected by the perimeter ditches. This lateral seepage to the toe of the WRSA during the early stages of construction is expected to

Unique Identifier	Agency IR #	Annex	Agency Group Stakeholder	Proponent Reference to Information Request Response
				occur within hours of a precipitation event. For this reason, monitoring of the water collected in the segregated pond from the perimeter ditches around the WRSA would commence at the beginning of the WRSA construction. As discussed in both the December 18, 2018, and the January 10, 2019 meetings with the Agency and their technical reviewers, the infiltration into the WRSA that would drain laterally through the WRSA to the perimeter of the WRSA would be captured by the perimeter ditches and directed to segregated runoff collection pond (collection pond #3 on Figure 3.0.1A of the revised EIS [April 2018]). The water within the collection pond would be monitored, and if required, caustic material would be added to the pond to treat the water prior to its incorporation into the overall water management system. The monitoring of this pond would start at the beginning of operations, at the start of the construction on the WRSA. During closure, a multi-layer, low permeability dry cover will be placed over the WRSA. The purpose of this dry cover is to reduce the rate of infiltration into the WRSA and thus the rate of seepage from the WRSA (both laterally to the edge of the WRSA and into the underlying overburden and bedrock). Since most of the material present in the uncapped WRSA at closure will have been there since the early stages of mining activities (i.e., for longer than 10 years), and will have been exposed to infiltrations into the WRSA for a period of more than 10 years, the material in the WRSA at closure is not expected to be dry, and already in a condition when saturation flow from the WRSA is occurring. A portion of the infiltration into the capped WRSA that would continue to drain laterally through the WRSA to the perimeter of the WRSA and would continue to be captured by the perimeter ditches and directed to a segregated runoff collection pond where it would be monitored before being directed to the open pit. Because monitoring of seepage from the WRSA collected in the perimeter ditches and directed to a segregated pond would commence during the beginning of the construction of the WRSA, this monitoring data will provide information on when the seepage from the base of the WRSA starts to occur, as well as providing an indication of when the effects of ARD affected seepage from the WRSA reaches the perimeter ditches.
				Final Response: Part A. To clarify the assumed infiltration rate of 100-200 mm/year represents a conservative rate of infiltration from the uncapped WRSA into the underlying overburden and bedrock and not the infiltration rate into the WRSA itself. As the waste rock in the WRSA will have a large amount of connected void space, it is agreed that most of the precipitation will infiltrate into the WRSA. The infiltration into the WRSA will either infiltrate into the underlying overburden and bedrock, or drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches. The amount of infiltration that either enters the underlying overburden and bedrock, or travels laterally to the perimeter of the WRSA depend on the relative hydraulic residences (where $c = \frac{flow\ length\ L}{hydraulic\ conductivity\ K}$). The hydraulic resistances are calculated as follows: • Infiltration that enters underlying bedrock and overburden: Based on the data collected from 2012–2014, the hydraulic conductivity of the shallow bedrock is 1×10^{-6} m/s (Section 5.6.5 of the revised EIS [April 2018]).

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				Assuming 1 m of vertical saturated infiltration into the underlying bedrock, the hydraulic resistance is: $c = \frac{1\,m}{1 \times 10^{-6}\,m/s} = 1 \times 10^{6}\,s.$ • Infiltration that travels laterally to the perimeter of WRSA: The hydraulic conductivity of the waste rock is likely to be in the range of 1×10^{-2} m/s, given the large amount of connected void space in a WRSA. Freeze and Cherry (1979) give the hydraulic conductivity of a gravel in the range of 1×10^{-3} m/s to greater than 1×10^{-1} m/s. Assuming less than 300 m of lateral travel to the perimeter of the WRSA, the hydraulic resistance is: $c = \frac{300\,m}{1 \times 10^{-2}\,m/s} = 3 \times 10^{4}\,s.$ The hydraulic resistance for infiltration that enters the underlying overburden and bedrock is about two (2) orders of magnitude higher than the hydraulic resistance for the infiltration that travels laterally to the perimeter of the WRSA. Therefore, most of the infiltration into the WRSA is likely to travel laterally to the perimeter of the WRSA to be captured by the perimeter ditches. Vertical infiltration into the underlying bedrock and overburden would only become significant if there was a potential for water to pond (e.g., being trapped in a topographic basin). As the WRSA is located on a topographic high next to the open pit, the potential for ponding and the build-up of a significant water table within the WRSA is very limited. Consequently, the infiltration rate of 100-200 mm/year into the underlying overburden and bedrock is conservative in our opinion and no changes are required to the modelled infiltration rate for the uncapped WRSA. The waste rock in the WRSA will have a large amount of connected void space. As a result, most of the precipitation will infiltrate into the WRSA. Given the annual rates of precipitation in the Dryden area (1969–2017) have ranged from 883 to 392 mm/year, with an average value of about 658 mm/year, and 100–200 mm/year is assumed to infiltrate into the underlying overburden and bedrock, then 458–558 mm/year of infiltration into the WRSA would drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches. As discussed in both the December 18, 2018, and the January 10, 2019 meetings with the Agency and their technical reviewers, the infiltration into the WRSA that would drain laterally through the WRSA to the perimeter of the WRSA would be captured by the perimeter ditches and directed to segregated runoff collection pond (collection pond #3 on Figure 3.0.1A of the revised EIS [April 2018]). The water within the collection pond would be monitored, and if required, the pond would be treated (e.g., lime addition) prior to its incorporation into the overall water management system. It is important to remember that the uncapped WRSA scenario will only exist during operations and for a short period of time during closure when a low-permeability, multi-layer, dry cover will be constructed over the WSRA as described in Section 3.16.8. As detailed in the response to TMI_911-GW(2)-04), seepage from the uncapped WRSA during operations will be captured by the drawdown created by dewatering and would enter the open pit. The seepage from the WRSA that drains laterally to the perimeter of the WRSA would be captured by the perimeter ditches and directed to segregated runoff collection pond where it would be monitored, and if required lime would be added prior to the incorporation of the seepage from the WRSA into the overall water management system.

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				During closure, when the low permeability cover is being placed over the WRSA, the water level in the open pit will be low, and the groundwater levels will be in the early stages of recovery. Water seeping from the uncapped WRSA into the underlying overburden and bedrock during the closure phase, will continue to be captured by the groundwater drawdown and will report to the open pit. The infiltration into the WRSA that would drain laterally through the WRSA to the perimeter of the WRSA would continue to be captured by the perimeter ditches and directed to segregated runoff collection pond where it would be tested, and if required treated before being directed to the open pit. Therefore, regardless of the assumed infiltration rate into the uncapped WRSA or the rate of seepage from the uncapped WRSA into the underlying overburden and bedrock, none of the seepage from the uncapped WRSA will be allowed to directly reach the receiving environment. Therefore, changing the rate of infiltration into the uncapped WRSA, or the rate of infiltration from the uncapped WRSA into the underlying overburden and bedrock would not have an effect on the predicted surface water quality predictions during the period when the WRSA is uncapped (the Water Addendum), and thus the predicted effects to fish and fish habitat (the Fish Addendum) would not be affected. Part B. The purpose of the multi-layer, low permeability dry cover over the WRSA is not to reduce ARD, but rather to reduce the rate of infiltration into the WRSA and thus the rate of seepage from the WRSA into the underlying overburden and bedrock. As described in Section 3.5.1 of the revised EIS (April 2018), waste rock from the mining operations will be placed in either the WRSA, or in the mined-out areas of the open pit. In the initial stages of mining, the only location suitable for the placement of waste rock is the WRSA. Therefore, much of the material present in the WRSA at closure will have been there since the early stages of mining activities (i.e., for longer than 10 years). Additionally, as stated in Section 5.4.3.4 of the revised EIS (April 2018), 93% of the material present in the WRSA is assumed to be PAG. Given that the rate of ARD onset for the Goliath Gold Project has conservatively been predicted to be 2 years (see TMI_904-MW(2)-08), the analysis of seepage from the WRSA is based upon the assumption that ARD has occurred, and will continue to occur, within the WRSA. The multi-layer, low permeability dry cover over the WRSA is intended to reduce the rate of infiltration into the WRSA and thus the rate of seepage from the WRSA into the underlying overburden and bedrock. The design and construction of low permeability covers on waste rock and landfills are well understood and covers that can achieve significant infiltration reductions (e.g., >95%) are well documented. The exact design of the cap for the WRSA will be determined during detailed design, but would likely include a compacted clay layer, which can reliably achieve hydraulic conductivities of less than 1×10^{-9} m/s (Hauser et al., 2001). If sufficient clay of suitable quality are not available on site, Treasury Metals will obtain the necessary materials from other sources to ensure the cap over the WSRA achieves the designed performance. Part B As discussed in both the December 18, 2018, and the January 10, 2019 meetings with the Agency and their technical reviewers, there were concerns raised regarding the ability of Treasury Metals to construct the multi-layer, low-

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				permeability dry cover over the WRSA in a manner that can achieve the desired hydraulic conductivities to reduce infiltrations into the capped WRSA over the long-term. This has been addressed in the following two ways: I. Provision of additional details regarding the conceptual design and materials to be used for multi-layer, low-permeability dry cover over the WRSA, including a discussion of factors that can lead to increased permeability of the cap; and II. Inclusion of a sensitivity analysis in the Goliath Gold project Water Addendum that includes fully 50% infiltration rate through the cap over the WRSA. **<u>Part I — WRSA Cap Details</u>** <u>Conceptual Design</u> The development of a closure cover design generally follows the diagram below where the process is ideally started prior to construction as part of the MENDM regulation and is finalized ideally a minimum of 1 year prior to start of closure cover construction after the mine is no longer in operation. Many revisions follow the initial closure cover design as part of the Closure Plan revision as outlined in the MENDM regulations.

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				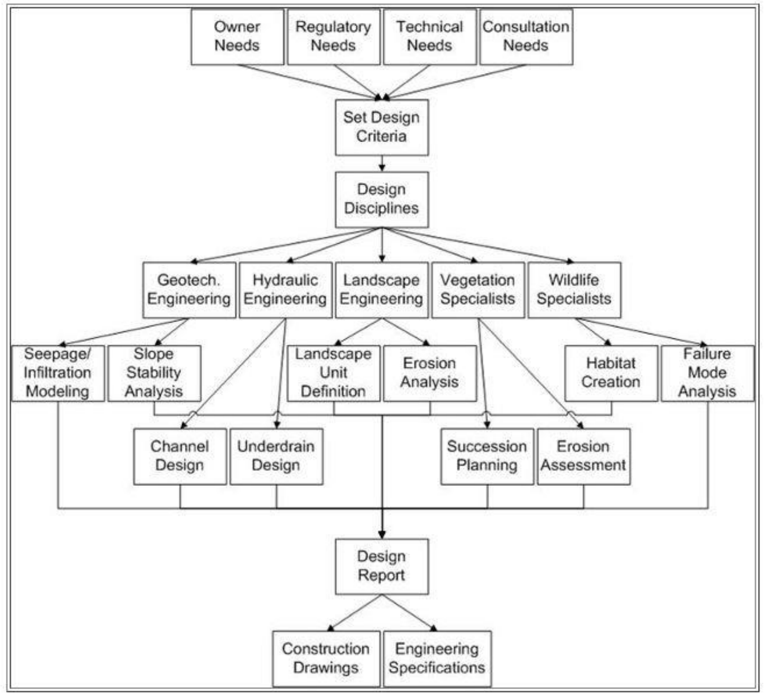 Diagram provided by Edumine online course: Covers for Mine Geowaste Facilities – 2: Design and Performance Analysis. At the request of the Agency's reviewer, a conceptual draft WRSA closure cover has been provided below. The WRSA closure cover has been designed to inhibit the failure modes described above and ensure encapsulation of the waste within the WRSA for an industry accepted functional lifetime using best available technologies. Every WRSA closure cover generally consists of the basic layers, from top to bottom are vegetation and rocky soil (1), water storage/frost protection layer (2), a hydraulic barrier (3) and finally material to separate the waste from the cover and prevent migration of the cover components into the waste (4). Layer 4 is a function of preventing migration only and is therefore not discussed further at this time. <u>Layer 1</u> The WRSA closure cover design includes a top layer (1) of rocky soil and vegetation. The depth is minimal, 20 cm maximum, and usually consist of topsoil mixed with granular. The topsoil provides the vegetation with nutrients while the granular provides some erosion protection.

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				Layer 2 (see below)

Layer 2

The water storage or frost protection layer (2) provides both water storage and growth medium for use by the vegetation as well as a frost protection layer for the deeper layers of the closure cover. In some cases, with a layer of thick soil and abundant vegetation, an evapotranspirative (ET) cover may be sufficient to limit infiltration. The purpose of the ET cover is that the water seeps into the soil and is stored in voids of the soil pending evapotranspiration by the vegetation.

The below diagram is a visual representation of three (3) different ET covers;

- Conventional ET cover with soil over the waste,
- ET cover with a lower permeability layer beneath the soil, likely a layer amended with bentonite or similar,
- ET cover with a lower permeability layer beneath the soil, in this case likely a compacted low permeability soil.

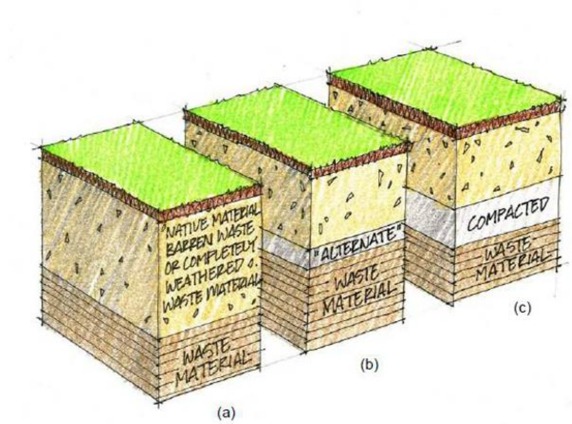

Diagram provided from O'Kane Consultants (ed.). (2012). Cold Regions Cover System Design Technical Guidance Document (MEND 1.61.5c). Prepared for MEND (Mine Environment Neutral Drainage) and funded by AANDC (Aboriginal Affairs and Northern Development Canada). Retrieved from: https://mvlwb.com/sites/default/files/mvlwb/documents/Cold%20Regions%20Cover%20System%20Design%20Technical%20Guidance%20Document%20(MEND%20Report%201.16.5c).pdf.

It is at this layer as well that should the top layer of the cover crack, the ET layer is of sufficient depth and material that to some degree is self healing and ensure the cover remains functional.

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				The ET layer has a major impact on the overall effective hydraulic conductivity of the closure cover as the ET layer in times outside of high intensity precipitation events, can effectively store all the water infiltration so no water makes it further into the cover. <u>Layer 3</u> Sites, like the Goliath Gold Project, that experience highly variable climatic conditions could see the high -intensity precipitation overwhelm the storage capacity of the ET cover material which would cause infiltration. ET covers with this hydraulic barrier are generally called enhanced store-and-release covers (ESR cover). To minimize migration of the infiltration into the waste, as part of the closure cover design, a hydraulic barrier has been included in the design. There are several materials that the hydraulic barrier could be constructed from including compacted low permeability soil, biosolids and sludges amended for specific use, a geosynthetic clay liner, a layer of waste amended with bentonite and any combination of the previous materials listed. Generally, the design of the hydraulic barrier is designed to meet a design hydraulic conductivity of 10^{-9} m/s to inhibit infiltration This is industry standard practice and best available technology. In the case of the Goliath Gold Project ESR cover a number of different materials are being considered that would deliver a design hydraulic conductivity of 10^{-9} m/s. Each material option has design positives and negatives, most glaringly being the functional life of a compacted clay liner, which could see the hydraulic conductivity of the Layer 3 component drop over the age of the ESR cover to 10^{-6} m/s approximately. However, the overall effective hydraulic conductivity of the ESR cover would be designed to accommodate a drop in the Layer 3 hydraulic conductivity. Regardless of the material chosen for the final closure cover design, the final ESR cover will be designed to meet the functional needs and regulatory requirements of the site. Although it is expected that the various failure mechanisms could result in an increase in the overall hydraulic conductivity, ultimately only a small portion of the precipitation falling on the WRSA would infiltrate through the degraded closure cover. To address potential uncertainties associated with the long-term viability and performance of the WRSA closure cover, the Goliath Gold Project Water Addendum includes a sensitivity run, with an extremely high rate of infiltration through the WRSA cover and into the WRSA (i.e. 50% of annual precipitation is assumed to infiltrate into the WRSA as agreed to during January 10, 2019 technical meeting with the Agency, and their technical reviews from the provincial and federal governments including NRCan and ECCC). The sensitivity analysis did not consider the overall effective hydraulic conductivity of an ESR cover such as the description above as further detailed design would have to be conducted prior to the inputs to the analysis being valid. <u>Failure Mechanisms</u> The failure modes considered in the waste rock storage area (WRSA) included more than just slope failure however given the intrinsic nature of design and the minimal level of detail included in the draft design, slope failure was considered the greatest risk and therefore the only identified failure mode within the IR#2 responses and discussed within the revised EIS.

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				Further to this, regarding the possible failure of the closure cover, there are several failure mechanisms and mitigations that can be done to enhance the design and extend the function life of a closure cover as discussed in the following table.

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Humans	Assuming a 1,000 + year functional life, may become location for habitation, therefore may dig into the cover, increasing infiltration	- Thicker (1 m +) water storage layer, safe for minimal human disturbance

Part II — Sensitivity Analysis

In addition, a separate sensitivity run has been included in the Goliath Gold Project Water Addendum to address uncertainties associated with the assumed hydraulic conductivity of 1×10^{-9} m/s that that models the effects on surface water quality due to an increased rate of infiltration into the capped WRSA during post-closure. Specifically, the total infiltration into the WRSA for this sensitivity run will be increased to 50% of the precipitation (i.e., 329 mm/year), 75 mm/year of which is assumed to infiltrate into the underlying overburden and bedrock, and the remaining 254 mm/year would drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches and ultimately report to the open pit. The surface water quality modelling continues to indicate that surface water quality will be largely unchanged as a result of the Project, with resulting water quality being the same as, or slightly improved from the existing condition for most parameters. The results of the surface water quality modelling with an increased infiltrations rate through the capped WRSA resulted in one (1) additional predicted residual adverse effects in Thunder Lake (residual adverse effects represent situations where the predicted concentrations for a parameter are higher than existing conditions). In the situation where the water quality is predicted to the higher than existing condition, the resulting water quality remains below the PWQO for the protection of aquatic life.

Part C.

Rate of ARD Generation

To clarify, in the revised EIS (April 2018) the seepage from the capped WRSA was assumed to contain metals that had leached from the material in the WRSA. This assumption was carried forward and considered in the surface water quality predictions also relied on in determining the effects to fish and fish habitat. It was assumed that the capped WRSA would be ARD/ML given that the geochemical predictions indicated that the rate of ARD onset would be as early as 2 years, the material in the WRSA will have been in place for longer than 10 years, and that 93% of the material in the WRSA would be PAG. The cap on the WRSA is not intended to reduce ARD, only infiltration and subsequently the rate of seepage from the capped WRSA.

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				<u>Infiltration Rates</u> The exact design of multi-layer, low permeability dry cover over the WRSA will be determined during detailed design. However, it would likely include a compacted clay layer, which can reliably achieve hydraulic conductivities of less than 1×10^{-9} m/s (Hauser et al., 2001). Thus, the assumed infiltration rate for the capped WRSA of 30 mm/year is consistent with the hydraulic conductivities that can be achieved (i.e., less than 1×10^{-9} m/s). As discussed in both the December 18, 2018, and the January 10, 2019 meetings with the Agency and their technical reviewers, there are measures that Treasury Metals could implement to help minimize the potential for settlement and slumping of the waste rock pile to adversely affect the final dry cover over the WRSA. An example would be the progressive excavation of overburden from the open pit areas so that non-organic material could be progressively placed over the completed area of the WRSA. This would help reduce the amount of settling expected following closure and would provide a relatively smooth foundation for the placement of the multi-layer, low-permeability dry cover during closure, or the late stages of operations. To help understand the implications of increased infiltration through into the capped WRSA, a separate sensitivity run has been included in the Goliath Gold Project Water Addendum that models the effects on surface water quality due to an increased rate of infiltration into the capped WRSA during post-closure. Specifically, the total infiltration into the WRSA for this sensitivity run will be increased to 50% of the precipitation (i.e., 329 mm/year), 75 mm/year of which is assumed to infiltrate into the underlying overburden and bedrock, and the remaining 254 mm/year would drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches and ultimately report to the open pit. The surface water quality modelling continues to indicate that surface water quality will be largely unchanged as a result of the Project, with resulting water quality being the same as, or slightly improved from the existing condition for most parameters. The results of the surface water quality modelling with an increased infiltrations rate through the capped WRSA resulted in one (1) additional predicted residual adverse effects in Thunder Lake (residual adverse effects represent situations where the predicted concentrations for a parameter are higher than existing conditions). In the situation where the water quality is predicted to the higher than existing condition, the resulting water quality remains below the PWQO for the protection of aquatic life. <u>Time for WRSA to become saturated</u> The uncapped WRSA will be constructed progressively over a period of one (1) to two (2) years and exposed to precipitation throughout that timeframe. Because the waste rock in the WRSA will have a large amount of connected void space, most of the precipitation that falls on the WRSA will infiltrate into the WRSA. Therefore, only material placed since the last precipitation event should be dry. Additionally, the WRSA will be relatively small during the early stages of construction, and infiltration into the WRSA will rapidly travel to the edge of the WSRA to be collected by the perimeter ditches. This lateral seepage to the toe of the WRSA during the early stages of construction is expected to occur within hours of a precipitation event. For this reason, monitoring of the water collected in the segregated pond from the perimeter ditches around the WRSA would commence at the beginning of the WRSA construction.

Unique Identifier	Agency IR #	Annex	Agency Group Stakeholder	Cross Reference / Response
				During closure, a multi-layer, low permeability dry cover will be placed over the WRSA. The purpose of this dry cover is to reduce the rate of infiltration into the WRSA and thus the rate of seepage from the WRSA (both laterally to the edge of the WRSA and into the underlying overburden and bedrock). Since most of the material present in the uncapped WRSA at closure will have been there since the early stages of mining activities (i.e., for longer than 10 years), and will have been exposed to infiltrations into the WRSA for a period of more than 10 years, the material in the WRSA at closure is not expected to be dry, and already in a condition where saturation flow from the WRSA is occurring. A portion of the infiltration into the capped WRSA that would continue to drain laterally through the WRSA to the perimeter of the WRSA and would continue to be captured by the perimeter ditches and directed to a segregated runoff collection pond where it would be monitored before being directed to the open pit. Because monitoring of seepage from the WRSA collected in the perimeter ditches and directed to a segregated pond would commence during the beginning of the construction of the WRSA, this monitoring data will provide information on when the seepage from the base of the WRSA starts to occur, as well as providing an indication of when the effects of ARD affected seepage from the WRSA reaches the perimeter ditches. <u>Part D.</u> The assessment conducted for ARD in the revised EIS (April 2018) indicated that 93% of the material in the WRSA is PAG (Section 5.4.3.4 "Material Characterization for ARD/ML Potential"). To clarify, Table 3.15.1 of the revised EIS (April 2018) describes refinements from the initial Project description provided in December 2012 to initiate the Environmental Assessment for the Goliath Gold Project to the Project description used as the basis of the original EIS submitted in April 2015. Therefore, "a greater percentage of waste rock may be PAG" mentioned in Table 3.15-1 refers to the indication that 93% of the waste rock would be PAG and this was incorporated in the original EIS (April 2015) and in the revised EIS (April 2018). The 93% PAG indication was also relied on in the revised EIS (April 2018) for the surface water quality prediction as well as the effects of the Project on fish and fish habitat. Given that the revised EIS (April 2018) relied on the consideration that "a greater percentage of mine rock may be PAG", no reassessment is required. <u>Part E.</u> As described in the responses to Parts A, infiltration into the uncapped WRSA will either infiltrate into the underlying overburden and bedrock or drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches. In the revised EIS (April 2018), 100–200 mm/year was conservatively assumed to infiltrate into the underlying overburden and bedrock. As detailed in the response to TMI_911-GW(2)-04), seepage from the uncapped WRSA to the underlying overburden and bedrock (groundwater) during operations will be captured by the open pit, and will not reach the receiving environment. The infiltration into the WRSA that would drain laterally through the WRSA to the perimeter of the WRSA would be captured by the perimeter ditches and directed to segregated runoff collection pond where it would be tested, and if required treated before being incorporation into the overall water management system. The surface water quality modelling includes consideration of the seepage from the uncapped WRSA into the

Unique Identifier	Agency IR #	Annex	Agency Group or Stakeholder	Proponent Reference to EIS / Guidelines or Information Request Response
				underlying bedrock and overburden, as well as the seepage laterally through the WRSA to the perimeter ditches. It is important to remember that the uncapped WRSA scenario will only exist during operations and for a short period of time during closure when a low-permeability, multi-layer, dry cover will be constructed over the WSRA as described in Section 3.16.8. As a result, there would be no changes to the surface water quality predictions during operations as a result of infiltration to, or seepage from the WRSA. As described in the responses to Parts B, a low-permeability, multi-layer, dry cover will be constructed over the WSRA during closure activities. The multi-layer, low permeability dry cover over the WRSA is intended to reduce the rate of infiltration into the WRSA and thus the rate of seepage from the WRSA into the underlying overburden and bedrock. The design and construction of low permeability covers on waste rock and landfills are well understood and covers that can achieve significant infiltration reductions (e.g., >95%) are well documented. The exact design of the cap for the WRSA will be determined during detailed design, but would likely include a compacted clay layer, which can reliably achieve hydraulic conductivities of less than 1×10^{-9} m/s (Hauser et al., 2001). As discussed in both the December 18, 2018, and the January 10, 2019 meetings with the Agency and their technical reviewers, there are measures that Treasury Metals could implement to help minimize the potential for settlement and slumping of the waste rock pile to adversely affect the final dry cover over the WRSA, such as progressively placing overburden over the completed area of the WRSA to help reduce the amount of settling expected following closure and provide a foundation for the placement of the cover. To provide assurances that increased seepage into the capped WRSA would not adversely affect surface water quality, a separate sensitivity run has been included in the Goliath Gold Project Water Addendum that models the effects on surface water quality due to an increased rate of infiltration (50% of precipitation) into the capped WRSA during post-closure. The surface water quality modelling for this sensitivity case identified one (1) additional predicted residual adverse effects in Thunder Lake (predicted concentrations for a parameter are higher than existing conditions), but the resulting water quality remains below the PWQO for the protection of aquatic life. Therefore, increased infiltration into the capped WRSA during post-closure is not predicted to change the conclusions regarding surface water quality. <u>Part F.</u> There will be no changes to the effects predicted to fish and fish habitat arising from the issues and concerns raised in Parts A through D of this information request because there are no changes to surface water quality arising from the issues and concerns raised in Parts A through D of this information request. <u>Part G.</u> As described in the responses to Parts A through F, there will be no changes to the effects predicted to fish and fish habitat arising from issues and concerns raised in this information request, therefore there are no additional mitigation measures required regarding seepage emanating from the WRSA.

Unique Identifier	Agency IR #	Annex	Agency Group Stakeholder	[illegible]
				<u>Part H.</u> There are no changes to the characterization of residual adverse effects from those presented in the revised EIS (April 2018), as there are no changes to the predicted effects, or the required mitigation measures from Round 2 issues or concerns regarding seepage emanating from the WRSA. <u>Part I.</u> No specific modifications to the Follow-Up Program were identified as a result of changes in seepage emanating from the WRSA. An updated Follow-Up Program has been provided in support of the Round 2 process as the Goliath Gold Follow Up Program Addendum. <u>Part J.</u> The information presented in this Round 2 response, has been incorporated into Sections W6 (Quantity and Fate of Seepage from the Project) and W7 (Quality of Seepage from the Project) of the Goliath Gold Water Addendum. The Water Addendum presents the updated water quality assessment that consolidates all of the identified Round 2 changes and concerns including those changes to groundwater and mine waste that would affect surface water quality. References: Hauser, Victor L., Barron L. Weand, and Marc D. Gill. "Natural covers for landfills and buried waste." *Journal of Environmental Engineering* 127.9 (2001): 768-775.

TMI_910-GW(2)-03

Unique Identifier	Agency IR #	Annex	Agency Group / Stakeholder	[illegible]	
TMI_910-GW(2)-03	GW(2)-03	1	CEA Agency	**Reference to EIS Guidelines:**	Part 2, Sections 9.1.2 and 10.
				Reference to EIS / Appendix	Appendix M; Appendix M-3.
				Cross-reference to Round 1 IRs	n/a
				Context and Rationale It is stated in Appendix M-2 of Appendix M of the revised EIS that “The average linear velocity of groundwater in the shallow bedrock may be of the order of 2E-06 m/s (~ 0.2 m/d) assuming a hydraulic conductivity of the shallow bedrock of 1E-06 m/s (Table 8, Appendix M), and a kinematic porosity of 0.01. Travel times from the waste rock storage area (WRSA) to Thunder Lake may be expected to be of the order of fifteen years given a flowpath length of about 1 km.” There is uncertainty with the assumed porosity, as 1% porosity cannot be deemed a conservative assumption considering that seepage will flow through weathered upper bedrock and the overburden. Section 5.3 of Appendix M mentions that the runoff and seepage collection ditches are “assumed to be 1m wide and 1m deep” surrounding the tailings storage facility (TSF). In Figure 5a of Appendix M, Cross-section A-A’ identifies deep overburden to the southwest of the TSF. This deep overburden will likely make the interception of seepage challenging for the seepage collection ditches; it is unclear whether uncertainties with factors like the kinematic porosity, and weathered upper bedrock and overburden have been considered in the design of the seepage collection system. This is important for the Agency to understand as it has implications for seepage quality, flow and travel times, which can ultimately affect the fish and fish habitat in surrounding surface water features.	

Unique Identifier	Agency IR #	Annex	Agency Group / Stakeholder	Proponent Reference to EIS / Information Request Response
				Specific Question/Request for Clarification A. Consider a reasonable range of porosity estimates for bedrock and provide an assessment of seepage behavior and travel time for seepage that travels through shallow bedrock and overburden; B. Assess the efficacy of the proposed 1 m deep and wide runoff and seepage collection ditches in areas of deep overburden around the TSF. Also identify other areas that may pose a challenge for seepage collection and propose additional mitigation measures in these areas to capture seepage; C. Incorporate the findings from Questions A and B into the revision of seepage water quality assessment requested in IR# MW(2)-06, and revision of groundwater model requested in IR# GW(2)-01.
				Response: Part A. When trying to understand the travel times for seepage in bedrock, the parameter of greatest importance is the kinematic porosity (or effective porosity). The kinematic porosity, which describes the ability of a fluid to travel through a media, is always lower than the porosity. Kinematic porosities for weathered bedrock provided in literature (Worthington, Smart and Ruland, 2012), suggests that values in the range of 0.01%–0.1% are possible carbonate aquifers, but posits a value of 1% is possible. The kinematic porosity of 0.01 used for the groundwater velocity calculation (memo to Mark Wheeler, Treasury Metals; “Additional Hydrogeological Information”, dated March 29, 2018, as appended to Appendix M) represents the porosity of open, weathered fractures at the bedrock surface. The Basal Sand at the base of the overburden is discontinuous as noted in the memo referred to above. Nevertheless, as fractures in the shallow bedrock will also be discontinuous, it is correct that flowpaths may exist that go through both shallow bedrock and the Basal Sand. However, groundwater velocities in the Basal Sand are more likely lower than in the shallow bedrock as the kinematic porosity of the Basal Sand is expected to be about an order of magnitude higher, whereas the hydraulic conductivities are expected to be of a similar range (see Table 8 of Appendix M). Nevertheless, Treasury Metals do recognize that there is uncertainty in the estimate of groundwater velocity, and acknowledges that groundwater velocities may be of the order of 2×10^{-6} m/s. Treasury Metals is committed to a comprehensive groundwater monitoring program to confirm all assumptions relied upon in the groundwater model, including the kinematic porosities and other factors that could influence transport times. To provide confidence in the post-closure predictions, Treasury Metals propose to update the groundwater model on a regular basis (i.e. every three (3) years) to incorporate the actual monitoring results that reflect the data gathered. Review in this manner provides the opportunity to reassess and update the hydrogeological conceptual model and the groundwater flow and transport predictions made for the impacts of the mine. This information has been incorporated into the Goliath Gold Follow-Up Addendum (which supersedes Section 13 of the revised EIS [April 2018]). Part B.

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				Since the filing of the original EIS, Treasury Metals has advanced their engineering for the Project, which includes additional details regarding the design of seepage and runoff collection ditches, as described in Section 3.7.3 of the revised EIS. While Figure 3.7.3-1 of the revised EIS (April 2018) provides typical cross sections for seepage and runoff collection ditches, Figure 3.7.3-2 (attached as TMI_910-GW(2)-03_Attachment 1) provides modifications specifically to address situations where existing conditions may pose challenges to the collection and capture of seepage including deep bedrock in both low and high permeability soils. It should also be kept in mind that the TSF will be lined with an HPDE liner, with a seepage rate of 2.4 m³/d as detailed in the responses to TMI_900-MW(2)-04 and TMI_901-(MW(2)-05. The 2.4 m³/day seepage rate used for the TSF liner in the revised EIS (April 2018) represents an approximate upper bound estimate for a properly installed HDPE geomembrane underlying mine tailings. Part C. The response to Part B shows the alternative designs of the seepage collection ditches to deal with deep bedrock situations near the TSF and does not warrant any updating the surface water quality model. The response to Part A dealing with the range of porosity estimates would not have an effect on the predicted surface water quality during the post-closure phase of the Project, as the modelled predictions are provided at a point in time when seepage will have reached the relevant receiving water bodies. While the responses to Parts A and B do not lead to the requirement of updating the surface water quality model, the surface water quality assessment has been updated as part of the Round 2 process, to reflect other required changes and refinements. The information presented in this Round 2 response, has been incorporated into Section W6.2 (Runoff and Seepage Collection Ditches) of the Goliath Gold Water Addendum. The Water Addendum presents the updated water quality assessment that consolidates all of the identified Round 2 changes and concerns including those changes to groundwater and mine waste that would affect surface water quality. References: Worthington, Stephen RH, C. Christopher Smart, and Wilf Ruland. "Effective porosity of a carbonate aquifer with bacterial contamination: Walkerton, Ontario, Canada." *Journal of hydrology* 464 (2012): 517-527.
				Age□□□□□□ □□ □e□□□□□Dr□□□Re□□□□□e□ Part A. The proponent has done a good job of characterizing the effects of different porosities on the estimation of travel times, but has not provided any validation of their porosity assumption. Part B. The 1 m ditches originally proposed will capture only 34% of the seepage from the TSF. Capture efficiency of other ditch configurations were not provided. The additional ditch configurations have not been committed to by the

Unique Identifier	Agency IR #	Annex	Agency Group / Stakeholder	[illegible]
				Proponent as it is stated that they are "conceptual, for discussion only". Pumping wells have not been proposed as an option. **Clarify whether the perimeter ditches and Mine Water Pond will still be in place during Post-closure, and if so, where will they direct the seepage (See Comment ID# 7 in Water Addendum)** Part C. **Recommend that this section be evaluated once inter-related comments from other IRs are addressed.**
				[illegible] Part A As discussed in the December 18, 2018 meeting with the Agency and their technical reviewers, the kinematic porosity used to assess groundwater velocities was selected to represent the bulk material of the site as described fully in the response to TMI_951-GW(2)-01B. NRCAN noted at the meeting, kinematic porosity may be estimated in the field using tracer testing. However, this methodology is not suitable to estimate bulk kinematic porosity from the shallow bedrock and basal sand overburden. As part of the Follow-up Program for groundwater, monitoring data will be able to detect the arrival of seepage from the mine. Detection of relatively non-retardent species (chloride, sulphate), will be used to establish bulk kinematic porosity values for the geology at the site. Detection of retardant species (metals, cyanide) will be used to establish transport parameter values (retardation, decay where applicable). Part B ***Perimeter Ditches*** The groundwater modelling completed for the Goliath Gold Project was run using the default ditch configurations of 1 m in depth (Figure 3.7.3-1 of the revised EIS). The results of the modelling indicated that these ditches would be effective at capturing 34% of the small amount of seepage from the TSF. The groundwater model was not run specifically for the additional ditch configurations illustrated on TMI_910-GW(2)-04_Attachment_1 as it is not possible to know which of the configurations would specifically be used at every location around the operation area. The alternative configurations shown on TMI_910 GW(2) 04_Attachment_1 represent a "toolbox of options" that will be used to select the configuration of ditches constructed around the perimeter of the site, based on the actual conditions encountered when constructing the perimeter ditches. The four configurations in TMI_910-GW(2) 04_Attachment_1 are labelled as "conceptual" and "for discussion only" as the detailed engineering for these features has yet to be completed. The final design for the construction of the perimeter ditches will be done to address specific conditions that are encountered. Another option that could be considered in the "toolbox" for the Project are pumping wells; however, these are unlikely to be the first options selected based on the site conditions and projected seepage. Although the seepage collection efficiencies for the alternative ditch configurations illustrated on TMI_910-GW(2)-04_Attachment_1 were not specifically modelled, the performance of these alternative configurations is expected to be considerably higher than 34%, ideally capturing 100% of the seepage from the site. To ensure the

Unique Identifier	Agency IR #	Annex	Agency Group or Stakeholder	Proponent Reference to EIS / Context / Information Request / Response
				predicted effects of the Project on the receiving environment were not underestimated in the revised EIS (April 2018), the groundwater modelling results associated with the default 1 m deep ditch configurations were used. With the implementation of the alternative configurations illustrated on TMI_910-GW(2)-04_Attachment_1, the collection efficiency of the perimeter ditches would be greatly enhanced and the amount of seepage from the on-site structures that reaches the receiving waterbodies, during post-closure would be greatly reduced. As a result, the receiving water quality in the surrounding water bodies would be improved relative to those presented in the Goliath Gold Project Water Report. However, the water quality modelling results presented in the Goliath Gold Project Water Report continue to indicate that surface water quality will be largely unchanged as a result of the Project, with resulting water quality being the same as, or slightly improved from the existing condition for most parameters. In the situation where the water quality is predicted to the higher than existing condition, the resulting water quality remains below the PWQO for the protection of aquatic life. ***Post Closure Landscapes*** The current conceptual design for the closure of the Project includes the decommissioning of the minewater pond and the grading of that portion of the site to drain towards the open pit. The perimeter ditching would be left in place at closure to help direct the runoff and seepage from the site towards the open pit. The water quality within the pit lake will be monitored as the pit lake is filling with water, and batch treatment (most likely bulk lime addition) will be applied as required during the filling process. Part C. As discussed in the specific response to Part B, the implementation of the alternative designs for the seepage collection ditches illustrated on TMI_910-GW(2)-04_Attachment_1 would reduce the quantity of seepage that is predicted to escape the operations area during post-closure, and ultimately reach receiving water bodies. If the alternative seepage collection ditches illustrated on TMI_910-GW(2)-04_Attachment_1 were implemented, the receiving water quality in the surrounding water bodies would be improved relative to those presented in the Goliath Gold Project Water Report. However, the water quality modelling results presented in the Goliath Gold Project Water Report continue to indicate that surface water quality will be largely unchanged as a result of the Project, with resulting water quality being the same as, or slightly improved from the existing condition for most parameters. In the situation where the water quality is predicted to the higher than existing condition, the resulting water quality remains below the PWQO for the protection of aquatic life.
				Final Responses: Part A. When trying to understand the travel times for seepage in bedrock, the parameter of greatest importance is the kinematic porosity (or effective porosity). The kinematic porosity, which describes the ability of a fluid to travel through a media, is always lower than the porosity. Kinematic porosities for weathered bedrock provided in literature (Worthington, Smart and Ruland, 2012), suggests that values in the range of 0.01%–0.1% are possible carbonate

Unique Identifier	Agency IR #	Annex	Agency Group / Stakeholder	Proponent Reference to Revised EIS / Information Request Response
				aquifers, but posits a value of 1% is possible. The kinematic porosity of 0.01 used for the groundwater velocity calculation (memo to Mark Wheeler, Treasury Metals; "Additional Hydrogeological Information", dated March 29, 2018, as appended to Appendix M) represents the porosity of open, weathered fractures at the bedrock surface. The Basal Sand at the base of the overburden is discontinuous as noted in the memo referred to above. Nevertheless, as fractures in the shallow bedrock will also be discontinuous, it is correct that flowpaths may exist that go through both shallow bedrock and the Basal Sand. However, groundwater velocities in the Basal Sand are more likely lower than in the shallow bedrock as the kinematic porosity of the Basal Sand is expected to be about an order of magnitude higher, whereas the hydraulic conductivities are expected to be of a similar range (see Table 8 of Appendix M). Nevertheless, Treasury Metals do recognize that there is uncertainty in the estimate of groundwater velocity, and acknowledges that groundwater velocities may be of the order of 2×10^{-6} m/s. As discussed in the December 18, 2018 meeting with the Agency and their technical reviewers, the kinematic porosity used to assess groundwater velocities was selected to represent the bulk material of the site as described fully in the response to TMI_951-GW(2)-01B. NRCan noted at the meeting, kinematic porosity may be estimated in the field using tracer testing. However, this methodology is not suitable to estimate bulk kinematic porosity from the shallow bedrock and basal sand overburden. As part of the Follow-up Program for groundwater, monitoring data will be able to detect the arrival of seepage from the mine. Detection of relatively non-retardent species (chloride, sulphate), will be used to establish bulk kinematic porosity values for the geology at the site. Detection of retardant species (metals, cyanide) will be used to establish transport parameter values (retardation, decay where applicable). <u>Part B.</u> ***Perimeter Ditches*** Since the filing of the original EIS, Treasury Metals has advanced their engineering for the Project, which includes additional details regarding the design of seepage and runoff collection ditches, as described in Section 3.7.3 of the revised EIS. While Figure 3.7.3-1 of the revised EIS (April 2018) provides typical cross sections for seepage and runoff collection ditches, Figure 3.7.3-2 (attached as TMI_910-GW(2)-03_Attachment 1) provides modifications specifically to address situations where existing conditions may pose challenges to the collection and capture of seepage including deep bedrock in both low and high permeability soils. The groundwater modelling completed for the Goliath Gold Project was run using the default ditch configurations of 1 m in depth (Figure 3.7.3-1 of the revised EIS). The results of the modelling indicated that these ditches would be effective at capturing 34% of the small amount of seepage from the TSF. The groundwater model was not run specifically for the additional ditch configurations illustrated on TMI_910-GW(2)-04_Attachment_1 as it is not possible to know which of the configurations would specifically be used at every location around the operation area as these alternative configurations shown on TMI_910 GW(2) 04_Attachment_1 represent a "toolbox of options" that will be used to select the configuration of ditches constructed around the perimeter of the site, based on the actual conditions encountered when constructing the perimeter ditches. The four configurations in TMI_910-GW(2) 04_Attachment_1 are labelled as "conceptual" and "for discussion only" as the detailed engineering for these features has yet to be

Unique Identifier	Agency IR #	Annex	Agency / Group / Stakeholder	Proponent Reference to EIS / Final Round 2 Information Request Response
				completed. The final design for the construction of the perimeter ditches to will be done to address specific conditions that are encountered. Another option that could be considered in the “toolbox” for the Project are pumping wells; however, these are unlikely to be the first options selected. Although the seepage collection efficiencies for the alternative ditch configurations illustrated on TMI_910-GW(2)-04_Attachment_1 were not specifically modelled, the performance of these alternative configurations is expected to be considerably higher than 34%, ideally capturing 100% of the seepage from the site. To ensure the predicted effects of the Project on the receiving environment were not underestimated in the revised EIS (April 2018), the groundwater modelling results associated with the default 1 m deep ditch configurations were used. With the implementation of the alternative configurations illustrated on TMI_910-GW(2)-04_Attachment_1, the collection efficiency of the perimeter ditches would be greatly enhanced and the amount of seepage from the on-site structures that reaches the receiving waterbodies, during post-closure would be greatly reduced. As a result, the receiving water quality in the surrounding water bodies would be improved relative to those presented in the Goliath Gold Project Water Report. However, the water quality modelling results presented in the Goliath Gold Project Water Report continue to indicate that surface water quality will be largely unchanged as a result of the Project, with resulting water quality being the same as, or slightly improved from the existing condition for most parameters. In the situation where the water quality is predicted to the higher than existing condition, the resulting water quality remains below the PWQO for the protection of aquatic life. It should also be kept in mind that the TSF will be lined, with an estimated seepage rate of 3.1 m^3/d as detailed in the responses to TMI_900-MW(2)-04 and TMI_901-(MW(2)-05. The 3.1 m^3/day seepage rate used for the TSF liner in the revised EIS (April 2018) represents an approximate upper bound estimate for a properly installed HDPE geomembrane underlying mine tailings. ***Post Closure Landscapes*** The current conceptual design for the closure of the Project includes the decommissioning of the minewater pond and the grading of that portion of the site to drain towards the open pit. The perimeter ditching would be left in place at closure to help direct the runoff and seepage from the site towards the open pit. The water quality within the pit lake will be monitored as the pit lake is filling with water, and batch treatment (most likely bulk lime addition) will be applied as required during the filling process. <u>Part C.</u> The response to Part A pertaining to the range of porosity estimates would not have an effect on the predicted surface water quality during the post-closure phase of the Project, as the modelled predictions are provided at a point in time when seepage will have reached the relevant receiving water bodies. As discussed in the response to Part B, the implementation of the alternative designs for the seepage collection ditches illustrated on TMI_910-GW(2)-04_Attachment_1 would reduce the quantity of seepage that is predicted to escape the operations area during post-closure, and ultimately reach receiving water bodies. If the alternative seepage collection ditches illustrated on TMI_910-GW(2)-04_Attachment_1 were implemented, the receiving water

Unique Identifier	Agency IR #	Annex	Agency or Group Commenter	Cross Reference [illegible] Request Response
				quality in the surrounding water bodies would be improved relative to those presented in the Goliath Gold Project Water Report. However, the water quality modelling results presented in the Goliath Gold Project Water Report continue to indicate that surface water quality will be largely unchanged as a result of the Project, with resulting water quality being the same as, or slightly improved from the existing condition for most parameters. In the situation where the water quality is predicted to the higher than existing condition, the resulting water quality remains below the PWQO for the protection of aquatic life.

TMI_911-GW(2)-04

Unique Identifier	Agency IR #	Annex	Agency Group / Stakeholder	[illegible]	
TMI_911-GW(2)-04	GW(2)-04	1	CEA Agency	**Reference to EIS Guidelines:**	Part 2, Sections 9.1.1, 9.1.2, 10
				Reference to EIS / Appendix	n/a
				Cross-reference to Round 1 IRs	n/a

Context and Rationale

It is stated in Section 3.3.2 of the revised EIS that "The zone of influence (water table drawdown) will prevent any seepage from the Operations Area to the surrounding environment". The Agency understands that the zone of influence is expected to capture any seepage that may bypass the seepage collection ditches due to the drawdown induced by open pit dewatering.

However, Figure 5.5.2-3 shows clay layers that may exist at depth between the TSF and the pit lake. The presence of this clay aquitard across much of the property can limit the influence of the drawdown on layers above the clay aquitard.

Additionally, locally high heads at the tailings storage area (TSF) and waste rock storage area (WRSA) will induce a radial outward flow of seepage from the TSF which may intersect topographic lows and discharge locally, regardless of the drawdown, and draw towards the pit lake.

Particle tracking figures were not provided for the dewatered pit scenario, which would have supported the claim that uncaptured seepage will be captured by the open pit drawdown.

The Agency requires the particle tracking figures for the dewatered pit scenario to substantiate the claim that uncaptured seepage would be captured by the open pit zone of influence, and not result in effects to fish and fish habitat.

Specific Question / Information Request

A. Provide a particle tracking figure for the dewatered pit scenario, and reconsider the conclusion that all of the seepage bypass during the operation phase would be captured by the open pit drawdown force.

B. Incorporate the findings of this IR into the revision of seepage water quality assessment requested in IR# MW(2)-06, and revision of groundwater model requested in IR# GW(2)-01.

Unique Identifier	Agency IR #	Annex	Agency Group Stakeholder	Cross Reference to Related Information Request Responses

Response:

Part A:

Specially conducted model runs have been undertaken with the Goliath groundwater flow model assuming the ultimate open pit and underground mine are completely dewatered and with an uncapped WRSA and an unlined and uncapped TSF. The simulated conditions of the WRSA and TSF are the same as the simulations for uncapped conditions described in Section 5.3.5 of Appendix M of the revised EIS (April 2018). Particle tracking results for the TSF and WRSA are shown in TMI_911-GW(2)-04_Figure_1 and TMI_911-GW(2)-04_Figure 2, respectively. The results are discussed further below.

Releases from TSF

The simulation has been undertaken to provide a physically realistic particle tracking release from the full footprint of the TSF. The water cover of the TSF is maintained 418 masl, which provides the driving head for flow out of the TSF. The results show that, of the seepage leaving the TSF, 46% is captured by the open pit; 34% is captured by the TSF perimeter drains; 14% is captured by the mine water pond, and 6% escapes the operations area and reports to Blackwater Creek. The proportion that escapes the operations area to report to Blackwater Creek occurs along the eastern perimeter of the TSF.

As discussed in the responses to TMI_900-MW(2)-04 and TMI_901-MW(2)-05; the TSF will be lined with an HPDE liner. The estimated seepage rate for the TSF liner of 2.4 m^3/day represents the approximate upper bound estimate for a properly installed HDPE geomembrane underlying mine tailings (Kerry Rowe et al., 2016). The estimated seepage rate is independent of the soil characteristics underneath the TSF liner.

Based on the upper bound estimate of seepage through the TSF liner (2.4 m^3/day), the leakage from the TSF towards Blackwater Creek would be small (2.4 m^3/day × 0.06 = 0.14 m^3/day). This small amount of seepage during operations has been incorporated into the revised surface water quality assessment provided in the Water Addendum.

Releases from WRSA

Particle tracking results shown in TMI_911-GW(2)-04_Figure 2 indicate that all water seeping from the base of the uncapped WRSA during operations is captured by the open pit. This is consistent with the assumption relied on in the revised EIS (April 2018).

Part B:

The surface water quality assessment has been updated as part of the Round 2 process, to reflect all necessary changes, refinements, or concerns identified in the Round 2 process. As described in the response to Parts A, a small amount of seepage (i.e. 6% of 2.4 m^3/day) from the TSF will report to Blackwater Creek during operations. The particle tracking confirms that all of the seepage from the uncapped WRSA reports to the open pit during operations. The information presented in this Round 2 response, has been incorporated into Section W6.5 of the Goliath Gold

Unique Identifier	Agency IR #	Annex	Agency Group (Reviewer)	Cross Reference to Round 2 Information Request and Responses
				Water Addendum (Seepage from WRSA and TSF to Offsite Receiving Waters). The Water Addendum presents the updated water quality assessment that consolidates all of the identified Round 2 changes and concerns including those changes to groundwater and mine waste that would affect surface water quality.
				Agency Comments on Draft Response Part A. As noted in the sufficiency review for TMI_951-GW(2)-01B, there are no boreholes between the TSF and the open pit. This lack of baseline data brings into question whether or not a clay layer exists there and at what depths and thicknesses. Considering that a high degree of reliance is placed on the purported travel of seepage into the open pit (note that the seepage capture efficiency of the TSF perimeter ditches is only 34%), there should be better baseline data in that region to give credence to the modelling results. The question about whether or not the clay layer would or should limit the drawdown effect that purportedly draws 46% of seepage towards the open pit during the Operations Phase has not been addressed. Furthermore, the larger zone of influence generated by lower recharge may be overestimating the zone of influence generated by the open pit. The particle tracks provided for the Operations Phase intersect the Hoffstrom's Bay Tributary to the west of the TSF, and Blackwater Tributary #2 to the south, but the seepage that may enter that tributary has not been predicted. This requires further explanation. It is important to also provide particle tracking for the Post-closure Phase when the open pit drawdown is greatly reduced (i.e. after the open pit has filled). This will be necessary to understand where seepage from the WRSA and the TSF will travel to in the Post-closure Phase. **Taking the above into consideration, clarify the response and in particular explain why seepage to Blackwater Tributary #2 to the south is not predicted** Part B. **Recommend that this section be evaluated once inter-related comments from other IRs are addressed.**
				Specific Response to the Agency Comments Part A. As described in the Goliath Gold Project Follow-up Program Addendum, the planned groundwater monitoring program will include a new well located between the TSF and the open pit (see Figure FUP1.10.3.2-1) It should be noted that, as discussed in the December 18, 2018 technical meeting with the Agency and their technical reviewers, that the groundwater model is predicting a vertical downward gradient beneath the TSF, then lateral flow through the basal sands and shallow weathered bedrock that exists beneath the overburden layers. The mechanism to support this is illustrated in the cross sections provided as Figures 5a and 5b of Appendix M of the revised EIS (April 2018), which show that the clay layer present under much of the site is absent beneath the tailings storage facility (TSF).

Unique Identifier	Agency IR #	Annex	Agency Group / Stakeholder	Proponent Reference to Technical Information Request Response
				Particle Tracking for the Operations Phase As discussed in the December 18, 2018 technical meeting with the Agency and their technical reviewers, the cross sections provided as Figures 5a and 5b of Appendix M of the revised EIS (April 2018) show that the clay layer present under much of the site is absent beneath the tailings storage facility (TSF). Figure 4 of Appendix M to the revised EIS (April 2018) provides the location of cross-section A (Figure 5a) and cross-section B (Figure 5b). The groundwater model predicts a vertical downward gradient beneath the TSF. Lateral movement of seepage from the TSF is predicted to occur in the basal sands and shallow weathered bedrock that exists beneath the overburden layers. TMI_911 GW(2) 04_Figure_1 provides the operations phase particle tracking for the fate of seepage from the TSF. The particle tracks from the TSF towards the open pit (purple tracks in the figure) represent flow primarily through the discontinuous basal sands and shallow weathered bedrock that occurs below the overburden layer. The surficial geology suggests that Hoffstrom's Bay Tributary (see Figure 5b) and Blackwater Tributary #2 to the south to the south of the TSF (see Figure 5a) are underlain with clay, and thus would be isolated from the seepage from the TSF that is travelling laterally through the basal sands and shallow weathered bedrock that exists beneath the overburden layers. ***Particle Tracking for the Post-Closure Phase*** Particle tracking figure for the post-closure phase were provided in Appendix M to the revised EIS (April 2018). The following particle track figures are provided in Appendix M: • Figure 22: particle tracking results for the seepage from the TSF with a wet cover (i.e., uncapped); • Figure 24: particle tracking results for the seepage from the TSF with a dry cover (i.e., capped); and • Figure 25: particle tracking results for the seepage from the capped WRSA. Part B. As discussed in the December 18, 2018 technical meeting with the Agency and their technical reviewers, the groundwater model predicts that a vertical downward gradient will exist during operations beneath the TSF. The lateral movement of seepage from the TSF will be through the basal sands and shallow weathered bedrock that exists beneath the overburden layers. The mechanism to support this is illustrated in the cross sections provided as Figures 5a and 5b of Appendix M of the revised EIS (April 2018), which show that the clay layer present under much of the site is absent beneath the tailings storage facility (TSF). Therefore, no additional changes to capture the effects of seepage incorporated into the surface water quality model described in the Goliath Gold Project Water Addendum. The Water Addendum presents the updated water quality assessment that consolidates all of the identified Round 2 changes and concerns including those changes to groundwater and mine waste that would affect surface water quality.
				Final Response: Part A.

Unique Identifier	Agency IR #	Annex	Agency Group / Reviewer	[illegible]
				Specially conducted model runs have been undertaken with the Goliath groundwater flow model assuming the ultimate open pit and underground mine are completely dewatered, an uncapped WRSA and an unlined and uncapped TSF (end of operations phase). Particle tracking results for the TSF and WRSA at the end of the operations phase are shown in TMI_911-GW(2)-04_Figure_1 and TMI_911-GW(2)-04_Figure 2, respectively. Particle tracking was also completed for the post-closure phase of the Project once the groundwater drawdown has ceased and the groundwater table reaches near pre-development levels and is provided in Appendix M. As described in the Goliath Gold Project Follow-up Program Addendum, the planned groundwater monitoring program will include a new well located between the TSF and the open pit (see Figure FUP1.10.3.2-1). It should be noted that, as discussed in the December 18, 2018 technical meeting with the Agency and their technical reviewers, that the groundwater model is predicting a vertical downward gradient beneath the TSF, then lateral flow through the basal sands and shallow weathered bedrock that exists beneath the overburden layers. The mechanism to support this is illustrated in the cross sections provided as Figures 5a and 5b of Appendix M of the revised EIS (April 2018), which show that the clay layer present under much of the site is absent beneath the tailings storage facility (TSF). The results of the particle tracking from the TSF and WRSA during operations and post-closure are discussed further below. ***Particle Tracking for the Operations Phase*** ***<u>TSF</u>*** The simulation has been undertaken to provide a realistic particle tracking release from the full footprint of the TSF. As discussed in the December 18, 2018 technical meeting with the Agency and their technical reviewers, the cross sections provided as Figures 5a and 5b of Appendix M of the revised EIS (April 2018) show that the clay layer present under much of the site is absent beneath the tailings storage facility (TSF). Figure 4 of Appendix M to the revised EIS (April 2018) provides the location of cross-section A (Figure 5a) and cross-section B (Figure 5b). This is the reason the groundwater model predicts a vertical downward gradient beneath the TSF. Lateral movement of seepage from the TSF is predicted to occur in the basal sands and shallow weathered bedrock that exists beneath the overburden and clay layers. TMI_911-GW(2) 04_Figure_1 provides the operations phase particle tracking for the fate of seepage from the TSF. The water cover of the TSF will be maintained 418 masl, which provides the driving head for flow out of the TSF. The results show that, of the seepage leaving the TSF, 46% is captured by the open pit; 34% is captured by the TSF perimeter drains; 14% is captured by the mine water pond, and 6% escapes the operations area and reports to Blackwater Creek. The particle tracks from the TSF towards the open pit (purple tracks in the figure) represent flow primarily through the discontinuous basal sands and shallow weathered bedrock that occurs below the overburden and clay layers. The proportion that escapes the operations area to report to Blackwater Creek occurs along the eastern perimeter of the TSF. Based on the upper bound estimate of seepage through the TSF liner (3.13 m^3/day), the seepage from the TSF towards Blackwater Creek would be small (3.13 m^3/day × 0.06 = 0.19 m^3/day). This small amount of seepage during

Unique Identifier	Agency IR #	Annex	Agency Group / Stakeholder	[illegible]
				operations has been incorporated into the revised surface water quality assessment provided in the Water Addendum. As discussed in the responses to TMI_900-MW(2)-04 and TMI_901-MW(2)-05; the TSF will be lined with an HPDE or similar liner. The estimated seepage rate for the TSF liner of 2.4 m^3/day represents the approximate upper bound estimate for a properly installed HDPE geomembrane underlying mine tailings (Kerry Rowe et al., 2016). As indicated in TMI_951-GW(2)-01B, the seepage rate from the TSF has been increased to account for the seams in the different HDPE liners used in the dam lifts throughout the Project. The surficial geology suggests that Hoffstrom's Bay Tributary (see Figure 5b) and Blackwater Creek Tributary 2 to the south of the TSF (see Figure 5a) are underlain with clay, and thus would be isolated from the seepage from the TSF that is travelling laterally through the basal sands and shallow weathered bedrock that exists beneath the overburden and clay layers. ***WRSA*** Particle tracking results shown in TMI_911-GW(2)-04_Figure_2 indicate that all water seeping from the base of the uncapped WRSA during operations is captured by the open pit. This is consistent with the assumption relied on in the revised EIS (April 2018). ***Particle Tracking for the Post-Closure Phase*** Particle tracking figures for the post-closure phase were provided in Appendix M to the revised EIS (April 2018). The following particle track figures are provided in Appendix M: • Figure 22: particle tracking results for the seepage from the TSF with a wet cover (i.e., uncapped); • Figure 24: particle tracking results for the seepage from the TSF with a dry cover (i.e., capped); and • Figure 25: particle tracking results for the seepage from the capped WRSA. Part B. As discussed in the December 18, 2018 technical meeting with the Agency and their technical reviewers, the groundwater model predicts that a vertical downward gradient will exist during operations beneath the TSF. The lateral movement of seepage from the TSF will be through the basal sands and shallow weathered bedrock that exists beneath the overburden layers. The mechanism to support this is illustrated in the cross sections provided as Figures 5a and 5b of Appendix M of the revised EIS (April 2018), which show that the clay layer present under much of the site is absent or discontinuous beneath the TSF. Therefore, no additional changes to capture the effects of seepage incorporated into the surface water quality model described in the Goliath Gold Project Water Addendum. The Water Addendum presents the updated water quality assessment that consolidates all of the identified Round 2 changes and concerns including those changes to groundwater and mine waste that would affect surface water quality.

TMI_912-GW(2)-05

Unique Identifier	Agency IR #	Annex	Agency Group or Stakeholder	Project Reference/ Description and Information Request/ Response	
TMI_912-GW(2)-05	GW(2)-05	1	CEA Agency	**Reference to EIS Guidelines:**	Part 2, Sections 9.1.2, 10
				Reference to EIS / Appendix	Section 3.16.5
				Cross-reference to Round 1 IRs	n/a
				Context and Rationale: • It is stated in Section 3.16.5 of the revised EIS that "A finger drain will be constructed in the existing creek channel that bisects the TSF." • This is a new addition to the description of the TSF, as compared to the original EIS. It is unclear what the purpose of this drain is, as it could increase the seepage from the TSF, affecting not only the water quality of the surrounding fish-bearing waterbodies, but also the ability of the wet cover over the TSF to be maintained in perpetuity.	
				Specific Question/ Request for Information: A. Describe the purpose of the finger drain that is proposed to be constructed in the existing creek channel that bisects the TSF. B. Provide an assessment of whether the finger drain has the potential to increase seepage from the TSF. If seepage is expected to increase, update the groundwater model and the corresponding surface water quality assessment. C. Describe the effects on fish and fish habitat taking the responses from Questions A and B into consideration. D. Describe mitigation measures to prevent adverse effects to fish and fish habitat, if necessary. E. Characterize residual effects, if any, after the mitigation measures identified in the response to Question D have been implemented. F. Update the follow-up program for potential effects to fish and fish habitat, including objectives and any monitoring measures that will be implemented to verify the predictions of effects and evaluate the effectiveness of the proposed mitigation measures. If follow-up is not required, provide a rationale.	

Unique Identifier	Agency IR #	Annex	Agency/Group/Stakeholder	Draft Reference to EIS / Response to Information Request Response
				Response: **Part A:** The figure drain will be installed as a foundation drain in the existing creek to collect and convey groundwater inflows that may report to the drainage during and following construction of the TSF. A proportion of the potential seepage from the TSF may also report to the finger drain. The finger drain outlet will provide a location to monitor the quality of the groundwater beneath the liner of the TSF. **Part B.** Seepage from the TSF will be a function of the geosynthetic basin liner and hydraulic conductivity of the settled tailings. The installation of a finger drain below the geosynthetic liner will not result in additional seepage from the TSF nor will it affect the ability to maintain the wet cover over the TSF in perpetuity. Therefore there is no need to update the models in response to this particular information request. **Part C:** Given that the finger drain is installed below the geosynthetic liner, and thus will not result in any additional seepage from the TSF, there will be no changes to predicted surface water quality as a result of the finger drain. Because the surface water quality predictions will not change as a result of the finger drain there will be no additional effects on fish and fish habitat as a result of the finger drain. **Part D:** Given that surface water quality predictions will not change as a result of the finger drain and that no changes to the predicted effects on fish and fish habitat will occur, no additional mitigation measures have been identified as being required to prevent adverse effects to fish and fish habitat as a result of the construction of a finger drain. **Part E** There no residual adverse effects identified to fish and fish habitat as a result of this Round 2 information request. **Part F:** No specific modifications to the Follow-Up Program were identified as a result of changes resulting from the presence of the finger drain. An updated Follow-Up Program has been provided in support of the Round 2 process as the Goliath Gold Follow Up Program Addendum.
				Agency Comments on Draft Response: **No comment on Draft Response**
				Specific Response to the Agency Comment: **None Required**

Unique Identifier	Agency IR #	Annex	Agency Group / Stakeholder	Draft Reference to Round 2 Information Request Response
				<u>Final Response:</u> **Part A:** A finger drain will be installed as a foundation drain in the existing creek to collect and convey groundwater inflows that may report to the drainage during and following construction of the TSF. A proportion of the potential seepage from the TSF may also report to the finger drain. The finger drain outlet will provide a location to monitor the quality of the groundwater beneath the liner of the TSF. **Part B.** Seepage from the TSF will be a function of the basin liner and hydraulic conductivity of the settled tailings. The installation of a finger drain below the liner will not result in additional seepage from the TSF nor will it affect the ability to maintain the wet cover over the TSF in perpetuity. Therefore there is no need to update the models in response to this particular information request. **Part C:** Given that the finger drain is installed below the liner, and thus will not result in any additional seepage from the TSF, there will be no changes to predicted surface water quality as a result of the finger drain. Because the surface water quality predictions will not change as a result of the finger drain there will be no additional effects on fish and fish habitat as a result of the finger drain. **Part D:** Given that surface water quality predictions will not change as a result of the finger drain and that no changes to the predicted effects on fish and fish habitat will occur, no additional mitigation measures have been identified as being required to prevent adverse effects to fish and fish habitat as a result of the construction of a finger drain. **Part E** There no residual adverse effects identified to fish and fish habitat as a result of this Round 2 information request. **Part F:** No specific modifications to the Follow-Up Program were identified as a result of changes resulting from the presence of the finger drain. An updated Follow-Up Program has been provided in support of the Round 2 process as the Goliath Gold Follow Up Program Addendum.

TMI_951-GW(2)-01B

Unique Identifier	Agency IR #	Annex	Agency Group / Stakeholder	Project Reference / Information Request & Response	
TMI_951-GW(2)-01B	GW(2)-01B	4	Eagle Lake First Nation	**Reference to EIS Guidelines:**	Part 2, Sections 9.1.1 and 9.1.2
				Reference to EIS / Appendix	Section 6.11.4.2
				Cross-reference to Round 1 IRs	TMI_909-GW(2)-02, TMI_910-GW(2)-03, TMI_911-GW(2)-04, TMI_897-MW(2)-01, TMI_898-MW(2)-02, TMI_899-MW(2)-03, TMI_900-MW(2)-04, TMI_901-MW(2)-05, TMI_902-MW(2)-06, TMI_903-MW(2)-07, TMI_904-MW(2)-08, TMI_905-MW(2)-09, TMI_906-MW(2)-10
				<u>**Context and Rationale:**</u> The groundwater model has a number of deficiencies, listed below, which raise uncertainties with the modelling exercise, the outputs of the model, and the effects assessments that incorporate those model outputs. These concerns are also tied with concerns raised in other IRs related to characterization of geochemistry on the site (see IR# MW(2)- 06 to MW(2)-10), cover options for TSF and WRSAs (see IR# MW(2)-01 to MW(2)-03 and GW(2)-02), and TSF base and liner (see IR# MW(2)-04 and -05). **1) Recharge for overburden layers** Recharge was based on very limited field observations which were conducted during unusually dry years (Appendix M of the revised EIS, Section 3.2 and Figure 9). Recharge rates have important implications for modelling the quantity of seepage. **2) Recharge for waste rock storage area (WRSA)** As discussed in IR# GW(2)-02, low values were used for infiltration though the WRSA. Using these low values for infiltration will cause the groundwater model to output a lower amount of seepage. **3) Hydraulic conductivity measurements** The hydraulic conductivity measurements as described in Section 5.6.2.2 of the revised EIS do not allow for proper characterization of the overburden layers or the bedrock. In addition, the number of measurements, particularly in key geologic units such as weathered bedrock and the different types of overburden appear to be limited.	

Unique Identifier	Agency IR #	Annex	Agency Group Reviewer	[illegible]
				Furthermore, the data in Table 5.6.2.2-1 of the same section, presenting the hydraulic conductivity values (K) of the overburden layers, indicates either an error in testing or misinterpretation of units **4) Thickness of the overburden** It is stated in Appendix M, Section 5.1.1 of the revised EIS that "Model layer 3 corresponds to the weathered Shallow Bedrock unit. This zone was assumed to have a uniform thickness of 7 m". A rationale for this assumption was not provided in the revised EIS. The thickness of the model layers, particularly the upper layers, will have an effect on seepage flow estimates. These layers are also likely to have the greatest potential for interaction with surface water bodies. **5) Porosity estimates** There is uncertainty with the assumed porosity of 1% for shallow bedrock in the groundwater model (See IR# GW(2)-03) **6) Particle tracking** A particle tracking for the open pit zone of influence was not provided in the EIS and it is unclear how the clay layers that may exist between the tailings storage facility (TSF) and the pit lake may influence the rate of capture of seepage (See IR# GW(2)-04) **7) Sensitivity analyses** A sensitivity analysis for the recharge and infiltration from WRSA is not provided in the revised EIS. A sensitivity analysis for the hydraulic conductivity of key geologic units such as the overburden and weathered bedrock also needs to be factored into the groundwater model. Due to the above deficiencies with the groundwater model, the Agency has uncertainty with the seepage assessment conducted for the Project. The seepage calculations should be based on an updated groundwater model that factors the design of the cover for the TSF and WRSA, TSF base and liner, and concerns raised in other IRs regarding characterization of geochemistry of mine rock and ore. This is important for the Agency to understand as seepage from the Project can lead to contamination of surrounding waterbodies and affect the fish and fish habitat. Seepage can also lead to contamination of private groundwater wells identified in Section 6.11.4.2, which may be used by Indigenous groups.

Unique Identifier	Agency IR #	Annex	Agency / Group Stakeholder	Cross Reference to EIS / Guidelines / Information Request / Response
				Specific Question / Request for Information: A. Provide an updated groundwater model that addresses all seven of the concerns raised in the "Context and Rationale" for this IR. Incorporate the findings from the IRs # MW(2)-08 and GW(2)-02 to GW(2)-04 in the revision of the model. B. Provide the potential range in seepage volumes (e.g. based on sensitivity analyses) from the TSF and WRSA. Also provide travel times for this seepage to various receptor locations. Include in this assessment, an explanation of how seepage volumes would be expected to flow through various geologic layers. C. Determine the capture efficiency of the seepage collection system, and assess the efficiency based on different ditch depths, and whether efficiency can be improved through the use of additional mitigation measures such as pump-back wells. D. Reassess the changes in water quality from seepage emanating from the TSF and WRSA and an updated groundwater model, taking the responses from Questions A to C into consideration. E. Revise the effects to fish and fish habitat and Indigenous health from impacted private groundwater wells taking the response from Question D into consideration. F. Describe additional mitigation measures to prevent adverse effects to fish and fish habitat and Indigenous health from impacted private groundwater wells, if necessary, taking into consideration the response to Question E. G. Characterize residual effects, if any, after the mitigation measures describes in Question F have been implemented. H. Update the follow-up program for potential effects to fish and fish habitat and Indigenous health from impacted private groundwater wells, including objectives and any monitoring measures that will be implemented to verify the predictions of effects and evaluate the effectiveness of the proposed mitigation measures. If follow-up is not required, provide a rationale. I. Incorporate the findings from this IR into the revision of seepage water quality assessment requested in IR# MW(2)-06. **THIS IR SUPERSEDES IR# GW(2)-01.**
				Response: Part A: Treasury Metals had undertaken a review of the inputs, assumptions and outputs of the groundwater model in response to the seven concerns raised in the "Context and Rationale". As detailed below, the review did not identify deficiencies in the assumptions and inputs that would warrant updating the groundwater model. The groundwater model used for the Goliath Gold Project was used to characterize the transport of seepage from the WRSA and TSF, as well as the rate of inflow into the open pit and underground mine workings. Detailed justification for retaining the

Unique Identifier	Agency IR #	Annex	Agency Group Stakeholder	[illegible]
				assumptions and inputs used in the groundwater model are provided below. As described in this response, the groundwater model was not relied on directly to estimate the volume of seepage from the WRSA and TSF, as the volume of seepage from the WRSA and TSF was determined by physical properties of these features as follows: • The seepage from the uncapped WRSA is a function of relative hydraulic residences of infiltration that enters the underlying overburden and bedrock, or infiltration that travels laterally to the perimeter of the WRSA; • The seepage from the capped WRSA is a function of the infiltration through the multi-layer, low permeability cover place over the WRSA at closure; and • The seepage from the TSF is determined by the characteristics and performance of the liner. The groundwater model is consistent with the responses to the issues raised in GW(2)-01B through GW(2)-05. Although the review of the groundwater model confirmed that virtually all of the seepage from the WRSA and TSF during operations would be captured in the drawdown created by dewatering, and would report to the open pit (see the response to TMI_911-GW(2)-04), the review identified that a small percentage of the seepage from the TSF (6%) during operations would escape the drawdown to report to Blackwater Creek. This change has been incorporated in the revised surface water quality model presented in the Goliath Gold Project Water Addendum and summarized in Part I to this information request. Treasury Metals acknowledges that all groundwater models (as applied to real hydrogeological systems) will have uncertainty, as models will always be based on sampling of a small fraction of the subsurface environment. To address these uncertainties, Treasury Metals has committed to groundwater monitoring throughout the entire life-cycle of the enterprise to assess if predictions are reliable. To provide confidence in the post-closure predictions, Treasury Metals propose to update the groundwater model on a regular basis (i.e. every three (3) years) to incorporate the actual monitoring results that reflect the data gathered. Review in this manner provides the opportunity to reassess and update the hydrogeological conceptual model and the groundwater flow and transport predictions made for the impacts of the mine. This information has been incorporated into the Goliath Gold Follow-Up Addendum (which supersedes Section 13 of the revised EIS [April 2018]). ***Detailed Justification*** 1. Recharge for Overburden Layers The rationale for the groundwater recharge applied to the groundwater model was discussed in TMI_072-GW(1)-09, and indicated that measuring low flows from small low gradient runoff-dominated creeks which experience frequent beaver impoundment is problematic and often the accuracy of gauged flows are low. Deriving recharge from baseflow is problematic as the hydrograph response that is attributable to groundwater is highly variable between different geologic strata. This is the reason why baseflow analysis is no longer being used in some countries (e.g., United Kingdom examples documented in Shepley et al. 2012) for the management of large water supply aquifers (i.e., > 100,000 m³/d) with high baseflow indexes (i.e., > 0.50). The problem is worse for runoff dominated creeks with very

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little baseflow given the likely inaccuracy of the gauged low flows. Ultimately the recharge is a calibration parameter that also needs to fit with the estimated hydraulic conductivities to produce the hydraulic gradients observed from groundwater level monitoring as well as being consistent with the low-flows measured in the creeks. Overall, this objective has been achieved with the groundwater model constructed for the Project. Finally, as discussed in TMI_71-GW(1)-08, the recharge values applied to the model are not considered high, which is conservative in following two ways.

- Firstly, the size of the zone of influence from mine dewatering is inversely proportional to the recharge applied to the groundwater model. Lower recharge results in a greater zone of influence, which means a greater potential for the Project to affect private water wells. In contrast, higher recharge rates would result in a smaller zone of influence and thus less private wells being potentially affected.
- Secondly, the seepage estimates from the WRSA and TMF are independent of the recharge applied to the groundwater model and not related to the calibration of the groundwater model. If the calibrated groundwater model had higher recharge it would result in higher groundwater flows and consequently greater dilution factors for seepage from either the WRSA or TSF.

<u>2. Recharge for Waste Rock Storage Area (WRSA)</u>As detailed in the response to TMI_909-GW(2)-02, the assumed infiltration rate of 100-200 mm/year represents a conservative estimate of infiltration from the uncapped WRSA into the underlying overburden and bedrock and not the infiltration rate into the WRSA itself. It should also be noted that the rate of seepage is not related to the rate in infiltration into the WRSA, but rather the relative hydraulic residences of infiltration that enters the underlying overburden and bedrock, to the infiltration that travels laterally to the perimeter of the WRSA. The hydraulic residences (where $c = \frac{flow\ length\ L}{hydraulic\ conductivity\ K}$) are calculated as follows:

- <u>Infiltration that enters underlying bedrock and overburden</u>: Based on the data collected from 2012–2014, the hydraulic conductivity of the shallow bedrock is $1{\times}10^{-6}$ m/s (Section 5.6.5 of the revised EIS [April 2018]). Assuming 1 m of vertical saturated infiltration into the underlying bedrock, the hydraulic resistance is:
  $c = \frac{1\ m}{1{\times}10^{-6}\ m/s} = 1 \times 10^{6}\ s.$
- <u>Infiltration that travels laterally to the perimeter of WRSA</u>: The hydraulic conductivity of the waste rock is likely to be in the range of $1{\times}10^{-2}$ m/s, given the large amount of connected void space in a WRSA. Freeze and Cherry (1979) give the hydraulic conductivity of a gravel in the range of $1{\times}10^{-3}$ m/s to greater than $1{\times}10^{-1}$ m/s. Assuming less than 300 m of lateral travel to the perimeter of the WRSA, the hydraulic resistance is:
  $c = \frac{300\ m}{1{\times}10^{-2}\ m/s} = 3 \times 10^{4}\ s.$

The hydraulic resistance for infiltration that enters the underlying overburden and bedrock is about two (2) orders of magnitude higher than the hydraulic resistance for the infiltration that travels laterally to the perimeter of the WRSA. Therefore, the infiltration rate of 100-200 mm/year from the uncapped WRSA into the underlying overburden and

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				bedrock is considered conservative for the strata present underneath the proposed WRSA and the location of the WRSA on a topographic high at the Goliath Gold Project. Most of the infiltration into the WRSA is likely to travel laterally to the perimeter of the WRSA to be captured by the perimeter ditches. As detailed in the response to TMI_911-GW(2)-04, seepage from the uncapped WRSA during operations and closure will be captured by the open pit, and will not reach the receiving environment. The uncapped WRSA scenario will only exist during operations and for a short period of time during closure when a cover will be constructed over the WSRA. The multi-layer, low permeability dry cover over the WRSA is intended to reduce the rate of infiltration into the WRSA and thus the rate of seepage from the WRSA into the underlying overburden and bedrock. The design and construction of low permeability covers on waste rock and landfills are well understood and covers that can achieve significant infiltration reductions (e.g., >95%) are well documented. The exact design of the cap for the WRSA will be determined during detailed design, but would likely include a compacted clay layer, which can reliably achieve hydraulic conductivities of less than 1×10^{-9} m/s (Hauser et al., 2001). If sufficient clay, of suitable quality are not available on site, Treasury Metals will obtain the necessary materials from other sources to ensure the cap over the WSRA achieves the designed performance. As described in Section 5.3.5 of Appendix M of the revised EIS (April 2018), the performance of a clay cap has been estimated at 30 mm/year using the US EPA HELP model, and hydraulic conductivities of less than 1×10^{-9} m/s for the clay (Hauser et al., 2001). <u>3. Hydraulic conductivity measurements</u> The level of hydrogeological and geotechnical investigations undertaken for the Goliath Gold Project are commensurate with the scale of the project, the complexity of the hydrogeology and the likely perturbation to the groundwater system. What comprises an appropriate hydrogeological characterization is dependent on many factors, which may include: complexity of hydrogeology, magnitude of undertaking, disturbance to the groundwater system, sensitivity of receptors, risk perception, and degree of mitigation to be applied through engineering. It is useful to compare groundwater geotechnical investigations for the Goliath Gold Project with other open pit mines recently constructed in Ontario, namely: Detour Gold; Rainy River Gold; and Victor Diamond mine. • While the Detour Gold project had larger number of hydrogeological/geotechnical measurements than undertaken for the Goliath Gold Project, the Detour Gold open pit is the largest producing goldmine in Canada, and thus a direct comparison to the Goliath Gold Project is not valid. • The Rainy River Gold project also had larger number of hydrogeological/geotechnical measurements than undertaken for the Goliath Gold Project. However, the Rainy River Gold open pit is much bigger than the Goliath Gold Project (10 times the ore production and 16 times the volume of the open pit). In addition, the hydrogeology for the rainy River Gold open pit is also more challenging due to the open pit intercepting a permeable artesian aquifer (mainly the Whiteshell Till). This aquifer and associated conditions have not been encountered at the Goliath Gold Project. • The Victor Diamond had larger number of hydrogeological/geotechnical measurements than undertaken for the Goliath Gold Project. However, the Victor Diamond open pit is about twice the volume of the

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Goliath Gold open pit, and the Victor kimberlite deposit is situated in several karstic dolostone formations. The groundwater pumping rates for the Victor Diamond open pit are two order of magnitudes greater than predicted for the Goliath Gold open pit.

Therefore, it would not be reasonable to expect the Goliath Gold Project to collect as many of hydrogeogical/geotechnical measurements as were collected for the Detour Gold, Rainy River Gold or Victor Diamond mining projects.

Regarding the information in Table 5.6.2.2-1 of the revised EIS (April 2018), these data are almost all correct and are the same as given in the AQTESOLVE analysis sheets provided in Appendix C of Appendix M of the revised EIS (April 2018) with the geological data corresponding to the borehole logs of Appendix C of Appendix M of the revised EIS (April 2018).

The exception is for Well 5A where the hydraulic conductivity should have been rounded to 1.1×10^{-6} m/s rather than 1.0×10^{-6} m/s. The geometric mean and arithmetic mean should be 9.1×10^{-7} m/s and 9.6×10^{-7} m/s rather than 9.2×10^{-7} m/s and 9.8×10^{-7} m/s, respectively. These typos concerning the means also occur in Section 4.1 of Appendix M of the revised EIS (April 2018). The hydraulic conductivity values are largely representative of silty sands that occur at the base of the overburden and are consistent with published literature (e.g., Freeze and Cherry, 1979). There is one anomalous value (Well 5A), which gave a value of 1.1×10^{-6} m/s, untypical for the screened unit of clay, as noted in Section 4.1 of Appendix M of the revised EIS (April 2018). The log for Well 5A (Appendix A of Appendix M of the revised EIS [April 2018]) shows three split spoons across the screened interval, which all indicate clay. It is possible that the higher than normal hydraulic conductivity may be due to a thin sand or gravel seam occurring between the split spoon samples not being recognized during drilling of the borehole.

<u>4. Thickness of the Overburden</u>

The upper three (3) layers of the groundwater model correspond to:

- Model Layer 1 is the surface layer and corresponds to the Clay, Sand and Gravel, the upper layer of the Sand-Clay/Silt Sand unit or bedrock knoll, depending on the surficial geology.
- Model layer 2 corresponds to the Basal Sand unit in the areas where it is expected to be thicker than 0.3 m. The basal band layer is discontinuous layer at the base of the clay, that is, on average, 3 to 4 m thick, when present.
- Model layer 3 corresponds to the weathered Shallow Bedrock unit, which was assumed to have a uniform thickness of 7 m. It is widely recognized that the shallow weathered and fractured bedrock tends to be the more permeable than the deeper bedrock in a shield crystalline bedrock setting, such as occurs at the Goliath Gold Project.

The thickness of the overburden, basal sands vary over the modelling domain based on the available data. TMI_951-GW(2)-01B_Figure_1, TMI_951-GW(2)-01B_Figure_2, and TMI_951-GW(2)-01B_Figure_1 show the thickness maps for the Basal Sands (Model Layer 2), Clay (Model Layer 1) and Sand and Gravel (Model Layer 1 and

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				2) respectively. For each of the maps, surface water bodies, private wells and monitoring wells, as well as the mining facilities are shown. Bedrock sits beneath the Basal Sand, Clay, and Sand and Gravel layers, with the upper 7 m identified as weathered and fractured shallow bedrock. <u>5. Porosity estimates</u> To clarify, 0.01 (or 1%) was used as the kinematic porosity for the shallow bedrock, not the total porosity. When trying to understand the travel times for seepage in bedrock, the parameter of greatest importance is the kinematic porosity (or effective porosity). The kinematic porosity, which describes the ability of a fluid to travel through a media, is always lower than the porosity. Kinematic porosities for weathered bedrock provided in literature (Worthington, Smart and Ruland, 2012), suggests that values in the range of 0.01%–0.1% are possible carbonate aquifers, but posits a value of 1% is possible. The kinematic porosity of 0.01 used for the groundwater velocity calculation (memo to Mark Wheeler, Treasury Metals; "Additional Hydrogeological Information", dated March 29, 2018, as appended to Appendix M) represents the porosity of open, weathered fractures at the bedrock surface. The Basal Sand at the base of the overburden is discontinuous as noted in the memo referred to above. Nevertheless, as fractures in the shallow bedrock will also be discontinuous, it is correct that flowpaths <u>6. Particle Tracking</u> Particle tracking has been undertaken with the groundwater model representing the ultimate dewatered mine condition with particles released from the TSF. As described in the response to TMI_911-GW(2)-04, the particle tracking plots for TSF during operations (TMI_911-GW(2)-04_Figure_1) show that, of the seepage leaving the TSF, 46% is captured by the open pit; 34% is captured by the TSF perimeter drains; 14% is captured by the minewater pond, and 6% escapes the operations area and reports to Blackwater Creek. The proportion that escapes the operations area to report to Blackwater Creek occurs along the eastern perimeter of the TSF. The particle tracking for the WRSA during operations (see TMI_911-GW(2)-04_Figure_2) indicates that all water seeping from the base of the uncapped WRSA during operations is captured by the open pit. <u>7. Sensitivity Analyses</u> Sensitivity analyses have already been undertaken with the groundwater model for the shallow bedrock and basal sand as shown in Table 9 of Appendix M to the revised EIS (April 2018). The focus of this sensitivity analysis was on the identification of seepage volumes into the open pit and underground mine workings, instead of the effects on the rates of seepage from the WRSA. As detailed in the responses to TMI_909-GW(2)-02 and TMI_911-GW(2)-04, all of seepage from the uncapped WRSA during operations and closure will be captured by the open pit, and will not reach the receiving environment. The uncapped WRSA scenario will only exist during operations and for a short period of time during closure when a low-permeability dry cover will be constructed over the WSRA as described in Section 3.16.8. The multi-layer, low permeability dry cover over the WRSA is intended to reduce the rate of infiltration into the

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				WRSA and thus the rate of seepage from the WRSA into the underlying overburden and bedrock. The design and construction of low permeability covers on waste rock and landfills are well understood and covers that can achieve significant infiltration reductions (e.g., >95%) are well documented. The exact design of the cap for the WRSA will be determined during detailed design, but would likely include a compacted clay layer, which can reliably achieve hydraulic conductivities of less than 1×10^{-9} m/s (Hauser et al., 2001). If sufficient clay of suitable quality are not available on site, Treasury Metals will obtain the necessary materials from other sources to ensure the cap over the WSRA achieves the designed performance. Seepage from the capped WRSA is driven by the rate of infiltration through the multi layered, low permeability cover, and would not limited by the hydraulic conductivity of the geologic layers below the WRSA.

Part B:

Seepage Volumes and Travel Times from the WRSA

The rate of seepage from the WRSA will be different depending on whether the WRSA is uncapped or capped. The uncapped WRSA will only exist during operations and closure, when a low-permeability dry cover will be constructed over the WSRA. As detailed in the responses to TMI_909 GW(2)-02, the rate of seepage from the uncapped WRSA is related to relative hydraulic residences of infiltration that enters the underlying overburden and bedrock, to the infiltration that travels laterally to the perimeter of the WRSA. Since the hydraulic resistance is two orders of magnitude higher for the infiltration that enters the underlying overburden and bedrock than the infiltration that travels laterally to the perimeter of the WRSA, the majority of the infiltration into the uncapped WRSA will travel laterally to the perimeter of the WRSA where it will be captured by the perimeter ditches.

The assumed range of 100–200 m³/d of seepage from the uncapped WRSA into the underlying overburden and bedrock is based on an infiltration rate from the WRSA of 100–200 mm/year, as shown in Table 1. Given that the annual precipitation rate in the Dryden area is 719.7 mm/year, 100–200 mm/year of infiltration entering the underlying overburden and bedrock represents between 13.9% and 27.8% of the precipitation, which is a conservative estimate given the difference in the hydraulic resistances. Regardless of the infiltration rates and seepage volumes, all of seepage from the uncapped WRSA during operations and closure will be captured by the open pit, and will not reach the receiving environment receiving. Seepage from the uncapped WRSA that is captured by the open pit will be incorporated into the water management system where, to the extent possible, it will be used in the process. Excess water not required in the process will be treated to meet PWQO, or background if background is greater than PWQO, prior to discharge to Blackwater Creek.

Table 1: Range of Seepage from WRSA

Scenario	Area of WRSA (m²)		Infiltration from WRSA (mm/yr)	Seepage from WRSA	
	(ha)	(m²)		(m³/year)	(m³/day)
Uncapped WRSA	36.5	365,000	100	36,500	100

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			200	73,000	200
Capped WRSA	36.5	365,000	30	10,950	30

The rate of seepage from the capped WRSA will be a function of the multi-layer, low permeability dry cover constructed as part of the closure activities. The exact design of the cap for the WRSA will be determined during detailed design, but would likely include a compacted clay layer, which can reliably achieve hydraulic conductivities of less than 1×10^{-9} m/s (Hauser et al., 2001). As described in Section 5.3.5 of Appendix M of the revised EIS (April 2018), the performance of a clay cap has been estimated at 30 mm/year using the US EPA HELP model, and hydraulic conductivities of less than 1×10^{-9} m/s for the clay.

During post-closure, 10 m³/d of seepage from the capped WRSA is predicted to leave the Project and eventually reach Thunder lake. The remaining 20 m³/d of seepage from the capped WRSA will report to the open pit. The present hydraulic groundwater gradient between the proposed location of the WRSA and Thunder Lake (Figure 10, Appendix M) is approximately 0.02. The basal sand of the overburden is known to be discontinuous and therefore the shallow bedrock (top ~10m) is likely the only aquifer horizon with lateral continuity between the WRSA and Thunder Lake. The average linear velocity of groundwater in the shallow bedrock may be of the order of 2×10^{-6} m/s (~ 0.2 m/d) assuming a hydraulic conductivity of the shallow bedrock of 1×10^{-6} m/s (Table 8, Appendix M), and a kinematic porosity of 0.01 (see response to TMI_910-GW(2)-03, and part A.5 of this response). Travel times from the WRSA to Thunder Lake may be expected to be of the order of fifteen years given a flowpath length of about 1 km.

Seepage Volumes and Travel Times from the TSF

The estimated seepage rate for the TSF liner is 2.4 m³/day. This is based on current industry research presented by Kerry Rowe et al. (2016) "Leakage Through Holes in Geomembrane Below Saturated Tailings" (based on 40L/ha/day × 60 ha). The research suggests that this rate is an approximate upper bound estimate for a properly installed HDPE geomembrane underlying mine tailings. This seepage rate is independent of the soil characteristics underneath the TSF liner; therefore, the seepage from the TSF would be unaffected by changes in the hydraulic conductivity of key geologic units, such as overburden and weathered bedrock. As such, the seepage rate of 2.4 m³/day from the TSF is unaffected by the results of the sensitivity analysis.

The review of the groundwater modelling results completed confirmed (see response TMI_911 GW(2)-04) that a portion (6% or 0.1 m³/d) of the seepage from the TSF during operations would escape the operations area to report to Blackwater Creek. The seepage that reaches Blackwater Creek during operations has been incorporated into the updated surface water quality modelling presented in the Water Addendum included as part of the Round 2 responses. The portion that escapes the operations area to report to Blackwater Creek occurs along the eastern perimeter of the TSF. During post-closure, when groundwater recovers to near pre-development levels, 0.8 m³/d of seepage from the TSF is estimated to leave the Project and reach Blackwater Creek. The remaining 1.6 m³/d of seepage from the TSF during post-closure is estimated to report to the open pit. The groundwater particle tracking (Figure 24 of Appendix M) indicated trace quantities of post-closure seepage from the TSF may also reach Thunder

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				Lake Tributary 3, Hoffstrom's Bay Tributary, and Thunder Lake. To conservatively capture potential effects associated with these trace amounts, the updated surface water quality modelling presented in the Water Addendum (included as part of the Round 2 responses), included 0.1 m³/d of seepage from the TSF to each of these waterbodies. Given the trace amounts of seepage from the TSF to these receptors, it would not be realistic to estimate travel times. However, the updated surface water quality modelling presented in the Water Addendum (included as part of the Round 2 responses), assumes that seepage leaving the TSF will have reached the receiving environment, and thus are incorporated in modelling predictions. <u>Part C:</u> The seepage collection ditches will be constructed according to good engineering practice. As described in the response to TMI_910-GW(2)-03, Treasury Metals has advanced their engineering for the Project, which includes additional details regarding the design of seepage and runoff collection ditches, as described in Section 3.7.3 of the revised EIS. While Figure 3.7.3-1 of the revised EIS (April 2018) provides typical cross sections for seepage and runoff collection ditches, Figure 3.7.3-2 of the revise EIS (April 2018) provides modifications to the typical ditch construction to address situations where existing conditions may pose challenges to the collection and capture of seepage including deep bedrock in both low and high permeability soils. As described in TMI_886-SW(2)-203, specific details (e.g., lining details) for the seepage collection ditches will be determined as part of the detailed design process to suit the site conditions. As shown in Figures 3.7.3-1 and 3.7.3-2 of the revised EIS (April 2018), the typical ditch lining would include a geosynthetic liner (HDPE or similar material) and/or slush grout depending on the conditions along the ditch alignment to minimize seepage from the ditches. Riprap and non-woven geotextile would be placed over the geosynthetic liner for erosion protection. The contact water ditches, as shown on Figure 3.0-1A of the revised EIS (April 2018) will be lined because the contact runoff water may contain materials that may need to be collected and treated prior to its release to the environment (note that the current arrangement for the Project includes for collection and treatment of all contact water as required). It should be noted that measures such as pump back wells are usually implemented after a problem has been identified by monitoring. When deciding on the placement of pump back wells, ditches frequently serve a monitoring function. Groundwater flow in bedrock and overburden is often restricted to a few discrete locations, which may be difficult to locate in monitoring wells, but are usually intercepted by long linear features such as ditches. By sampling of the ditches and visual inspection, contaminated groundwater can often be identified, and once identified, discharge controlled by pump back wells. In this manner the depth of the ditch is not necessarily the most critical design factor. Ditches should be seen as just one part of an integrated system of groundwater management that includes monitoring, hydraulic control, capping and lining of facilities to reduce the potential for the movement of contaminated groundwater. <u>Part D.</u>

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				The surface water quality assessment has been updated to reflect changes related to seepage from the TSF and WRSA that could affect surface water quality, as described in the responses to Parts A through C. The revised surface water quality assessment is provided in the Goliath Gold Water Addendum and specifically the information provided in this response has been incorporated into Section W6.5 (Seepage from WRSA and TSF to Offsite Receiving Waters). The Water Addendum presents the updated water quality assessment that consolidates all of the identified Round 2 changes and concerns including those changes to groundwater and mine waste that would affect surface water quality. Part E. **Revised Assessment of Effects on Fish and Fish Habitat** The results of the updated water quality assessment are presented in Section W8 (Revised Predictions of Surface Water Quality Effects) of the Water Addendum. Residual adverse effects for surface water quality were identified to be those situations when the predicted concentration of the indicator compounds as a result of the Project are higher than the concentrations for existing conditions. The resulting residual adverse effects predicted for surface water quality modelling are provided in Section W9 (Revised Predictions of Residual Surface Water Quality Effects) for the operations and post-closure phases of the Project. None of the predicted residual adverse effects of the Project on surface water quality during either operations or post-closure exceed the respective water quality criteria established to protect aquatic life (i.e. PWQO). To state that another way, the updated surface water quality modelling continues to indicate that surface water quality will be largely unchanged as a result of the Project, with resulting water quality being the same as, or slightly improved from the existing condition for most parameters. In the situation where the water quality is predicted to the higher than existing condition, the resulting water quality remains below the PWQO for the protection of aquatic life. Therefore, there are no predicted effects to fish and fish habitat as a result of changes to surface water quality as a result of the Project, including seepage from the TSF and WRSA. **Revised Assessment of Effects on Indigenous Health from Private Groundwater Wells** During operations, dewatering of the open pit and underground mine workings will result in a drawdown of groundwater levels, which will continue through the closure phase until the open pit is filled. As described TMI_911-GW(2)-04, none of the seepage from the WSRA and only 6% (0.14 m^3/day) of the seepage from the TSF is predicted to escape the effects of groundwater drawdown to reach the receiving environment. The seepage from the TSF that escapes the drawdown during operations reports directly to Blackwater Creek and thus would not affect any private groundwater wells. During operations the seepage from the WRSA and TSF that do not escape the effects of drawdown will be incorporated into the water management system where, to the extent possible, it will be used in the process. Therefore, during operations none of the seepage from the WRSA and TSF will reach private groundwater wells and pose potential risk to the health of Indigenous people who rely on those wells. During post-closure, there were no material increases in volumes of seepage from either the WRSA or TSF reaching Thunder Lake predicted as a result of the issues raised and responded to in Parts A through D. Therefore, there are

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				no changes to the predicted effects of the Project on Private groundwater wells from those presented in the Revised EIS (April 2018). Section 6.10.4 of the revised EIS (April 2018), identified that although seepage from the WRSA may reach the private water wells along Thunder Lake, it will be diluted by between 5 to 25 times. The modelling also identified that, with a liner beneath the TSF, only trace amounts of seepage from the TSF would have the potential to reach the private wells along Thunder Lake. The seepage from the TSF would also be diluted 5 to 25 times. The resulting groundwater quality in the private water wells along Thunder Lake would not noticeably change from current conditions as a result of seepage from either the WRSA or the TSF. Therefore, during post-closure, seepage from the WRSA and the TSF will not pose potential risk to the health of Indigenous people who rely on those wells. Part F. As stated in the response to Part E, with respect to seepage from the TSF and WRSA, the revised assessment of effects on fish and fish habitat and the revised assessment of effects on Indigenous health from private groundwater wells are unchanged from the results presented in the revised EIS (April 2018). Therefore, no additional mitigation measures have been identified as being required to prevent effects to fish and habitat, and Indigenous health, as a result of changes in seepage emanating from the TSF and WRSA. Part G. As described in the responses to Parts A through F, there are no changes to the adverse effects to fish and habitat, and Indigenous health, than those described in the revised EIS (April 2018) as a result of changes in seepage emanating from the TSF and WRSA. Therefore, no residual adverse effects were identified as a result of changes in seepage emanating from the TSF and WRSA. Part H. The Follow-Up Program for Groundwater Quantity and Quality has been revised to reflect the issues and concerns with respect to seepage from the WRSA and TSF identified in this Round 2 information request. Specifically, Treasury Metals propose to update the groundwater model on a regular basis (i.e. every three (3) years) to incorporate the actual monitoring results that reflect the data gathered. Review in this manner provides the opportunity to reassess and update the hydrogeological conceptual model and the groundwater flow and transport predictions made for the impacts of the mine. As part of the Round 2 information request process, Treasury Metals received a number of questions regarding the Follow-Up Program. As a result, Treasury Metals has prepared the Goliath Gold Project Follow-Up Program Addendum to capture the responses to these issues and provide a consolidated update to the Follow-Up Program. The Goliath Gold Project Follow-Up Program Addendum supersedes Section 13 of the revised EIS (April 2018). Part I.

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				The findings of this IR (TMI_951-GW(2)-01B) have been used to update the various models relied on for predicting the effects of the Project on groundwater, seepage, surface water quality, and ultimately the effects on fish and fish habitat from changes to surface water quality. The models relied on in the effects assessments are summarized as follows. **Groundwater Model** The groundwater model used for the Goliath Gold Project was used to characterize the transport of seepage from the WRSA and TSF, as well as the rate of inflow into the open pit and underground mine workings. As described in Parts A through D, the groundwater model was not relied on directly to estimate the volume of seepage from the WRSA and TSF, as the volume of seepage from the WRSA and TSF was determined by physical properties of these features as described below: • The uncapped WRSA is a function of the infiltration from the WRSA into the underlying overburden and bedrock; • The capped WRSA is a function of the infiltration through the multi-layer, low permeability cover place over the WRSA at closure; and • The TSF is determined by the characteristics and performance of the liner. The current groundwater model was reviewed in support of the Round 2 process, and is consistent with the responses to the issues raised in GW(2)-01B through GW(2)-05. **Geochemical Models** The quality of seepage from the WRSA and TSF as well as the resulting water quality in the pit lake was determined as part of the geochemical analyses presented in Section 6.3 of the revised EIS (April 2018), Section 5 of Appendix JJ (The Water Report) of the revised EIS, as modified by any changes required in support of the Round 2 process as described in MW(2)-01 though MW(2)-12. **Surface Water Model** The model used for evaluating the effects of the Project on surface water quality is an integrated model that combines existing conditions, releases and discharges from the Project, seepage from the WRSA and TSF, and changes in surface water flow as a result of the Project. Effectively, the outputs from the groundwater and geochemical models are inputs to the surface water model. Given the number of Round 2 information requests regarding changes to the groundwater and mine waste (as well as surface water) technical disciplines, the surface water quality model has been revised to capture those changes. All of the changes as well as a revised prediction on surface water quality have been described in detail in the Goliath Gold Project Water Addendum. References:

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				Shepley, M.G., Whiteman, M.I, Hulme P.J. & Grout, M.W. 2012. Groundwater Resources Modelling: a Case Study from the UK. Geological Society, London, Special Publication, v. 364.
				<u>**Agency Comment on Draft Response:**</u> A. This IR is extensive and fundamental to environmental effects. Below are some preliminary comments to guide the technical discussion on December 11 The response indicates that the recharge values for existing hydrogeological units are irrelevant, and do not need to be provided because the seepage rates will be defined by the physical characteristics of the TSF's HDPE liner and the multi-layer cap that will be emplaced over the WRSA. However, the information being sought by the IR is fundamental to the calibration of the hydrogeological model, which is needed to ensure that the model can make valid predictions of groundwater behavior, irrespective of the seepage rates of the TSF and WRSA. For example, particle tracks that predict the direction of groundwater flow require a properly calibrated groundwater model. The response also suggests that estimating recharge as a lower value is a positive thing since it will generate a larger zone of influence and thereby reflect a "greater potential for the Project to affect private water wells". There are two concerns with that approach: 1. A low recharge value underestimates seepage volumes, which thereby underestimates the potential effect to surface water quality. 2. The larger zone of influence generated by lower recharge may be overestimating the zone of influence generated by the open pit, which the Proponent claims will draw 46% of the seepage from the TSF into the pit during the Operations Phase. Of further note, the potential for seepage from the Minewater Pond to enter Blackwater Creek is not assessed, and there is no baseline data collected in that region (See Comment ID# 7 for Water Addendum). **Clarify the response to take into account the above noted comments.** B. The assumptions made regarding the rate of seepage through the TSF liner and the capped WRSA appear to be overly optimistic: • <u>TSF Liner:</u>. It is unclear if seepage through the TSF perimeter dams has been calculated. The reviewer was unable to find this in the revised EIS or follow up comments. Based on the discussion of how the seepage rate was calculated through the base of the liner, it appears that seepage through the perimeter dams has not been accounted for, which may significantly increase the amount of seepage from the TSF (thereby affecting surface water quality and the ability of the wet cover to be maintained on the tailings in perpetuity). • <u>Uncapped WRSA:</u> The infiltration rate into the uncapped WRSA is presented as being conservative because they are estimating more infiltration than they feel warranted into the weathered bedrock and overburden. This does not take into account that it is the overall amount of infiltration into the WRSA that will generate the

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				seepage that can affect surface water quality in the Pit Lake, which includes radial flow outward from the base of the WRSA, rather than just the component that passes through the bedrock and overburden. The overall amount of recharge into the WRSA, estimated by the Proponent to be 100-200 mm/year are low as compared to estimates made by proponents of other mines that feature waste rock piles. **Confirm the assumptions for the volume of infiltration/ recharge into the WRSA.** <u>Capped WRSA:</u> The response makes a non-conservative assumption that the multi-layer cap over the WRSA will achieve a hydraulic conductivity of less than 1X10-9 m/s. Although this might be achievable in the context of a landfill (the citation provided is in relation to landfills), this is not achievable on a sustained basis for the cap. A number of physical processes will degrade the performance of the cap; these include: settlement and slumping of the waste rock pile, freeze-thaw cycles, and the drying out of the clay that will irreversibly increase the hydraulic conductivity through the clay (regardless of the re-wetting of the clay). Thus, the infiltration of water and subsequent release of seepage are underestimated. **Please clarify, for the capped WRSA scenario, the potential effects of higher seepage volumes from the ARD-generating WRSA on surface water quality.** D-I. These sections of the response need to be re-evaluated after the issues in Part A-C, and any other inter-related issues from other IRs have been adequately addressed.
				<u>[illegible]</u> <u>Part A.</u> As discussed in the December 18, 2018 meeting with the Agency and their technical reviewers, further clarification is provided regarding the flow paths in and around the TSF during mining. According to the site investigation (Figures 4 an 5a of Appendix M) the TSF is underlain by Sand-Clay/Silt-Sand sequence. It differs from the overburden at the Open Pit and WRSA and further to the west towards Thunder Lake (Figures 4 and 5b of Appendix M) that has a relatively thick aquitard of Clay. As part of the Project design, the TSF will be constructed with an HDPE liner at its base, or a liner with similar performance. The discharge pathways of leakage from the TSF has been assessed with the groundwater model for the following: • The end of operations, assuming the open pit and underground mine are fully dewatered (see TMI_911-GW(2)-04_Figure_1); • Post-closure, assuming the open pit and underground mine are fully re-saturated and a wet cover over the TSF (see Figure 22 of Appendix M); and • Post-closure, assuming the open pit and underground mine are fully re-saturated and a dry cover over the TSF (see Figure 24 of Appendix M).

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				These simulations have been carried out without the TSF liner so that particle tracking can be undertaken in a physically consistent and conservative manner from the entire footprint of the TSF. The particle tracks simulated fall into two flow path categories: 1. Particles that go into the shallow sand aquifer, that move horizontally and are captured by the perimeter ditches or the minewater pond. These particles represent the release from the edges of the TSF where the flow path is relatively short; and 2. Particles that move vertically beneath the TSF, through the Silt/Clay aquitard to the basal sand / shallow bedrock. The vertical flow through the Clay/Silt aquitard occurs from the more central portion of the TSF as this short vertical flow path has a lower hydraulic resistance than the much longer horizontal flow path to the perimeter of the TSF. Overall, this is considered reasonable as the Clay/Silt aquitard beneath the TSF is likely less effective in limiting vertical flow than the clay aquitard to the south and west of the TSF. The resultant deeper flow path along the basal sand / shallow bedrock results in much longer particle tracks. In the fully dewatered mine working scenario (see TMI_911-GW(2)-04_Figure_1) the particles are mostly captured by the open pit. This flow bypasses surfaces water features (Hoffstrom's Bay Tributary and Blackwater Creek Tributary 2) that are situated on the clay aquitard. In the re-saturated mine working scenario (Figures 22 and 24 of Appendix M) the particles discharge at the open pit and surface water features (Thunder Lake Tributary 2 and 3, Thunder Lake, Hoffstrom's Bay Tributary and Blackwater Creek), but in places bypassing surfaces water features that are situated on the clay aquitard. Presently node-by-node flows of the rivers / creeks pre-mining and during mining have not been generated from the results of the groundwater model. The groundwater model has been run on the Visual Modflow platform and this program currently does not directly output this information in a format that can be readily plotted. <u>Minewater Pond</u> The minewater pond will be used during operations to manage the water from the open pit and will be used as a source of water to support the extraction process. The quality of the water within the minewater pond is a function of the quantity and quality of the sources of water. Table A1 provides a listing of the sources of water that will ultimately contribute the water quality within the minewater pond.

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Table A1: Source of Water to the Minewater Pond		
Source	**Volume (m³/day)**	**Fraction of Inflow**
Groundwater dewatering	1,320.0	49.89%
Seepage through the base of uncapped WRSA (ARD affected)	150.0	5.67%
Seepage from the toe of uncapped WRSA (batch treated) (1)	569.7	21.53%
Rainfall on portions of open pit with waste rock (ARD affected)	402.2	15.20%
Rainfall on portions of open pit without waste rock	201.1	7.60%
Seepage from the TSF to the open pit (including ditches)	2.5	0.09%
Seepage from TSF to the minewater pond	0.4	0.02%
Total Volume of the Open Pit	**2,646**	**—**

Note: The runoff from the toe of the WRSA will be collected in a segregated collection pond, tested and treated, if necessary, using batch lime addition prior to the integration into the water management system.

It should be noted that some of the contributions to the minewater pond listed in the above table include the potential effects of ARD (seepage from the uncapped WRSA and rainfall on portions of open pit with waste rock). In the case of the seepage from the toe of the waste rock storage area, this water will be collected in perimeter ditches around the WRSA and directed to a segregated runoff collection pond where the water will be tested and treated (as required) using batch lime addition prior to being integrated in the water management system, as discussed during the December 18, 2018 and January 10, 2019 technical meetings. The resulting water quality within the minewater pond, including the contributions of ARD, were included in the calculations of water treatment plant influent quality values presented in TMI_887-SW(2)-04_Table_1 and TMI_887-SW(2)-04_Table_2. Any seepage from the minewater pond would have the same quality as the water within the minewater pond, as detailed in TMI_951-GW(2)-01B_Table_A2.

As described in the response to TMI_911-GW(2)-04, refined particle tracking completed for the Project identified that all of the seepage from the WRSA would be captured by the drawdown created by the dewatering activities, and would report to the open pit during operations. Additionally, the refined particle tracking identified that 94% of the seepage from the TSF would also be captured by the drawdown and report to the open pit. Only a small amount of seepage from the eastern edge of the TSF (6% of the total seepage through the floor and walls of the TSF) would escape the drawdown and leave the site during operations. Based on this modelling, and the proximity of the minewater pond to the open pit, all of the seepage from the minewater pond is expected to be captured by the drawdown and report to the open pit. None of the seepage from the minewater pond is expected to leave the site, have an effect on surface water quality, including Blackwater Creek, or have an effect on fish and fish habitat.

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				The current conceptual design for the closure of the Project includes the decommissioning of the minewater pond and the grading of that portion of the site to drain towards the open pit. <u>Groundwater/Surface Water Interactions</u> During the December 18, 2018 meeting between Treasury Metals and the Agency and their technical reviewers, a discussion point was raised regarding a desire to see the histograms of the node-by-node output rates from the groundwater model to better understand the groundwater discharge variations on surface water flows. As discussed in the December 18, 2018 meeting, the groundwater model used for evaluating the effects of the Project was a steady-state model, therefore only a single output rate is available for each node. However, by combining the nodes within each of the four watersheds overlaying the Goliath Gold Project (see Figure 6.9.2.3-1 of the revised EIS [April 2018]), the histograms provided in TMI_951-GW(2)-01B_Figure_A1 were produced. These histograms show the following two distinct set of results: • **Pre-mine:** These results represent the conditions that currently exist in the area, before mining and dewatering activities start. • **Ultimate Mine:** These represent the results when the mining activities are at their maximum extent, and the corresponding drawdown from dewatering in maximized. For clarity, the two sets of results are shown side-by-side for each watershed, with the negative nodal flows representing flows from surface to groundwater (i.e., recharge) and the positive flows representing flows from groundwater to surface water (i.e., discharge). The changes in the integrated discharge/recharge values were also incorporated into the surface water quantity modelling presented in the revised EIS (April 2018), and used to determine potential effects of changes in flows on fish and fish habitat as presented in the Goliath Gold Project Fish Addendum. Two additional figures are also included as part of this response, which show how the discharge/recharge outputs from the model vary over the modelling domain. TMI_951-GW(2)-01B_Figure_A2 shows the node-by-node results for the pre-mining conditions, while TMI_951-GW(2)-01B_Figure_A3 shows the comparable results for the ultimate mine case. <u>Part B.</u> <u>TSF Liner</u> The HPDE liner or material with similar performance would be placed during the initial construction activities and would cover the floors and walls of the initial of the TSF construction, shown as Stage 1 on Figure 3.7.2-3 of the revised EIS (April 2018). This figure has been updated as TMI_951-GW(2)-01B_Attachment_1 to reflect the inclusion of the liner material, as well as the soil cover material over the liner to protect it until covered by tailings. As described in Section 3.7.2 of the revised EIS (April 2018), the subsequent stage of the TSF construction (Stages 2 through 4) would be constructed using clay on the inboard slope to limit the potential for seepage through the walls of

Unique Identifier	Agency IR #	Annex	Agency / Group / Stakeholder	Proponent Reference to Preliminary Information Request Response
				(continued below)

the TSF. Additional liner material would be placed on the inboard side of the vertical drains for each lift. Given the floor and initial walls of the TSF (Stage 1) will be covered with the liner material, only the vertical areas above the crest of the Stage 1 dam (i.e., the 6 vertical metres of dam comprising the Stage 2, 3 and 4 lifts) will not be covered by the original liner. This "wall area" represents just 3% of the TSF basin.

The effect on the wall areas above the original liner on the overall seepage rates from the TSF would be relatively small, possibly increasing the overall seepage for the later stages of the operations to as much as 3.13 m^3/d. This number is calculated assuming the rate of seepage through the wall areas for the Stage 2, 3 and 4 lifts (which would have material on the inboard side of the vertical drains) would have an order of magnitude higher rate of seepage per unit area than the original liner. This higher rate of seepage per unit area was assumed given there would be joins between the new HPDE materials and the original liner.

To reflect this adjustment to the overall seepage rate from the TSF, the water addendum has been updated. Specifically, the modelling for pit lake water quality and surface water quality will both be adjusted to include this higher overall seepage rate from the TSF. In addition, this higher rate of seepage from the TSF was incorporated into the multi-year water cover model described in the response to TMI_898-MW(2)-02.

<u>Uncapped WRSA</u>

As described in the response to TMI_909-GW(2)-02, Part A, the assumed infiltration rate of 100-200 mm/year represents a conservative rate of infiltration from the uncapped WRSA into the underlying overburden and bedrock and not the infiltration rate into the WRSA itself. As the waste rock in the WRSA will have a large amount of connected void space, it is assumed that all of the precipitation will infiltrate into the WRSA. The infiltration into the WRSA will either infiltrate into the underlying overburden and bedrock, or drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches. The amount of infiltration that either enters the underlying overburden and bedrock, or travels laterally to the perimeter of the WRSA depend on the relative hydraulic residences (where $c = \frac{flow\ length\ L}{hydraulic\ conductivity\ K}$). The hydraulic resistances are calculated as follows:

- <u>Infiltration that enters underlying bedrock and overburden</u>: Based on the data collected from 2012–2014, the hydraulic conductivity of the shallow bedrock is $1{\times}10^{-6}$ m/s (Section 5.6.5 of the revised EIS [April 2018]). Assuming 1 m of vertical saturated infiltration into the underlying bedrock, the hydraulic resistance is: $c = \frac{1\,m}{1{\times}10^{-6}\,m/s} = 1 \times 10^{6}\ s.$
- <u>Infiltration that travels laterally to the perimeter of WRSA</u>: The hydraulic conductivity of the waste rock is likely to be in the range of $1{\times}10^{-2}$ m/s, given the large amount of connected void space in a WRSA. Freeze and Cherry (1979) give the hydraulic conductivity of a gravel in the range of $1{\times}10^{-3}$ m/s to greater than $1{\times}10^{-1}$ m/s. Assuming less than 300 m of lateral travel to the perimeter of the WRSA, the hydraulic resistance is: $c = \frac{300\,m}{1{\times}10^{-2}\,m/s} = 3 \times 10^{4}\ s.$

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				The hydraulic resistance for infiltration that enters the underlying overburden and bedrock is about two (2) orders of magnitude higher than the hydraulic resistance for the infiltration that travels laterally to the perimeter of the WRSA. Therefore, most of the infiltration into the WRSA is likely to travel laterally to the perimeter of the WRSA to be captured by the perimeter ditches. Vertical infiltration into the underlying bedrock and overburden would only become significant if there was a potential for water to pond (e.g., being trapped in a topographic basin). As the WRSA is located on a topographic high next to the open pit, the potential for ponding and the build-up of a significant water table within the WRSA is very limited. Consequently, the infiltration rate of 100-200 mm/year into the underlying overburden and bedrock is conservative and no changes are required to the modelled infiltration rate for the uncapped WRSA. The waste rock in the WRSA will have a large amount of connected void space. As a result, it is assumed that all of the precipitation will infiltrate into the WRSA. Using the annual rates of precipitation in the Dryden area over the last 50 years (1969–2017), annual precipitation has ranged from 392 to 883 mm/year, with an average value of about 658 mm/year, and 100–200 mm/year is assumed to infiltrate into the underlying overburden and bedrock, then 458–558 mm/year of infiltration into the WRSA would drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches. As discussed in both the December 18, 2018, and the January 10, 2019 meetings with the Agency and their technical reviewers, the infiltration into the WRSA that would drain laterally through the WRSA to the perimeter of the WRSA would be captured by the perimeter ditches and directed to segregated runoff collection pond (collection pond #3 on Figure 3.0.1A of the revised EIS [April 2018]). The water within the collection pond would be monitored, and if required, the pond would be treated (e.g., lime addition) prior to its incorporation into the overall water management system. It is important to remember that the uncapped WRSA scenario will only exist during operations and for a short period of time during closure when a low-permeability, multi-layer, dry cover will be constructed over the WSRA as described in Section 3.16.8. As detailed in the response to TMI_911-GW(2)-04), seepage from the uncapped WRSA during operations will be captured by the drawdown created by dewatering and would enter the open pit. The seepage from the WRSA that drains laterally to the perimeter of the WRSA would be captured by the perimeter ditches and directed to segregated runoff collection pond where it would be monitored, and if required lime would be added prior to the incorporation of the seepage from the WRSA into the overall water management system. During closure, when the low permeability cover is being placed over the WRSA, the water level in the open pit will be low, and the groundwater levels will be in the early stages of recovery. Water seeping from the uncapped WRSA into the underlying overburden and bedrock during the closure phase, will continue to be captured by the groundwater drawdown and will report to the open pit. The infiltration into the WRSA that would drain laterally through the WRSA to the perimeter of the WRSA would continue to be captured by the perimeter ditches and directed to segregated runoff collection pond where it would be tested, and if required treated before being directed to the open pit. Therefore, regardless of the assumed infiltration rate into the uncapped WRSA or the rate of seepage from the uncapped WRSA into the underlying overburden and bedrock, none of the seepage from the uncapped WRSA will be

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				allowed to directly reach the receiving environment. Therefore, changing the rate of infiltration into the uncapped WRSA, or the rate of infiltration from the uncapped WRSA into the underlying overburden and bedrock would not have an effect on the predicted surface water quality predictions during the period when the WRSA is uncapped (the Water Addendum), and thus the predicted effects to fish and fish habitat (the Fish Addendum) would not be affected. <u>Capped WRSA</u> As described in the response to TMI_909-GW(2)-02, Part B, during closure the WRSA will be capped with a multi-layer, low permeability dry cover that is intended to reduce the rate of infiltration into the WRSA and thus the rate of seepage from the WRSA into the underlying overburden and bedrock. The design and construction of low permeability covers on waste rock and landfills are well understood and covers that can achieve significant infiltration reductions (e.g., >95%) are well documented. The exact design of the cap for the WRSA will be determined during detailed design, but would likely include a compacted clay layer, which can reliably achieve hydraulic conductivities of less than 1×10^{-9} m/s (Hauser et al., 2001). If sufficient clay of suitable quality are not available on site, Treasury Metals will obtain the necessary materials from other sources to ensure the cap over the WSRA achieves the designed performance. As discussed in both the December 18, 2018, and the January 10, 2019 meetings with the Agency and their technical reviewers, there are measures that Treasury Metals could implement to help minimize the potential for settlement and slumping of the waste rock pile to adversely affect the final dry cover over the WRSA. An example would be progressively placing overburden stripped from the open pits over the completed area of the WRSA. This would help reduce the amount of settling expected following closure and would provide a relatively smooth foundation for the placement of the multi-layer, low-permeability dry cover during closure, or the late stages of operations. To help understand the implications of increased infiltration through into the capped WRSA, a separate sensitivity run has been included in the Goliath Gold Project Water Addendum that models the effects on surface water quality due to an increased rate of infiltration into the capped WRSA during post-closure. Specifically, the total infiltration into the WRSA for this sensitivity run will be increased to 50% of the precipitation (i.e., 329 mm/year), 75 mm/year of which is assumed to infiltrate into the underlying overburden and bedrock, and the remaining 254 mm/year would drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches and ultimately report to the open pit. The surface water quality modelling continues to indicate that surface water quality will be largely unchanged as a result of the Project, with resulting water quality being the same as, or slightly improved from the existing condition for most parameters. The results of the surface water quality modelling with an increased infiltrations rate through the capped WRSA resulted in one (1) additional predicted residual adverse effects in Thunder Lake (residual adverse effects represent situations where the predicted concentrations for a parameter are higher than existing conditions). In the situation where the water quality is predicted to the higher than existing condition, the resulting water quality remains below the PWQO for the protection of aquatic life.

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Final Response:

Part A:

Treasury Metals had undertaken a review of the inputs, assumptions and outputs of the groundwater model in response to the seven concerns raised in the “Context and Rationale”. As detailed below, the review did not identify deficiencies in the assumptions and inputs that would warrant updating the groundwater model. The groundwater model used for the Goliath Gold Project was used to characterize the transport of seepage from the WRSA and TSF, as well as the rate of inflow into the open pit and underground mine workings. Detailed justification for retaining the assumptions and inputs used in the groundwater model are provided below. As described in this response, the groundwater model was not relied on directly to estimate the volume of seepage from the WRSA and TSF, as the volume of seepage from the WRSA and TSF was determined by physical properties of these features as follows:

- The seepage from the uncapped WRSA is a function of relative hydraulic resistances to infiltration that enters the underlying overburden and bedrock, or to infiltration that travels laterally to the perimeter of the WRSA;
- The seepage from the capped WRSA is a function of the infiltration through the multi-layer, low permeability cover place over the WRSA at closure; and
- The seepage from the TSF is determined by the characteristics and performance of the liner.

The groundwater model is consistent with the responses to the issues raised in GW(2)-01B through GW(2)-05. Although the review of the groundwater model confirmed that virtually all of the seepage from the WRSA and TSF during operations would be captured in the drawdown created by dewatering, and would report to the open pit (see the response to TMI_911-GW(2)-04), the review identified that a small percentage of the seepage from the TSF (6%) during operations would escape the drawdown to report to Blackwater Creek. This change has been incorporated in the revised surface water quality model presented in the Goliath Gold Project Water Addendum and summarized in Part I to this information request.

As discussed in the December 18, 2018 meeting with the Agency and their technical reviewers, further clarification is provided regarding the flow paths in and around the TSF during mining. According to the site investigation (Figures 4 an 5a of Appendix M) the TSF is underlain by Sand-Clay/Silt-Sand sequence. It differs from the overburden at the Open Pit and WRSA and further to the west towards Thunder Lake (Figures 4 and 5b of Appendix M) that has a relatively thick aquitard of Clay.

As part of the Project design, the TSF will be constructed with a liner at its base. The discharge pathways of leakage from the TSF has been assessed with the groundwater model for the following:

- The end of operations, assuming the open pit and underground mine are fully dewatered (see TMI_911-GW(2)-04_Figure_1);
- Post-closure, assuming the open pit and underground mine are fully re-saturated and a wet cover over the TSF (see Figure 22 of Appendix M); and

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				• Post-closure, assuming the open pit and underground mine are fully re-saturated and a dry cover over the TSF (see Figure 24 of Appendix M). These simulations have been carried out without the TSF liner so that particle tracking can be undertaken in a physically consistent and conservative manner from the entire footprint of the TSF. The particle tracks simulated fall into two flow path categories: 1. Particles that go into the shallow sand aquifer, that move horizontally and are captured by the perimeter ditches or the minewater pond. These particles represent the release from the edges of the TSF where the flow path is relatively short; and 2. Particles that move vertically beneath the TSF, through the Silt/Clay aquitard to the basal sand / shallow bedrock. The vertical flow through the Clay/Silt aquitard occurs from the more central portion of the TSF as this short vertical flow path has a lower hydraulic resistance than the much longer horizontal flow path to the perimeter of the TSF. Overall, this is considered reasonable as the Clay/Silt aquitard beneath the TSF is likely less effective in limiting vertical flow than the clay aquitard to the south and west of the TSF. The resultant deeper flow path along the basal sand / shallow bedrock results in much longer particle tracks. In the fully dewatered mine working scenario (see TMI_911-GW(2)-04_Figure_1) the particles are mostly captured by the open pit. This flow bypasses surfaces water features (Hoffstrom's Bay Tributary and Blackwater Creek Tributary 2) that are situated on the clay aquitard. In the re-saturated mine working scenario (Figures 22 and 24 of Appendix M) the particles discharge at the open pit and surface water features (Thunder Lake Tributary 2 and 3, Thunder Lake, Hoffstrom's Bay Tributary and Blackwater Creek), but in places bypassing surfaces water features that are situated on the clay aquitard. Presently node-by-node flows of the rivers / creeks pre-mining and during mining have not been generated from the results of the groundwater model. The groundwater model has been run on the Visual Modflow platform and this program currently does not directly output this information in a format that can be readily plotted. The importance of the groundwater recharge to the modelling results was discussed in the December 18, 2018 meeting with the Agency and their technical reviewers. It was confirmed that the mass contaminant load that is estimated to seep out of the base of the WRSA and TSF are derived outside of the groundwater model and independent from the estimated natural recharge rates applied to the overburden and bedrock (where at surface) in the groundwater model. As a result, any groundwater dilution factors applied in the surface water model are conservative with respect to contaminant transport of effluent from the WRSA and TSF to surface water features. Therefore, the groundwater recharge rates used in the model will not result in underestimates of seepage volumes. As such, the potential effect to surface water quality and fish and fish habitat are not underestimated. Treasury Metals acknowledges that all groundwater models (as applied to real hydrogeological systems) will have uncertainty, as models will always be based on sampling of a small fraction of the subsurface environment. To address these uncertainties, Treasury Metals has committed to groundwater monitoring throughout the entire life-cycle of the enterprise to assess if predictions are reliable. To provide confidence in the post-closure predictions, Treasury Metals propose to update the groundwater model on a regular basis (i.e. every three (3) years) to

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				incorporate the actual monitoring results that reflect the data gathered. Review in this manner provides the opportunity to reassess and update the hydrogeological conceptual model and the groundwater flow and transport predictions made for the impacts of the mine. This information has been incorporated into the Goliath Gold Follow-Up Addendum (which supersedes Section 13 of the revised EIS [April 2018]).

Detailed Justification

<u>1. Recharge for Overburden Layers</u>

The rationale for the groundwater recharge applied to the groundwater model was discussed in TMI_072-GW(1)-09, and indicated that measuring low flows from small low gradient runoff-dominated creeks which experience frequent beaver impoundment is problematic and often the accuracy of gauged flows are low. Deriving recharge from baseflow is problematic as the hydrograph response that is attributable to groundwater is highly variable between different geologic strata. This is the reason why baseflow analysis is no longer being used in some countries (e.g., United Kingdom examples documented in Shepley et al. 2012) for the management of large water supply aquifers (i.e., > 100,000 m^3/d) with high baseflow indexes (i.e., > 0.50). The problem is worse for runoff dominated creeks with very little baseflow given the likely inaccuracy of the gauged low flows. Ultimately the recharge is a calibration parameter that also needs to fit with the estimated hydraulic conductivities to produce the hydraulic gradients observed from groundwater level monitoring as well as being consistent with the low-flows measured in the creeks. Overall, this objective has been achieved with the groundwater model constructed for the Project. Finally, as discussed in TMI_71-GW(1)-08, the recharge values applied to the model are not considered high, which is conservative in following two ways.

- Firstly, the size of the zone of influence from mine dewatering is inversely proportional to the recharge applied to the groundwater model. Lower recharge results in a greater zone of influence, which means a greater potential for the Project to affect private water wells. In contrast, higher recharge rates would result in a smaller zone of influence and thus less private wells being potentially affected.
- Secondly, the seepage estimates from the WRSA and TMF are independent of the recharge applied to the groundwater model and not related to the calibration of the groundwater model. If the calibrated groundwater model had higher recharge it would result in higher groundwater flows and consequently greater dilution factors for seepage from either the WRSA or TSF.

<u>2. Recharge for Waste Rock Storage Area (WRSA)</u>As detailed in the response to TMI_909-GW(2)-02, the assumed infiltration rate of 100-200 mm/year represents a conservative estimate of infiltration from the uncapped WRSA into the underlying overburden and bedrock and not the infiltration rate into the WRSA itself. It should also be noted that the rate of seepage is not related to the rate in infiltration into the WRSA, but rather the relative hydraulic residences of infiltration that enters the underlying overburden and bedrock, to the infiltration that travels laterally to the perimeter of the WRSA. The hydraulic residences (where $c = \frac{flow\ length\ L}{hydraulic\ conductivity\ K}$) are calculated as follows:

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				• <u>Infiltration that enters underlying bedrock and overburden</u>: Based on the data collected from 2012–2014, the hydraulic conductivity of the shallow bedrock is 1×10^{-6} m/s (Section 5.6.5 of the revised EIS [April 2018]). Assuming 1 m of vertical saturated infiltration into the underlying bedrock, the hydraulic resistance is: $c = \frac{1\ m}{1\times10^{-6}\ m/s} = 1 \times 10^{6}\ s.$ • <u>Infiltration that travels laterally to the perimeter of WRSA</u>: The hydraulic conductivity of the waste rock is likely to be in the range of 1×10^{-2} m/s, given the large amount of connected void space in a WRSA. Freeze and Cherry (1979) give the hydraulic conductivity of a gravel in the range of 1×10^{-3} m/s to greater than 1×10^{-1} m/s. Assuming less than 300 m of lateral travel to the perimeter of the WRSA, the hydraulic resistance is: $c = \frac{300\ m}{1\times10^{-2}\ m/s} = 3 \times 10^{4}\ s.$ The hydraulic resistance for infiltration that enters the underlying overburden and bedrock is about two (2) orders of magnitude higher than the hydraulic resistance for the infiltration that travels laterally to the perimeter of the WRSA. Therefore, the infiltration rate of 100-200 mm/year from the uncapped WRSA into the underlying overburden and bedrock is considered conservative for the strata present underneath the proposed WRSA and the location of the WRSA on a topographic high at the Goliath Gold Project. Most of the infiltration into the WRSA is likely to travel laterally to the perimeter of the WRSA to be captured by the perimeter ditches. As detailed in the response to TMI_911-GW(2)-04, seepage from the uncapped WRSA during operations and closure will be captured by the open pit, and will not reach the receiving environment. The uncapped WRSA scenario will only exist during operations and for a short period of time during closure when a cover will be constructed over the WSRA. The multi-layer, low permeability dry cover over the WRSA is intended to reduce the rate of infiltration into the WRSA and thus the rate of seepage from the WRSA into the underlying overburden and bedrock. The design and construction of low permeability covers on waste rock and landfills are well understood and covers that can achieve significant infiltration reductions (e.g., >95%) are well documented. The exact design of the cap for the WRSA will be determined during detailed design, but would likely include a compacted clay layer, which can reliably achieve hydraulic conductivities of less than 1×10^{-9} m/s (Hauser et al., 2001). If sufficient clay, of suitable quality are not available on site, Treasury Metals will obtain the necessary materials from other sources to ensure the cap over the WSRA achieves the designed performance. As described in Section 5.3.5 of Appendix M of the revised EIS (April 2018), the performance of a clay cap has been estimated at 30 mm/year using the US EPA HELP model, and hydraulic conductivities of less than 1×10^{-9} m/s for the clay (Hauser et al., 2001). <u>3. Hydraulic conductivity measurements</u> The level of hydrogeological and geotechnical investigations undertaken for the Goliath Gold Project are commensurate with the scale of the project, the complexity of the hydrogeology and the likely perturbation to the groundwater system. What comprises an appropriate hydrogeological characterization is dependent on many factors, which may include: complexity of hydrogeology, magnitude of undertaking, disturbance to the groundwater system,

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				sensitivity of receptors, risk perception, and degree of mitigation to be applied through engineering. It is useful to compare groundwater geotechnical investigations for the Goliath Gold Project with other open pit mines recently constructed in Ontario, namely: Detour Gold; Rainy River Gold; and Victor Diamond mine. • While the Detour Gold project had larger number of hydrogeological/geotechnical measurements than undertaken for the Goliath Gold Project, the Detour Gold open pit is the largest producing gold mine in Canada, and thus a direct comparison to the Goliath Gold Project is not valid. • The Rainy River Gold project also had larger number of hydrogeological/geotechnical measurements than undertaken for the Goliath Gold Project. However, the Rainy River Gold open pit is much bigger than the Goliath Gold Project (10 times the ore production and 16 times the volume of the open pit). In addition, the hydrogeology for the Rainy River Gold open pit is also more challenging due to the open pit intercepting a permeable artesian aquifer (mainly the Whiteshell Till). This aquifer and associated conditions have not been encountered at the Goliath Gold Project. • The Victor Diamond Mine had larger number of hydrogeological/geotechnical measurements than undertaken for the Goliath Gold Project. However, the Victor Diamond open pit is approximately twice the volume of the Goliath Gold open pit, and the Victor kimberlite deposit is situated in several karstic dolostone formations. The groundwater pumping rates for the Victor Diamond open pit are two orders of magnitudes greater than predicted for the Goliath Gold open pit. Therefore, it would not be reasonable to expect the Goliath Gold Project to collect as many of hydrogeological/geotechnical measurements as were collected for the Detour Gold, Rainy River Gold or Victor Diamond mining projects. Regarding the information in Table 5.6.2.2-1 of the revised EIS (April 2018), these data are almost all correct and are the same as given in the AQTESOLVE analysis sheets provided in Appendix C of Appendix M of the revised EIS (April 2018) with the geological data corresponding to the borehole logs of Appendix C of Appendix M of the revised EIS (April 2018). The exception is for Well 5A where the hydraulic conductivity should have been rounded to 1.1×10^{-6} m/s rather than 1.0×10^{-6} m/s. The geometric mean and arithmetic mean should be 9.1×10^{-7} m/s and 9.6×10^{-7} m/s rather than 9.2×10^{-7} m/s and 9.8×10^{-7} m/s, respectively. These typos concerning the means also occur in Section 4.1 of Appendix M of the revised EIS (April 2018). The hydraulic conductivity values are largely representative of silty sands that occur at the base of the overburden and are consistent with published literature (e.g., Freeze and Cherry, 1979). There is one anomalous value (Well 5A), which gave a value of 1.1×10^{-6} m/s, untypical for the screened unit of clay, as noted in Section 4.1 of Appendix M of the revised EIS (April 2018). The log for Well 5A (Appendix A of Appendix M of the revised EIS [April 2018]) shows three split spoons across the screened interval, which all indicate clay. It is possible that the higher than normal hydraulic conductivity may be due to a thin sand or gravel seam occurring between the split spoon samples not being recognized during drilling of the borehole.

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				4. Thickness of the Overburden The upper three (3) layers of the groundwater model correspond to: • Model Layer 1 is the surface layer and corresponds to the Clay, Sand and Gravel, the upper layer of the Sand-Clay/Silt Sand unit or bedrock knoll, depending on the surficial geology. • Model layer 2 corresponds to the Basal Sand unit in the areas where it is expected to be thicker than 0.3 m. The basal band layer is discontinuous layer at the base of the clay, that is, on average, 3 to 4 m thick, when present. • Model layer 3 corresponds to the weathered Shallow Bedrock unit, which was assumed to have a uniform thickness of 7 m. It is widely recognized that the shallow weathered and fractured bedrock tends to be the more permeable than the deeper bedrock in a shield crystalline bedrock setting, such as occurs at the Goliath Gold Project. The thickness of the overburden, basal sands vary over the modelling domain based on the available data. TMI_951-GW(2)-01B_Figure_1, TMI_951-GW(2)-01B_Figure_2, and TMI_951-GW(2)-01B_Figure_1 show the thickness maps for the Basal Sands (Model Layer 2), Clay (Model Layer 1) and Sand and Gravel (Model Layer 1 and 2) respectively. For each of the maps, surface water bodies, private wells and monitoring wells, as well as the mining facilities are shown. Bedrock sits beneath the Basal Sand, Clay, and Sand and Gravel layers, with the upper 7 m identified as weathered and fractured shallow bedrock. 5. Porosity estimates As discussed in the December 18, 2018 meeting with the Agency and their technical reviewers, the kinematic porosity used to assess groundwater velocities was selected to represent the bulk material of the site as described fully in the response to TMI_951-GW(2)-01B. NRCAN noted at the meeting, kinematic porosity may be estimated in the field using tracer testing. However, this methodology is not suitable to estimate bulk kinematic porosity from the shallow bedrock and basal sand overburden. As part of the Follow-up Program for groundwater, monitoring data will be able to detect the arrival of seepage from the mine. Detection of relatively non-retardent species (chloride, sulphate), will be used to establish bulk kinematic porosity values for the geology at the site. Detection of retardant species (metals, cyanide) will be used to establish transport parameter values (retardation, decay where applicable). 6. Particle Tracking Particle tracking has been undertaken with the groundwater model representing the ultimate dewatered mine condition with particles released from the TSF. As described in the response to TMI_911-GW(2)-04, the particle tracking plots for TSF during operations (TMI_911-GW(2)-04_Figure_1) show that, of the seepage leaving the TSF, 46% is captured by the open pit; 34% is captured by the TSF perimeter drains; 14% is captured by the minewater pond, and 6% escapes the operations area and reports to Blackwater Creek. The proportion that escapes the operations area to report to Blackwater Creek occurs along the eastern perimeter of the TSF. The particle tracking for

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				the WRSA during operations (see TMI_911-GW(2)-04_Figure_2) indicates that all water seeping from the base of the uncapped WRSA during operations is captured by the open pit. 7. Sensitivity Analyses Sensitivity analyses have already been undertaken with the groundwater model for the shallow bedrock and basal sand as shown in Table 9 of Appendix M to the revised EIS (April 2018). The focus of this sensitivity analysis was on the identification of seepage volumes into the open pit and underground mine workings, instead of the effects on the rates of seepage from the WRSA. As detailed in the responses to TMI_909-GW(2)-02 and TMI_911-GW(2)-04, all of seepage from the uncapped WRSA during operations and closure will be captured by the open pit, and will not reach the receiving environment. The uncapped WRSA scenario will only exist during operations and for a short period of time during closure when a low-permeability dry cover will be constructed over the WSRA as described in Section 3.16.8. The multi-layer, low permeability dry cover over the WRSA is intended to reduce the rate of infiltration into the WRSA and thus the rate of seepage from the WRSA into the underlying overburden and bedrock. The design and construction of low permeability covers on waste rock and landfills are well understood and covers that can achieve significant infiltration reductions (e.g., >95%) are well documented. The exact design of the cap for the WRSA will be determined during detailed design, but would likely include a compacted clay layer, which can reliably achieve hydraulic conductivities of less than 1×10^{-9} m/s (Hauser et al., 2001). If sufficient clay of suitable quality is not available on site, Treasury Metals will obtain the necessary materials from other sources to ensure the cap over the WSRA achieves the designed performance. Seepage from the capped WRSA is driven by the rate of infiltration through the multi layered, low permeability cover, and would not limited by the hydraulic conductivity of the geologic layers below the WRSA. Minewater Pond The minewater pond will be used during operations to manage the water from the open pit and will be used as a source of water to support the extraction process. The quality of the water within the minewater pond is a function of the quantity and quality of the sources of water. Table A1 provides a listing of the sources of water that will ultimately contribute the water quality within the minewater pond.

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Table A1: Source of Water to the Minewater Pond		
Source	**Volume (m³/day)**	**Fraction of Inflow**
Groundwater dewatering	1,320.0	49.89%
Seepage through the base of uncapped WRSA (ARD affected)	150.0	5.67%
Seepage from the toe of uncapped WRSA (batch treated) (1)	569.7	21.53%
Rainfall on portions of open pit with waste rock (ARD affected)	402.2	15.20%
Rainfall on portions of open pit without waste rock	201.1	7.60%
Seepage from the TSF to the open pit (including ditches)	2.5	0.09%
Seepage from TSF to the minewater pond	0.4	0.02%
Total Volume of the Open Pit	**2,646**	**—**

Note: The runoff from the toe of the WRSA will be collected in a segregated collection pond, tested and treated, if necessary, using batch lime addition prior to the integration into the water management system.

It should be noted that some of the contributions to the minewater pond listed in the above table include the potential effects of ARD (seepage from the uncapped WRSA and rainfall on portions of open pit with waste rock). In the case of the seepage from the toe of the waste rock storage area, this water will be collected in perimeter ditches around the WRSA and directed to a segregated runoff collection pond where the water will be tested and treated (as required) using batch lime addition prior to being integrated in the water management system, as discussed during the December 18, 2018 and January 10, 2019 technical meetings. The resulting water quality within the minewater pond, including the contributions of ARD, were included in the calculations of water treatment plant influent quality values presented in TMI_887-SW(2)-04. Any seepage from the minewater pond would have the same quality as the water within the minewater pond, as detailed in TMI_951-GW(2)-01B_Table_A2.

As described in the response to TMI_911-GW(2)-04, refined particle tracking completed for the Project identified that all of the seepage from the WRSA would be captured by the drawdown created by the dewatering activities, and would report to the open pit during operations. Additionally, the refined particle tracking identified that 94% of the seepage from the TSF would also be captured by the drawdown and report to the open pit. Only a small amount of seepage from the eastern edge of the TSF (6% of the total seepage through the floor and walls of the TSF) would escape the drawdown and leave the site during operations. Based on this modelling, and the proximity of the minewater pond to the open pit, all of the seepage from the minewater pond is expected to be captured by the drawdown and report to the open pit. None of the seepage from the minewater pond is expected to leave the site, have an effect on surface water quality, including Blackwater Creek, or have an effect on fish and fish habitat.

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				The current conceptual design for the closure of the Project includes the decommissioning of the minewater pond and the grading of that portion of the site to drain towards the open pit. <u>Groundwater/Surface Water Interactions</u> During the December 18, 2018 meeting between Treasury Metals and the Agency and their technical reviewers, a discussion point was raised regarding a desire to see the histograms of the node-by-node output rates from the groundwater model to better understand the groundwater discharge variations on surface water flows. As discussed in the December 18, 2018 meeting, the groundwater model used for evaluating the effects of the Project was a steady-state model, therefore only a single output rate is available for each node. However, by combining the nodes within each of the four watersheds overlaying the Goliath Gold Project (see Figure 6.9.2.3-1 of the revised EIS [April 2018]), the histograms provided in TMI_951-GW(2)-01B_Figure_A1 were produced. These histograms show the following two distinct set of results: • **Pre-mine:** These results represent the conditions that currently exist in the area, before mining and dewatering activities start. • **Ultimate Mine:** These represent the results when the mining activities are at their maximum extent, and the corresponding drawdown from dewatering in maximized. For clarity, the two sets of results are show side-by-side for each watershed, with the negative nodal flows representing flows from surface to groundwater (i.e., recharge) and the positive flows representing flows from groundwater to surface water (i.e., discharge). The changes in the integrated discharge/recharge values were also incorporated into the surface water quantity modelling presented in the revised EIS (April 2018), and used to determine potential effects of changes in flows on fish and fish habitat as presented in the Goliath Gold Project Fish Addendum. Two additional figures are also included as part of this response, which show how the discharge/recharge outputs from the model vary over the modelling domain. TMI_951-GW(2)-01B_Figure_A2 shows the node-by-node results for the pre-mining conditions, while TMI_951-GW(2)-01B_Figure_A3 shows the comparable results for the ultimate mine case. <u>Part B:</u> ***Seepage Volumes and Travel Times from the WRSA*** The rate of seepage from the WRSA will be different depending on whether the WRSA is uncapped or capped. The uncapped WRSA will only exist during operations and closure, when a low-permeability dry cover will be constructed over the WSRA.

Uncapped WRSA

As described in the response to TMI_909-GW(2)-02, Part A, the assumed infiltration rate of 100-200 mm/year represents a conservative rate of infiltration from the uncapped WRSA into the underlying overburden and bedrock and not the infiltration rate into the WRSA itself. As the waste rock in the WRSA will have a large amount of connected void space, it is assumed that all of the precipitation will infiltrate into the WRSA. The infiltration into the WRSA will either infiltrate into the underlying overburden and bedrock, or drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches. The amount of infiltration that either enters the underlying overburden and bedrock, or travels laterally to the perimeter of the WRSA depend on the relative hydraulic residences (where $c = \frac{flow\ length\ L}{hydraulic\ conductivity\ K}$). The hydraulic resistances are calculated as follows:

- Infiltration that enters underlying bedrock and overburden: Based on the data collected from 2012–2014, the hydraulic conductivity of the shallow bedrock is 1×10^{-6} m/s (Section 5.6.5 of the revised EIS [April 2018]). Assuming 1 m of vertical saturated infiltration into the underlying bedrock, the hydraulic resistance is: $c = \frac{1\ m}{1\times10^{-6}\ m/s} = 1 \times 10^{6}\ s.$
- Infiltration that travels laterally to the perimeter of WRSA: The hydraulic conductivity of the waste rock is likely to be in the range of 1×10^{-2} m/s, given the large amount of connected void space in a WRSA. Freeze and Cherry (1979) give the hydraulic conductivity of a gravel in the range of 1×10^{-3} m/s to greater than 1×10^{-1} m/s. Assuming less than 300 m of lateral travel to the perimeter of the WRSA, the hydraulic resistance is: $c = \frac{300\ m}{1\times10^{-2}\ m/s} = 3 \times 10^{4}\ s.$

The hydraulic resistance for infiltration that enters the underlying overburden and bedrock is about two (2) orders of magnitude higher than the hydraulic resistance for the infiltration that travels laterally to the perimeter of the WRSA. Therefore, most of the infiltration into the WRSA is likely to travel laterally to the perimeter of the WRSA to be captured by the perimeter ditches. Vertical infiltration into the underlying bedrock and overburden would only become significant if there was a potential for water to pond (e.g., being trapped in a topographic basin). As the WRSA is located on a topographic high next to the open pit, the potential for ponding and the build-up of a significant water table within the WRSA is very limited. Consequently, the infiltration rate of 100-200 mm/year into the underlying overburden and bedrock is conservative and no changes are required to the modelled infiltration rate for the uncapped WRSA.

The waste rock in the WRSA will have a large amount of connected void space. As a result, it is assumed that all of the precipitation will infiltrate into the WRSA. Given the annual rates of precipitation in the Dryden area (1969–2017) have ranged from 392 to 883 mm/year, with an average value of about 658 mm/year, and 100–200 mm/year is assumed to infiltrate into the underlying overburden and bedrock, then 458–558 mm/year of infiltration into the WRSA would drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches.

As discussed in both the December 18, 2018, and the January 10, 2019 meetings with the Agency and their technical reviewers, the infiltration into the WRSA that would drain laterally through the WRSA to the perimeter of the WRSA would be captured by the perimeter ditches and directed to segregated runoff collection pond (collection pond #3 on Figure 3.0.1A of the revised EIS [April 2018]). The water within the collection pond would be monitored, and if

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required lime would be added to the pond to treat the water prior to its incorporation into the overall water management system.

It is important to remember that the uncapped WRSA scenario will only exist during operations and for a short period of time during closure when a low-permeability, multi-layer, dry cover will be constructed over the WSRA as described in Section 3.16.8. As detailed in the response to TMI_911-GW(2)-04), seepage from the uncapped WRSA during operations will be captured by the drawdown created by dewatering and would enter the open pit. The seepage from the WRSA that drains laterally to the perimeter of the WRSA would be captured by the perimeter ditches and directed to segregated runoff collection pond where it would be monitored, and if required lime would be added prior to the incorporation of the seepage from the WRSA into the overall water management system.

During closure, when the low permeability cover is being placed over the WRSA, the water level in the open pit will be low, and the groundwater levels will be in the early stages of recovery. Water seeping from the uncapped WRSA into the underlying overburden and bedrock during the closure phase, will continue to be captured by the groundwater drawdown and will report to the open pit. The infiltration into the WRSA that would drain laterally through the WRSA to the perimeter of the WRSA would continue to be captured by the perimeter ditches and directed to segregated runoff collection pond where it would be tested, and if required treated before being directed to the open pit.

Therefore, regardless of the assumed infiltration rate into the uncapped WRSA or the rate of seepage from the uncapped WRSA into the underlying overburden and bedrock, none of the seepage from the uncapped WRSA will be allowed to directly reach the receiving environment. Therefore, changing the rate of infiltration into the uncapped WRSA, or the rate of infiltration from the uncapped WRSA into the underlying overburden and bedrock would not have an effect on the predicted surface water quality predictions during the period when the WRSA is uncapped (the Water Addendum), and thus the predicted effects to fish and fish habitat (the Fish Addendum) would not be affected.

<u>Capped WRSA</u>

As described in the response to TMI_909-GW(2)-02, Part B, during closure the WRSA will be capped with a multi-layer, low permeability dry cover that is intended to reduce the rate of infiltration into the WRSA and thus the rate of seepage from the WRSA into the underlying overburden and bedrock. The design and construction of low permeability covers on waste rock and landfills are well understood and covers that can achieve significant infiltration reductions (e.g., >95%) are well documented. The exact design of the cap for the WRSA will be determined during detailed design, but would likely include a compacted clay layer, which can reliably achieve hydraulic conductivities of less than 1×10^{-9} m/s (Hauser et al., 2001). If sufficient clay of suitable quality is not available on site, Treasury Metals will obtain the necessary materials from other sources to ensure the cap over the WSRA achieves the designed performance.

As discussed in both the December 18, 2018, and the January 10, 2019 meetings with the Agency and their technical reviewers, there are measures that Treasury Metals could implement to help minimize the potential for settlement and slumping of the waste rock pile to adversely affect the final dry cover over the WRSA. An example would be progressively placing overburden stripped from the open pits over the completed area of the WRSA. This would help

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				reduce the amount of settling expected following closure and would provide a relatively smooth foundation for the placement of the multi-layer, low-permeability dry cover during closure, or the late stages of operations. To help understand the implications of increased infiltration through into the capped WRSA, a separate sensitivity run has been included in the Goliath Gold Project Water Addendum that models the effects on surface water quality due to an increased rate of infiltration into the capped WRSA during post-closure. Specifically, the total infiltration into the WRSA for this sensitivity run will be increased to 50% of the precipitation (i.e., 329 mm/year), 75 mm/year of which is assumed to infiltrate into the underlying overburden and bedrock, and the remaining 254 mm/year would drain laterally through the WRSA to the perimeter to be captured by the perimeter ditches and ultimately report to the open pit. The surface water quality modelling continues to indicate that surface water quality will be largely unchanged as a result of the Project, with resulting water quality being the same as, or slightly improved from the existing condition for most parameters. The results of the surface water quality modelling with an increased infiltrations rate through the capped WRSA resulted in one (1) additional predicted residual adverse effects in Thunder Lake (residual adverse effects represent situations where the predicted concentrations for a parameter are higher than existing conditions). In the situation where the water quality is predicted to the higher than existing condition, the resulting water quality remains below the PWQO for the protection of aquatic life. <u>Travel Times to WRSA to Thunder Lake</u> The uncapped WRSA will only exist during the operations phase, and during closure when it will be capped with a multi-year, low-permeability dry cover. The capped WRSA will exist throughout post-closure. As described in the response to TMI_911-GW(2)-04, during operations when the groundwater levels have been drawn down by dewatering activities, all of the seepage from the WRSA that enters the underlying overburden and bedrock will report to the open pit. During post-closure, 10 m^3/d of seepage from the capped WRSA is predicted to leave the Project and eventually reach Thunder lake. The remaining 20 m^3/d of seepage from the capped WRSA will report to the open pit. The present hydraulic groundwater gradient between the proposed location of the WRSA and Thunder Lake (Figure 10, Appendix M) is approximately 0.02. The basal sand of the overburden is known to be discontinuous and therefore the shallow bedrock (top ~10m) is likely the only aquifer horizon with lateral continuity between the WRSA and Thunder Lake. The average linear velocity of groundwater in the shallow bedrock may be of the order of 2×10^{-6} m/s (~ 0.2 m/d) assuming a hydraulic conductivity of the shallow bedrock of 1×10^{-6} m/s (Table 8, Appendix M), and a kinematic porosity of 0.01 (see response to TMI_910-GW(2)-03, and part A.5 of this response). Travel times from the WRSA to Thunder Lake may be expected to be of the order of fifteen years given a flowpath length of about 1 km. <u>Seepage Volumes from the TSF</u> The estimated seepage rate for the TSF liner is 2.4 m^3/day. This is based on current industry research presented by Kerry Rowe et al. (2016) "Leakage Through Holes in Geomembrane Below Saturated Tailings" (based on 40L/ha/day × 60 ha). The research suggests that this rate is an approximate upper bound estimate for a properly installed HDPE

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				geomembrane underlying mine tailings. This seepage rate is independent of the soil characteristics underneath the TSF liner; therefore, the seepage from the TSF would be unaffected by changes in the hydraulic conductivity of key geologic units, such as overburden and weathered bedrock. The liner would be placed during the initial construction activities and would cover the floors and walls of the initial of the TSF construction, shown as Stage 1 on Figure 3.7.2-3 of the revised EIS (April 2018). This figure has been updated as TMI_951-GW(2)-01B_Attachment_1 to reflect the inclusion of the liner material, as well as the soil cover material over the liner to protect it until covered by tailings. As described in Section 3.7.2 of the revised EIS (April 2018), the subsequent stage of the TSF construction (Stages 2 through 4) would be constructed using clay on the inboard slope to limit the potential for seepage through the walls of the TSF. Additional liner material would be placed on the inboard side of the vertical drains for each lift. Given the floor and initial walls of the TSF (Stage 1) will be covered with the liner material, only the vertical areas above the crest of the Stage 1 dam (i.e., the 6 vertical meters of dam comprising the Stage 2, 3 and 4 lifts) will not be covered by the original HPDE liner. This “wall area” represents just 3% of the TSF basin. The effect on the wall areas above the original liner on the overall seepage rates from the TSF would be relatively small, possibly increasing the overall seepage for the later stages of the operations to as much as 3.13 m^3/d. This number is calculated assuming the rate of seepage through the wall areas for the Stage 2, 3 and 4 lifts (which would have liner material on the inboard side of the vertical drains) would have an order of magnitude higher rate of seepage per unit area than the original liner. This higher rate of seepage per unit area was assumed given there would be joints between the new HPDE materials and the original liner. To reflect this adjustment to the overall seepage rate from the TSF, the water addendum has been updated. Specifically, the modelling for pit lake water quality and surface water quality will both be adjusted to include this higher overall seepage rate from the TSF. In addition, this higher rate of seepage from the TSF was incorporated into the multi-year water cover model described in the response to TMI_898-MW(2)-02. The review of the groundwater modelling results completed confirmed (see response TMI_911 GW(2)-04) that a portion (6% or 0.19 m^3/d) of the seepage from the TSF during operations would escape the operations area to report to Blackwater Creek. The seepage that reaches Blackwater Creek during operations has been incorporated into the updated surface water quality modelling presented in the Water Addendum included as part of the Round 2 responses. The portion that escapes the operations area to report to Blackwater Creek occurs along the eastern perimeter of the TSF. During post-closure, when groundwater recovers to near pre-development levels, 0.83 m^3/d of seepage from the TSF is estimated to leave the Project and reach Blackwater Creek. An estimated 2.0 m^3/d of seepage from the TSF during post-closure will report to the open pit. The groundwater particle tracking (Figure 24 of Appendix M) indicated trace quantities of post-closure seepage from the TSF may also reach Thunder Lake Tributary 3, Hoffstrom’s Bay Tributary, and Thunder Lake. To conservatively capture potential effects associated with these trace amounts, the updated surface water quality modelling presented in the Water Addendum (included as part of the Round 2 responses), included 0.1 m^3/d of seepage from the TSF to each of these waterbodies.

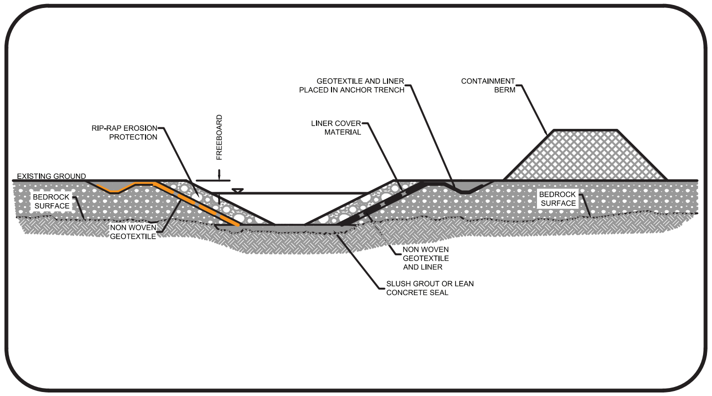
Unique Identifier	Agency IR #	Annex	Agency Group / Stakeholder	Cross Reference ... Information Request Response
				<u>Travel Times from the TSF to Receiving Waterbodies</u> During post-closure, when groundwater recovers to near pre-development levels, 0.8 m³/d of seepage from the TSF is estimated to leave the Project and reach Blackwater Creek. The remaining 1.6 m³/d of seepage from the TSF during post-closure is estimated to report to the open pit. The groundwater particle tracking (Figure 24 of Appendix M) indicated trace quantities of post-closure seepage from the TSF may also reach Thunder Lake Tributary 3, Hoffstrom's Bay Tributary, and Thunder Lake. To conservatively capture potential effects associated with these trace amounts, the updated surface water quality modelling presented in the Water Addendum (included as part of the Round 2 responses), included 0.1 m³/d of seepage from the TSF to each of these waterbodies. Given the trace amounts of seepage from the TSF to these receptors, it would not be realistic to estimate travel times. However, the updated surface water quality modelling presented in the Water Addendum (included as part of the Round 2 responses), assumes that seepage leaving the TSF will have reached the receiving environment, and thus are incorporated in modelling predictions. <u>Part C:</u> The seepage collection ditches will be constructed according to good engineering practice. As described in the response to TMI_910-GW(2)-03, Treasury Metals has advanced their engineering for the Project, which includes additional details regarding the design of seepage and runoff collection ditches, as described in Section 3.7.3 of the revised EIS. While Figure 3.7.3-1 of the revised EIS (April 2018) provides typical cross sections for seepage and runoff collection ditches, Figure 3.7.3-2 of the revise EIS (April 2018) provides modifications to the typical ditch construction to address situations where existing conditions may pose challenges to the collection and capture of seepage including deep bedrock in both low and high permeability soils. As described in TMI_886-SW(2)-203, specific details (e.g., lining details) for the seepage collection ditches will be determined as part of the detailed design process to suit the site conditions. As shown in Figures 3.7.3-1 and 3.7.3-2 of the revised EIS (April 2018), the typical ditch lining would include a geosynthetic liner (HDPE or similar material) and/or slush grout depending on the conditions along the ditch alignment to minimize seepage from the ditches. Riprap and non-woven geotextile would be placed over the geosynthetic liner for erosion protection. The contact water ditches, as shown on Figure 3.0-1A of the revised EIS (April 2018) will be lined because the contact runoff water may contain materials that may need to be collected and treated prior to its release to the environment (note that the current arrangement for the Project includes for collection and treatment of all contact water as required). It should be noted that measures such as pump back wells are usually implemented after a problem has been identified by monitoring. When deciding on the placement of pump back wells, ditches frequently serve a monitoring function. Groundwater flow in bedrock and overburden is often restricted to a few discrete locations, which may be difficult to locate in monitoring wells, but are usually intercepted by long linear features such as ditches. By sampling of the ditches and visual inspection, contaminated groundwater can often be identified, and once identified, discharge controlled by pump back wells. In this manner the depth of the ditch is not necessarily the most critical design factor. Ditches should be seen as just one part of an integrated system of groundwater management that includes

Unique Identifier	Agency IR	Annex	Agency Group Stakeholder	[illegible]
				monitoring, hydraulic control, capping and lining of facilities to reduce the potential for the movement of contaminated groundwater. <u>Part D.</u> The surface water quality assessment has been updated to reflect changes related to seepage from the TSF and WRSA that could affect surface water quality, as described in the responses to Parts A through C. The revised surface water quality assessment is provided in the Goliath Gold Water Addendum and specifically the information provided in this response has been incorporated into Section W6.5 (Seepage from WRSA and TSF to Offsite Receiving Waters). The Water Addendum presents the updated water quality assessment that consolidates all of the identified Round 2 changes and concerns including those changes to groundwater and mine waste that would affect surface water quality. <u>Part E.</u> **Revised Assessment of Effects on Fish and Fish Habitat** The results of the updated water quality assessment are presented in Section W8 (Revised Predictions of Surface Water Quality Effects) of the Water Addendum. Residual adverse effects for surface water quality were identified to be those situations when the predicted concentration of the indicator compounds as a result of the Project are higher than the concentrations for existing conditions. The resulting residual adverse effects predicted for surface water quality modelling are provided in Section W9 (Revised Predictions of Residual Surface Water Quality Effects) for the operations and post-closure phases of the Project. None of the predicted residual adverse effects of the Project on surface water quality during either operations or post-closure exceed the respective water quality criteria established to protect aquatic life (i.e. PWQO). To state that another way, the updated surface water quality modelling continues to indicate that surface water quality will be largely unchanged as a result of the Project, with resulting water quality being the same as, or slightly improved from the existing condition for most parameters. In the situation where the water quality is predicted to the higher than existing condition, the resulting water quality remains below the PWQO for the protection of aquatic life. Therefore, there are no predicted effects to fish and fish habitat as a result of changes to surface water quality as a result of the Project, including seepage from the TSF and WRSA. **Revised Assessment of Effects on Indigenous Health from Private Groundwater Wells** During operations, dewatering of the open pit and underground mine workings will result in a drawdown of groundwater levels, which will continue through the closure phase until the open pit is filled. As described TMI_911-GW(2)-04, none of the seepage from the WSRA and only 6% (0.14 m^3/day) of the seepage from the TSF is predicted to escape the effects of groundwater drawdown to reach the receiving environment. The seepage from the TSF that escapes the drawdown during operations reports directly to Blackwater Creek and thus would not affect any private groundwater wells. During operations the seepage from the WRSA and TSF that do not escape the effects of

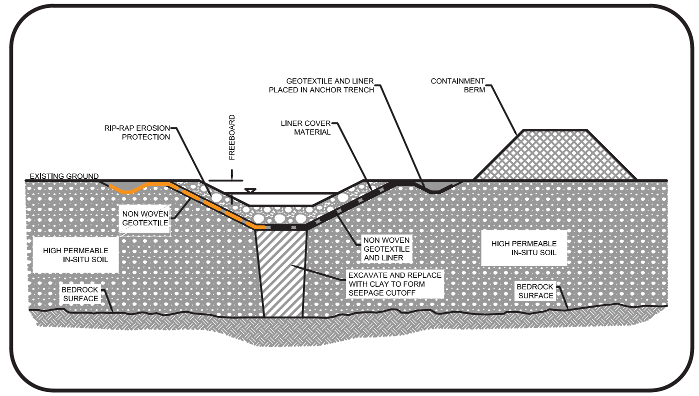
Unique Identifier	Agency IR #	Annex	Agency / Group / Stakeholder	Proponent Reference to Information Request Response
				drawdown will be incorporated into the water management system where, to the extent possible, it will be used in the process. Therefore, during operations none of the seepage from the WRSA and TSF will reach private groundwater wells and pose potential risk to the health of Indigenous people who rely on those wells. During post-closure, there were no material increases in volumes of seepage from either the WRSA or TSF reaching Thunder Lake predicted as a result of the issues raised and responded to in Parts A through D. Therefore, there are no changes to the predicted effects of the Project on Private groundwater wells from those presented in the Revised EIS (April 2018). Section 6.10.4 of the revised EIS (April 2018), identified that although seepage from the WRSA may reach the private water wells along Thunder Lake, it will be diluted by between 5 to 25 times. The modelling also identified that, with a liner beneath the TSF, only trace amounts of seepage from the TSF would have the potential to reach the private wells along Thunder Lake. The seepage from the TSF would also be diluted 5 to 25 times. The resulting groundwater quality in the private water wells along Thunder Lake would not noticeably change from current conditions as a result of seepage from either the WRSA or the TSF. Therefore, during post-closure, seepage from the WRSA and the TSF will not pose potential risk to the health of Indigenous people who rely on those wells. <u>Part F.</u> As stated in the response to Part E, with respect to seepage from the TSF and WRSA, the revised assessment of effects on fish and fish habitat and the revised assessment of effects on Indigenous health from private groundwater wells are unchanged from the results presented in the revised EIS (April 2018). Therefore, no additional mitigation measures have been identified as being required to prevent effects to fish and habitat, and Indigenous health, as a result of changes in seepage emanating from the TSF and WRSA. <u>Part G.</u> As described in the responses to Parts A through F, there are no changes to the adverse effects to fish and habitat, and Indigenous health, other than those described in the revised EIS (April 2018) as a result of changes in seepage emanating from the TSF and WRSA. Therefore, no residual adverse effects were identified as a result of changes in seepage emanating from the TSF and WRSA. <u>Part H.</u> The Follow-Up Program for Groundwater Quantity and Quality has been revised to reflect the issues and concerns with respect to seepage from the WRSA and TSF identified in this Round 2 information request. Specifically, Treasury Metals propose to update the groundwater model on a regular basis (i.e. every three (3) years) to incorporate the actual monitoring results that reflect the data gathered. Review in this manner provides the opportunity to reassess and update the hydrogeological conceptual model and the groundwater flow and transport predictions made for the impacts of the mine.

Unique Identifier	Agency IR #	Annex	Agency/Group/Stakeholder	[illegible]
				As part of the Round 2 information request process, Treasury Metals received a number of questions regarding the Follow-Up Program. As a result, Treasury Metals has prepared the Goliath Gold Project Follow-Up Program Addendum to capture the responses to these issues and provide a consolidated update to the Follow-Up Program. The Goliath Gold Project Follow-Up Program Addendum supersedes Section 13 of the revised EIS (April 2018). <u>Part I.</u> The findings of this IR (TMI_951-GW(2)-01B) have been used to update the various models relied on for predicting the effects of the Project on groundwater, seepage, surface water quality, and ultimately the effects on fish and fish habitat from changes to surface water quality. The models relied on in the effects assessments are summarized as follows. **Groundwater Model** The groundwater model used for the Goliath Gold Project was used to characterize the transport of seepage from the WRSA and TSF, as well as the rate of inflow into the open pit and underground mine workings. As described in Parts A through D, the groundwater model was not relied on directly to estimate the volume of seepage from the WRSA and TSF, as the volume of seepage from the WRSA and TSF was determined by physical properties of these features as described below: • The uncapped WRSA is a function of the infiltration from the WRSA into the underlying overburden and bedrock; • The capped WRSA is a function of the infiltration through the multi-layer, low permeability cover place over the WRSA at closure; and • The TSF is determined by the characteristics and performance of the liner. The current groundwater model was reviewed in support of the Round 2 process, and is consistent with the responses to the issues raised in GW(2)-01B through GW(2)-05. **Geochemical Models** The quality of seepage from the WRSA and TSF as well as the resulting water quality in the pit lake was determined as part of the geochemical analyses presented in Section 6.3 of the revised EIS (April 2018), Section 5 of Appendix JJ (The Water Report) of the revised EIS, as modified by any changes required in support of the Round 2 process as described in MW(2)-01 though MW(2)-12. **Surface Water Model** The model used for evaluating the effects of the Project on surface water quality is an integrated model that combines existing conditions, releases and discharges from the Project, seepage from the WRSA and TSF, and changes in surface water flow as a result of the Project. Effectively, the outputs from the groundwater and geochemical models are inputs to the surface water model. Given the number of Round 2 information requests regarding changes to the groundwater and mine waste (as well as surface water) technical disciplines, the surface water quality model has

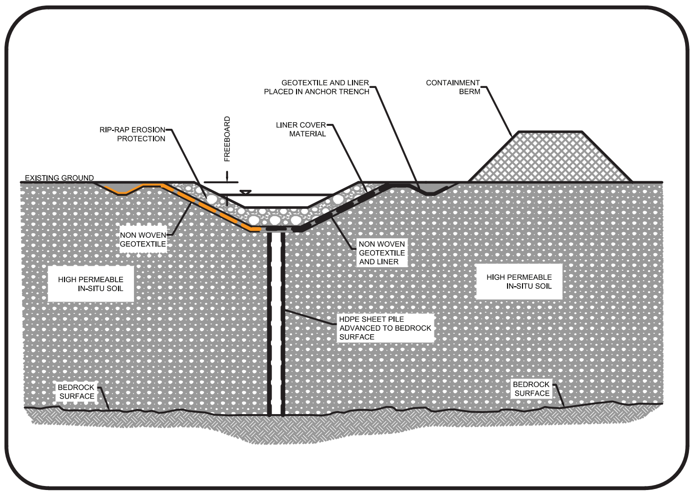
Unique Identifier	Agency IR	Annex	Agency / Group Stakeholder	[illegible]
				been revised to capture those changes. All of the changes as well as a revised prediction on surface water quality have been described in detail in the Goliath Gold Project Water Addendum. References: Shepley, M.G., Whiteman, M.I, Hulme P.J. & Grout, M.W. 2012. Groundwater Resources Modelling: a Case Study from the UK. Geological Society, London, Special Publication, v. 364.



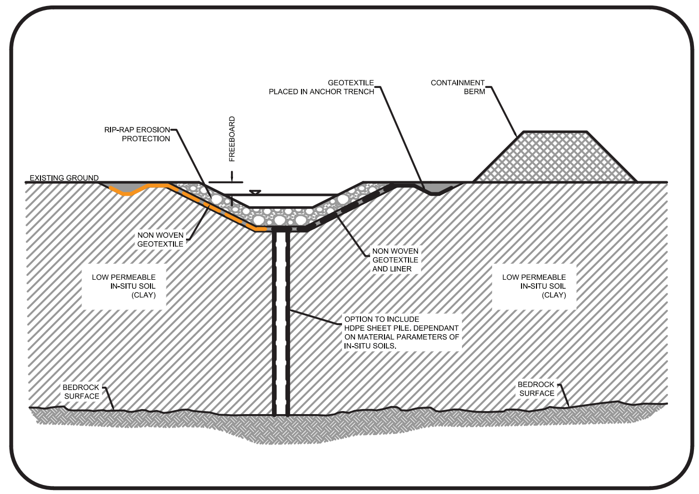
SEEPAGE COLLECTION DITCH TYPE A-1
BEDROCK AT OR CLOSE TO SURFACE



SEEPAGE COLLECTION DITCH TYPE A-2
SHALLOW BEDROCK WITH HIGH PERMEABLE SOILS



SEEPAGE COLLECTION DITCH TYPE A-3
DEEP BEDROCK WITH HIGH PERMEABLE SOILS



SEEPAGE COLLECTION DITCH TYPE A-4
LOW PERMEABLE SOILS OVER BEDROCK

NOTES:

1. INFORMATION SHOWN IS CONCEPTUAL AND IS PROVIDED FOR DISCUSSION.
2. SELECTION OF DITCH SECTIONS FOR CONSTRUCTION TO BE DETERMINED FROM SITE INVESTIGATION RESULTS.
3. ALL DITCHES TO BE DESIGNED WITH FLOW CAPACITY FOR THE ENVIRONMENTAL DESIGN STORM FOR THE SITE. DITCH LINING TO INCLUDE EROSION AND SCOUR PROJECTION (I.E. RIPRAP) BASED ON PEAK VELOCITY.
4. LINER FOR CONTAINMENT TO CONSIST OF LOW PERMEABLE ENGINEERED PRODUCT (I.E. GCL, HDPE).
5. CONTAINMENT BERM TO BE CONSTRUCTED OF EXCAVATED MATERIAL FROM DITCH ALIGNMENT. CONTAINMENT BERM TO PROVIDE ADDITIONAL CONTAINMENT IF WATER BREACHES THE DITCH.
6. LINER COVER PLACED TO PROVIDE PROTECTION AGAINST DAMAGE. LINER COVER MATERIAL TO CONSIST OF FINER GRADED GRANULAR MATERIAL (I.E. SAND) AND WILL BE DEPENDENT ON THE LINER SUPPLIER RECOMMENDATIONS.
7. TYPE A-4 - USE OF SHEET PILE DEPENDENT MATERIAL PROPERTIES OF THE POTENTIAL LOW PERMEABLE IN-SITU SOILS AND WILL BE DETERMINED BY LABORATORY TESTING ON SAMPLES COLLECTED FROM PLANNED SITE INVESTIGATIONS.

PRELIMINARY
FOR DISCUSSION PURPOSES

NOT FOR CONSTRUCTION

CLIENT: TREASURY METALS Inc.

CLIENT REF. #:

PROJECT: GOLIATH GOLD PROJECT
WABIGOON, ONTARIO

CONSULTANT: WSP

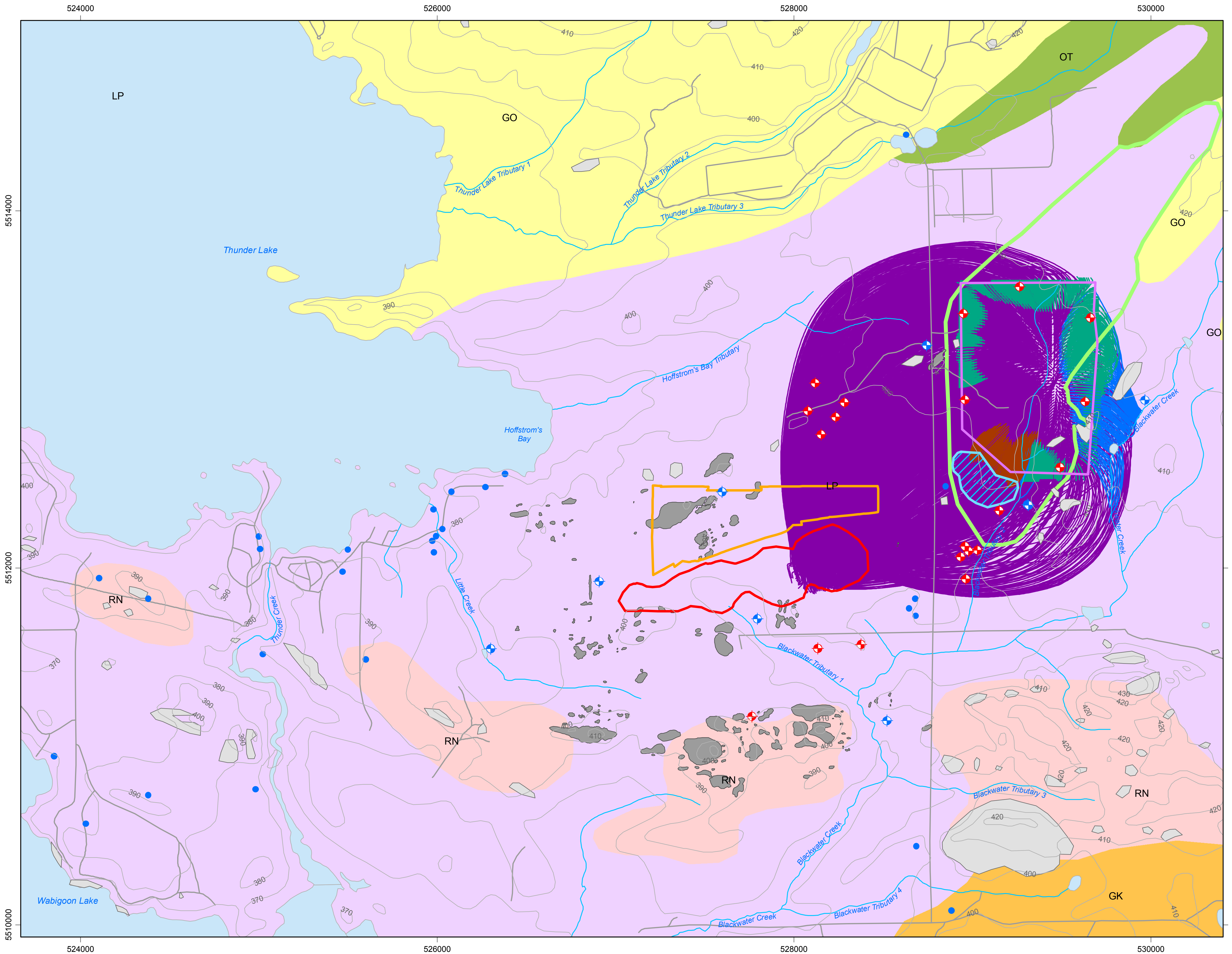
SEAL:

IS	RE	DATE (M/D/Y)	DESCRIPTION
1		02/9/17	ISSUED FOR CLIENT REVIEW

PROJECT NO: 161-15853-00
DATE: NOVEMBER 2016
ORIGINAL SCALE: NOT TO SCALE
IF THIS BAR IS NOT 25mm LONG, ADJUST YOUR PLOTTING SCALE.
25mm
DESIGNED BY: B.PLUMRIDGE
DRAWN BY: G.HOOGWERF
CHECKED BY:
DISCIPLINE: MINING

TITLE: **CONCEPTUAL SEEPAGE/RUNOFF COLLECTION DITCHES**

DOCUMENT NUMBER: FIGURE 3.7.3-2
SHEET #: 1 OF 2
ISSUE: ISSUED FOR CLIENT REVIEW
DATE OF: FEBRUARY 9, 2017
REV #: A



HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

TMI_911-GW(2)-04_Figure 1

Particle-Tracking Results for Uncapped TSF and Dewatered Mine Workings (Base Case)

Legend

- 2013 Monitoring Well
- 2014 Geotechnical Hole
- MOE Private Water Well

Pathlines Discharging to:

- TMA Drains
- Minewater Pond
- Blackwater Creek
- Open Pit and UMWs
- Proposed Open Pit
- Waste Rock Storage
- Area Tailings Storage
- Facility Minewater Pond

Surficial Geology

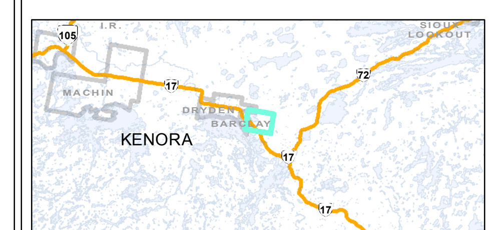
- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

Conditions encountered in the field may be different from the interpreted information presented on this figure.

Project #: TC160516
Date: August, 2018
Client: Treasury Metals Inc

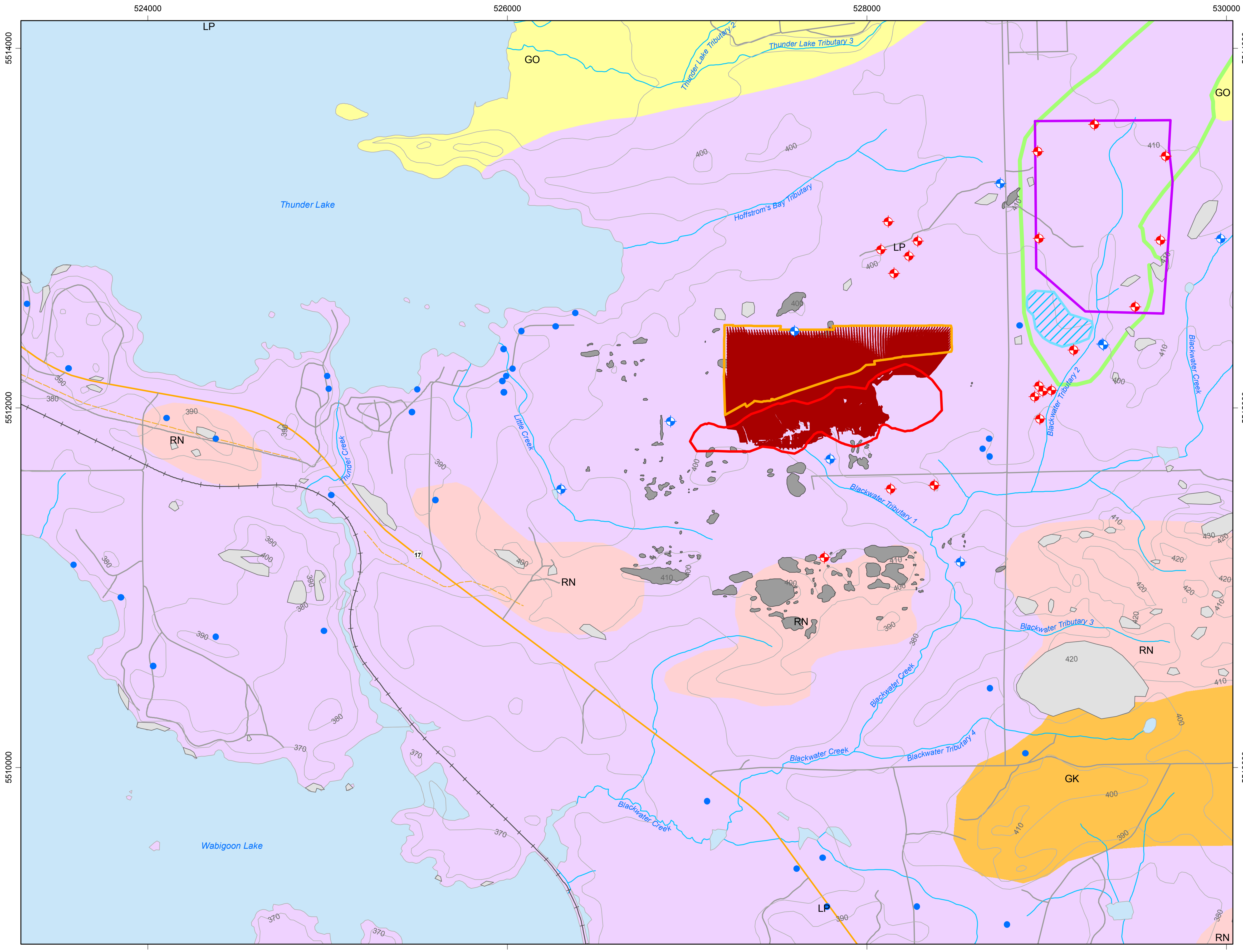
Drawn by: LJ
Checked by: MS
Revision No.: 0

UTM NAD 83
Zone 15N
1:20,000

Meters
0 100 200 300 400 500

TREASURY wood.

Wood Environment & Infrastructure Solutions
160 Traders Blvd E #110
Mississauga, ON L4Z 3K7



HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

TMI_911-GW(2)-04_Figure 2

Particle-Tracking Results for Uncapped WRSA and Dewatering Mine Workings (Base Case)

Legend

- 2013 Monitoring Well
- 2014 Geotechnical Hole
- MOE Private Water Well
- Proposed Open Pit
- Waste Rock Storage
- Tailings Storage Facility
- Minewater Pond
- Pathline Discharging to Waste Rock
- Elevation Contour (masl, 10 m intervals)

Surficial Geology

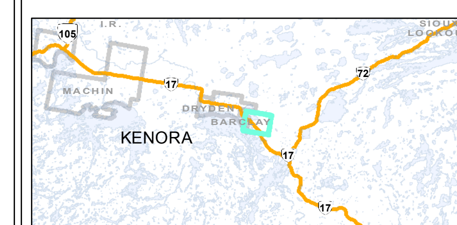
- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

Conditions encountered in the field may be different from the interpreted information presented on this figure.

Project #: TC160516
Date: August, 2018
Client: Treasury Metals Inc

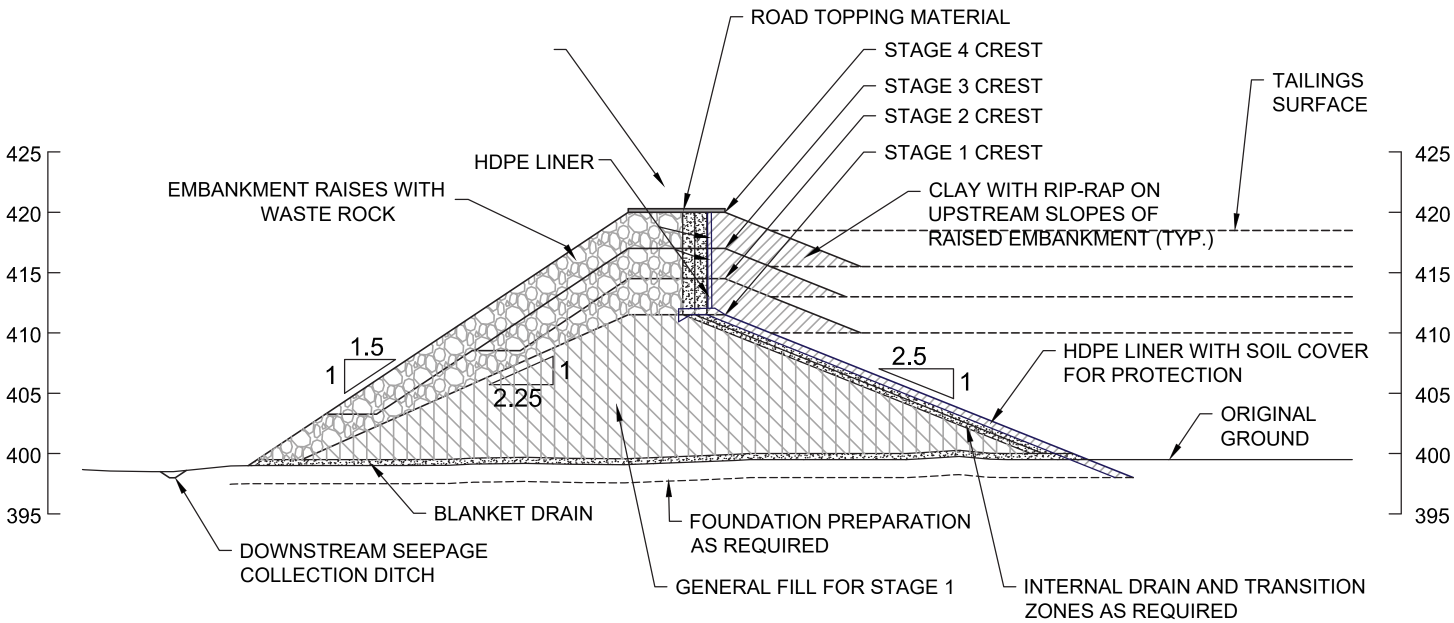
Drawn by: LJ
Checked by: MS
Revision No.: 0

UTM NAD 83
Zone 15N
1:20,000

Meters: 0 100 200 300 400 500

TREASURY METALS Inc.

Wood Environment & Infrastructure Solutions
160 Traders Blvd E #110
Mississauga, ON L4Z 3K7



NOTES:

1. DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. CONCEPT SHOWN IS PRELIMINARY AND NOT INTENDED FOR CONSTRUCTION. THIS CONCEPT ASSUMES CENTRELINE STYLE FOR EMBANKMENT RAISE.
3. EMBANKMENT STAGING AND STYLE OF RAISE TO BE CONFIRMED / OPTIMIZED WITH SUBSEQUENT LEVELS OF DESIGN.
4. CONCEPT SHOWN IS FOR LOCATION 1 ONLY.
5. FOUNDATION PREPARATION TO BE DETERMINED WITH SITE INVESTIGATION.
6. EMBANKMENT DIMENSIONS AND SLOPES TO BE CONFIRMED WITH DETAILED STABILITY. ASSESSMENT.

LEGEND

- GENERAL FILL
- NAG WASTE ROCK
- LOW PERMEABLE MATERIAL (CLAY)
- DRAIN AND TRANSITION
- HDPE LINER WITH SOIL COVER

WSP
1269 PREMIER WAY,
THUNDER BAY (ONTARIO)
CANADA P7B 0A3
TEL.: 807 625-6700 | FAX: 807 625-4491
WWW.WSPGROUP.COM

GOLIATH GOLD PROJECT
P.O. BOX 783
DRYDEN, ONTARIO P8N 2Z4
T: (807) 938-6961
F: (807) 938-6499

PROJECT: TREASURY METALS - GOLIATH PROJECT TAILINGS STORAGE FACILITY ALTERNATIVES ASSESSMENT

TITLE: LOCATION 1 POTENTIAL CROSS SECTION

PROJECT NO: 141-12598-00

SCALE: AS SHOWN

DRAWN BY: G. HOOGWERF

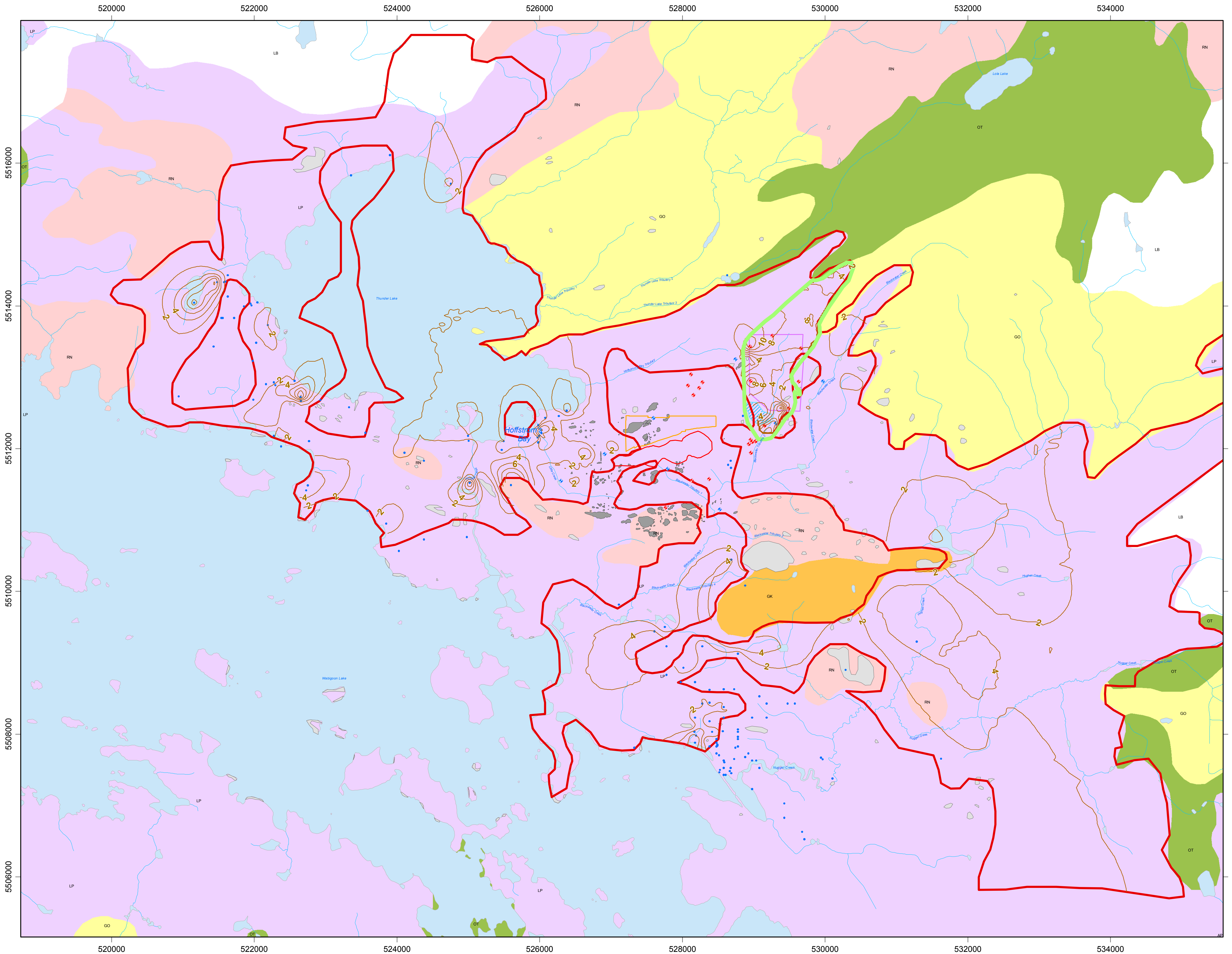
CHECKED BY: B. PLUMRIDGE

TREASURY METALS inc.

ISSUE/REVISION: DRAFT REPORT A

ISSUE DATE: MARCH 28, 2014

FIGURE NO: Figure 3.7.2-3



HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

TMI_951-GW(2)-01B_Figure 1

Thickness of Basal Sand

Legend

- Thickness of Basal Sand
- 2013 Monitoring Well
- 2014 Geotechnical Hole
- MOE Private Water Well
- Model Areas of Basal
- Proposed Open Pit
- Waste Rock Storage
- Tailings Storage Facility
- Minewater Pond

Surficial Geology

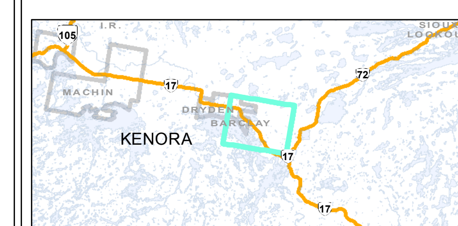
- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

Conditions encountered in the field may be different from the interpreted information presented on this figure.

Project #: TC160516
Date: August, 2018
Client: Treasury Metals Inc

Drawn by: LJ
Checked by: MS
Revision No.: 0

UTM NAD 83
Zone 15N
1:50,000

Meters
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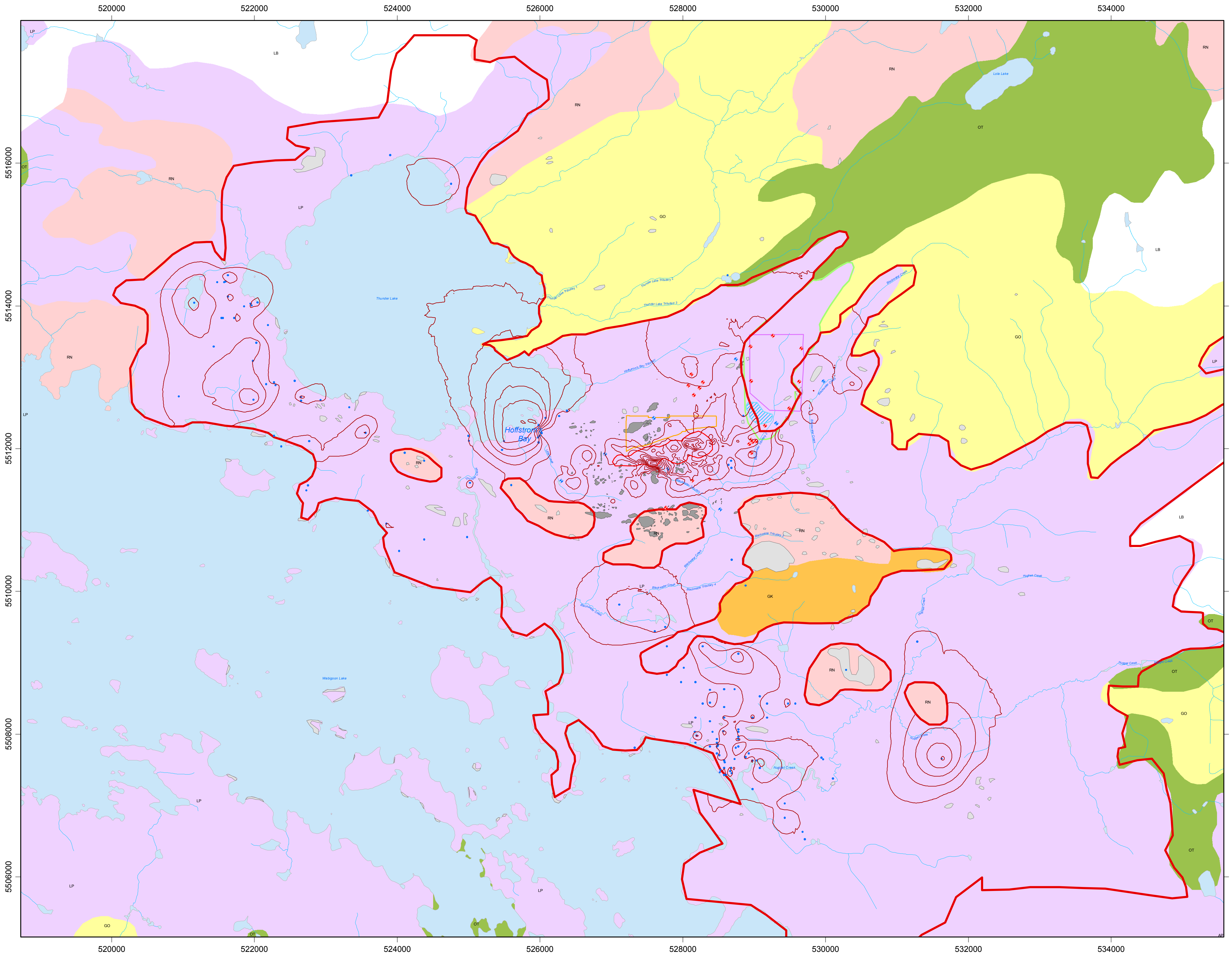
Wood Environment & Infrastructure Solutions
160 Traders Blvd E #110
Mississauga, ON L4Z 3K7



HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

TMI_951-GW(2)-01B_ Figure 2

Thickness of Clay

Legend

- Thickness of Clay
- 2013 Monitoring Well
- 2014 Geotechnical Hole
- MOE Private Water Well
- Model Areas of Clay
- Proposed Open Pit
- Waste Rock Storage Area
- Tailings Storage Facility
- Minewater Pond

Surficial Geology

- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
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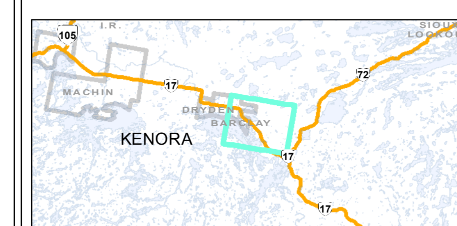
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

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Project #: TC160516
Date: August, 2018
Client: Treasury Metals Inc

Drawn by: LJ
Checked by: MS
Revision No.: 0

UTM NAD 83
Zone 15N
1:50,000

Meters
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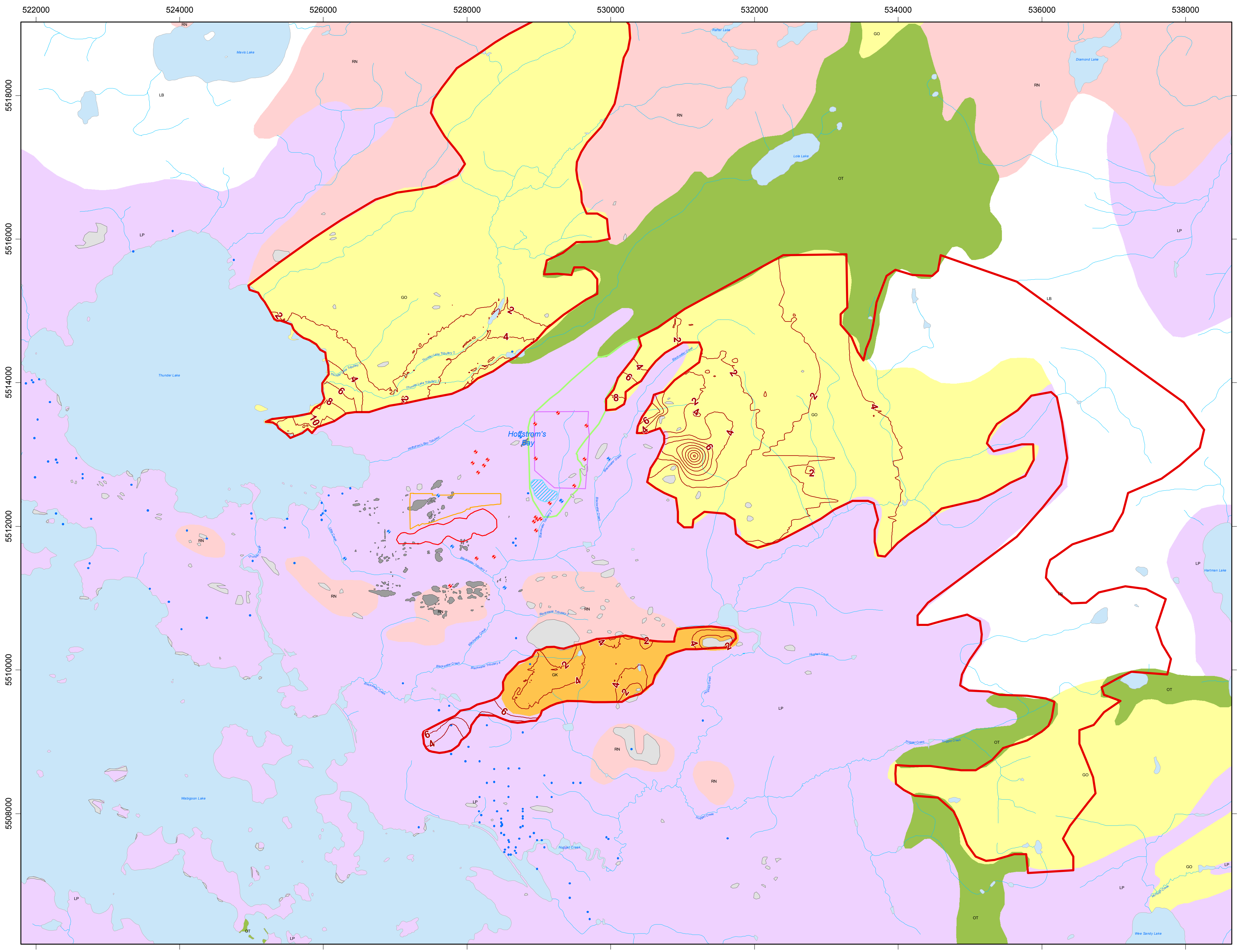
Mississauga, ON L4Z 3K7



HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

TMI_951-GW(2)-01B_Figure 3

Thickness of Sand and Gravel

Legend

- Thickness of Sand and Gravel
- 2013 Monitoring Well
- 2014 Geotechnical Hole
- MOE Private Water Well
- Model Area of Sand and Gravel
- Proposed Open Pit
- Waste Rock Storage
- Tailings Storage Facility
- Minewater Pond

Surficial Geology

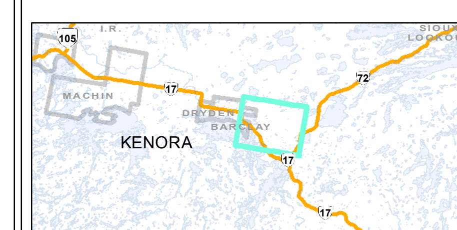
- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals



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Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

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0 260 520 780 1,040 1,300

TREASURY METALS

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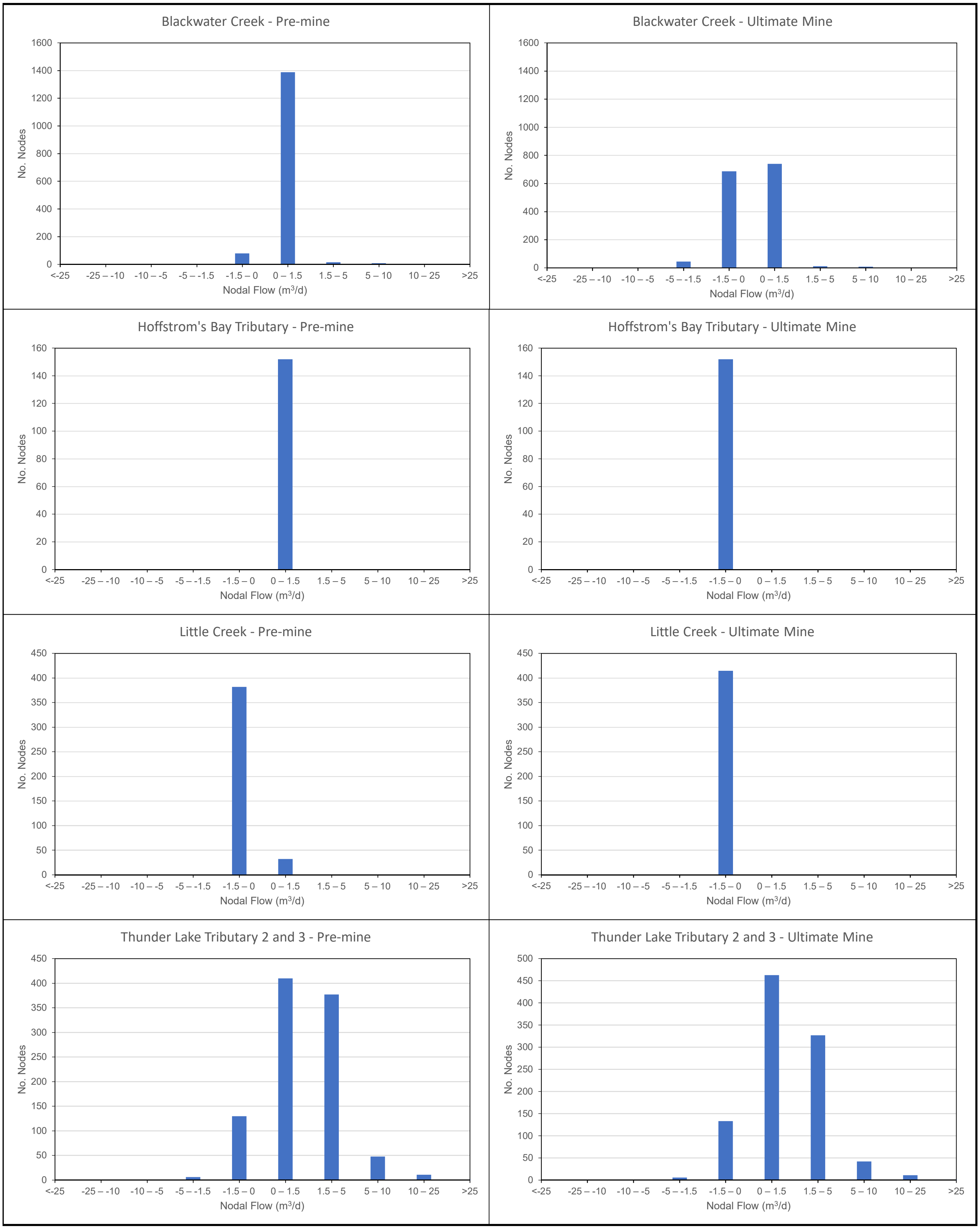
TMI_951-GW(2)-01B_Figure_A1

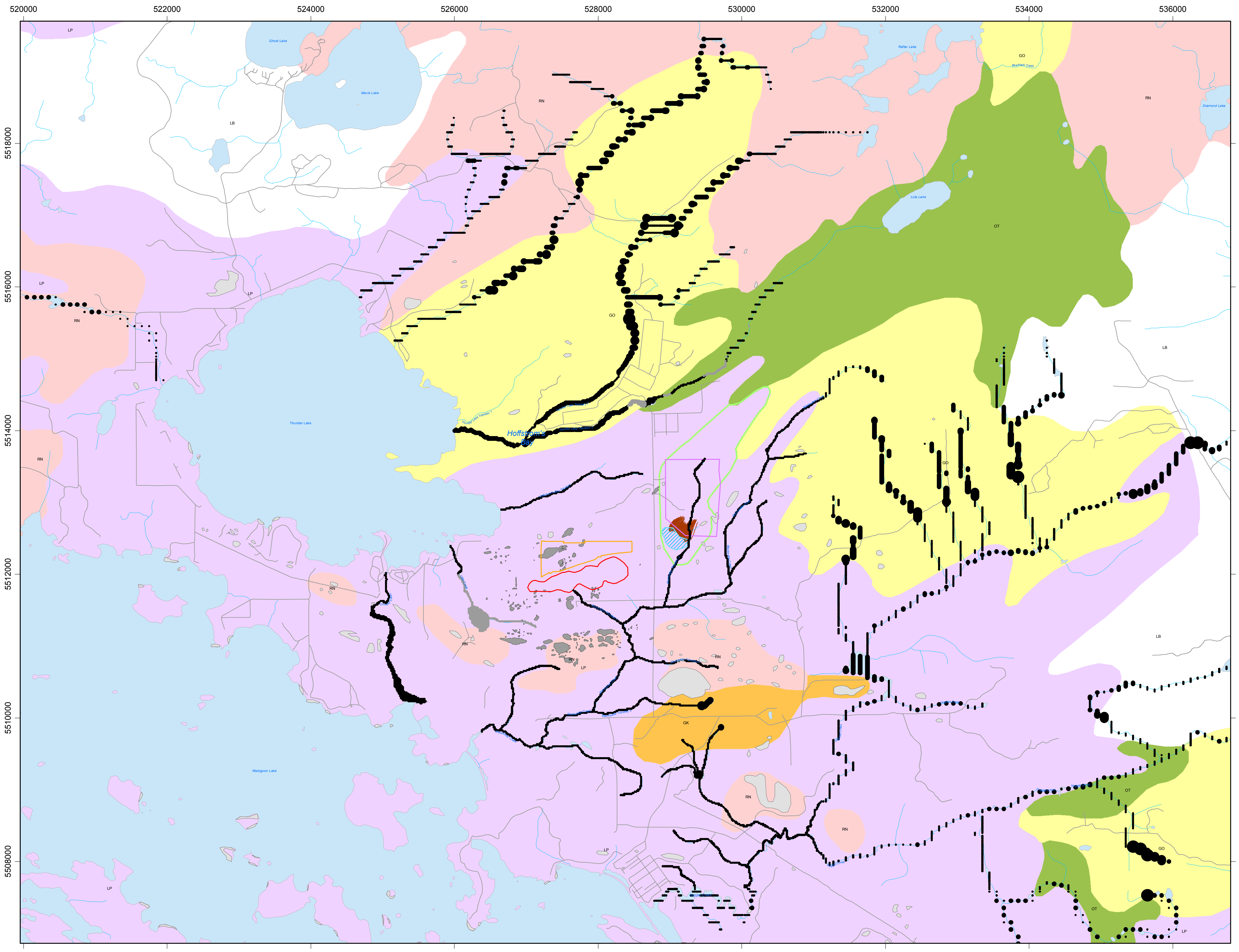


HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

TMI_951-GW(2)-01B_Figure_A2

Groundwater to Surface Water Interaction Simulated for Creeks and Rivers Base Case Pre-Mining



Legend

Flow Groundwater to Surface Water (Flow Rate m3/d)	Flow Surface Water to Groundwater (Flow Rate m3/d)
0.00 - 1.5	-1.5-0.0
1.5 - 5.0	-3.9 - -1.5
5.0 - 10.0	
10.0 - 25.0	
25.0 - 64.0	

- WMP
- Proposed Open Pit
- Waste Rock Storage
- Tailings Management
- Tailings Management Pond

Surficial Geology

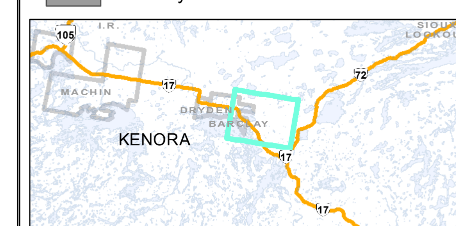
- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

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Project #: TC160516
Date: March, 2019
Client: Treasury Metals Inc

Drawn by: LJ
Checked by: MS
Revision No.: 0

UTM NAD 83
Zone 15N
1:50,000

Meters: 0 260 520 780 1,040 1,300

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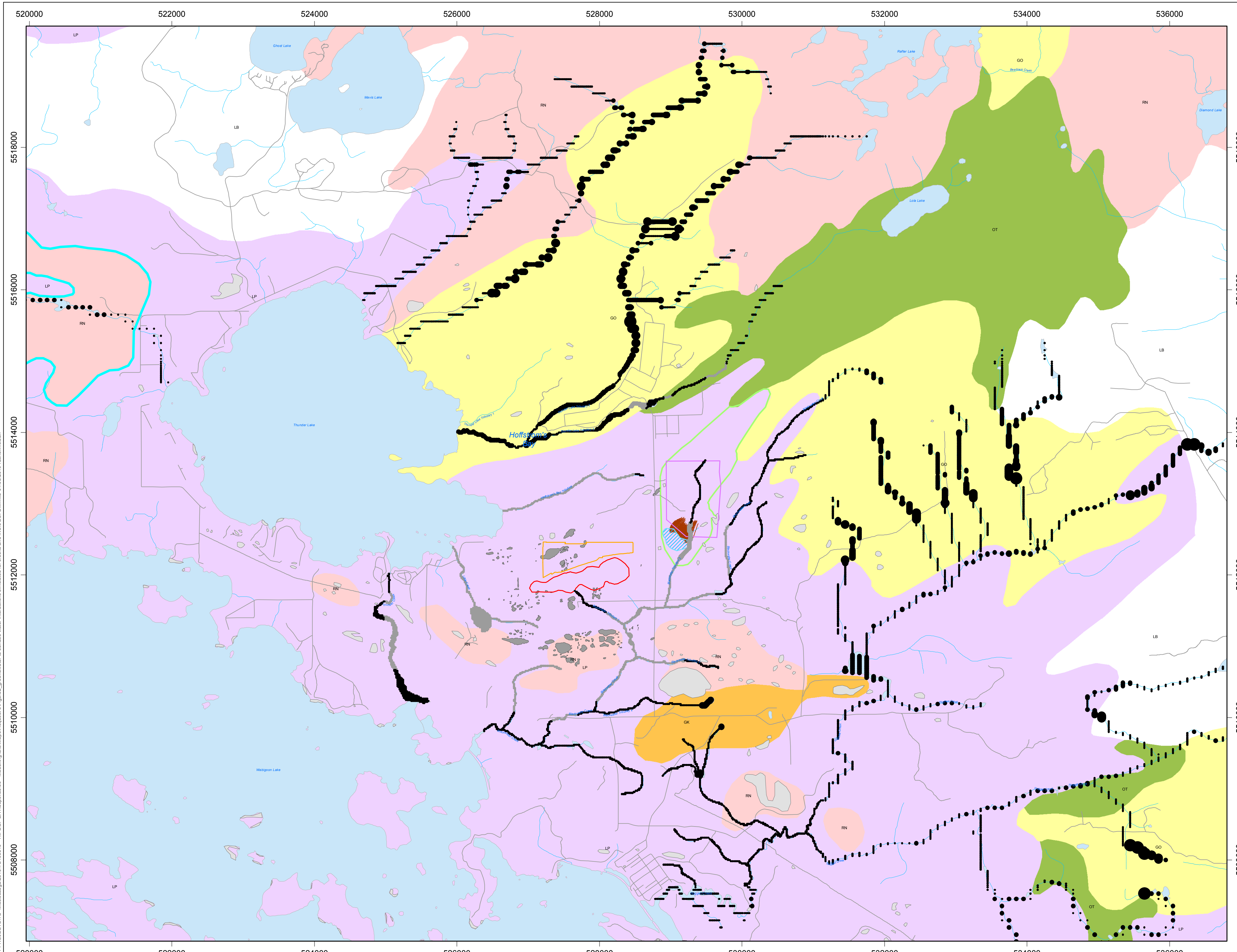


HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

TMI_951-GW(2)-01B_Figure_A3

Groundwater to Surface Water Interaction Simulated for Creeks and Rivers Base Case Ultimate Mine

Legend

Flow Groundwater to Surface Water (Flow Rate m3/d)
- 0.0 - 1.5
- 1.5 - 5.0
- 5.0 - 10.0
- 10.0 - 25.0
- 25.0 - 64.0

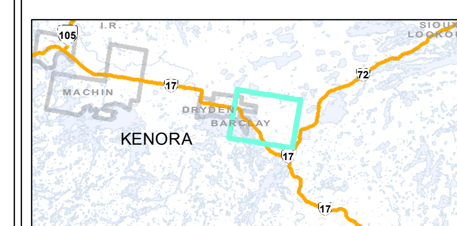
Flow Surface Water to Groundwater (Flow Rate m3/d)
- -1.5 - 0.0
- -3.9 - -1.5

- WMP
- Proposed Open Pit
- Waste Rock Storage Area
- Tailings Management Area
- Tailings Management Pond

Surficial Geology
- Sand - Clay / Silt - Sand Boundary

Landform
- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping
- Beakhouse and Pigeon, 2003
- Treasury Metals



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

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TMI_951-GW(2)-01B_Table_A2: Minewater Pond Water Quality and Seepage Quality

Parameter	Source	Groundwater Inflow	ARD Affected Rainwater on Open Pit	Clean Rainfall on open pit	WRSA Seepage	WRSA Runoff	TSF Seepage to Open Pit (including ditches)	TSF Seepage to Minewater Pond	Resulting Minewater Pond Quality
	Volume (m³/d)	1320	402.2432877	201.1216438	150	569.7	2.48	0.434	
Aluminum (mg/L)		0.01470	85.24533	0.68267	85.24533	0.27350	0.19900	0.19900	17.90991
Ammonia (unionized) (mg/L)		0.00316	2.83022	2.83241	2.83022	2.83022	0.22800	0.22800	1.41718
Ammonia (total) (mg/L)		0.08308	74.47938	74.53716	74.47938	74.47938	6.00000	6.00000	37.29426
Antimony (mg/L)		0.00074	0.00107	0.00130	0.00107	0.00107	0.00200	0.00200	0.00092
Arsenic (mg/L)		0.00248	0.03801	0.00134	0.03801	0.03801	0.01800	0.01800	0.01747
Barium (mg/L)		0.04099	—	0.01067	—	—	0.01200	0.01200	0.03693
Beryllium (mg/L)		0.00204	0.00495	0.00106	0.00495	0.00495	0.00050	0.00050	0.00320
Bismuth (mg/L)		0.00197	—	0.00089	—	—	0.00050	0.00050	0.00182
Boron (mg/L)		0.11971	0.12022	0.04111	0.12022	0.12022	0.02000	0.02000	0.11384
Cadmium (mg/L)		0.00004	0.00735	0.00005	0.00735	0.00020	0.00200	0.00200	0.00161
Calcium (mg/L)		59.57917	—	7.32556	—	—	7.15000	7.15000	52.58320
Carbonate (mg/L)		—	—	—	—	—	15.88000	15.88000	15.88000
Chromium (mg/L)		0.00200	0.00210	0.00171	0.00210	0.00210	0.00010	0.00010	0.00202
Chloride (mg/L)		22.76542	—	1.37667	—	—	0.78000	0.78000	19.90078
Cobalt (mg/L)		0.00156	0.75566	0.00067	0.75566	0.00090	0.00400	0.00400	0.15874
Copper (mg/L)		0.00564	0.27122	0.00128	0.27122	0.00500	0.01800	0.01800	0.06062
Cyanide (mg/L)		0.00200	—	0.00302	—	—	1.00000	1.00000	0.00404
Iron (mg/L)		0.26671	265.72775	1.76556	265.72775	1.49500	0.35800	0.35800	56.04967
Lead (mg/L)		0.00197	0.21064	0.00095	0.21064	0.00500	0.08200	0.08200	0.04618
Lithium (mg/L)		0.09950	—	0.03875	—	—	0.02400	0.02400	0.09134
Magnesium (mg/L)		12.76458	—	1.60222	—	—	1.44000	1.44000	11.26987
Manganese (mg/L)		0.36046	—	0.05504	—	—	0.06300	0.06300	0.31958
Mercury (mg/L)		0.00004	0.00005	0.00002	0.00005	0.00002	0.00180	0.00180	0.00004
Molybdenum (mg/L)		0.00233	0.00053	0.00101	0.00053	0.00053	0.00100	0.00100	0.00147
Nickel (mg/L)		0.00535	5.75745	0.00200	5.75745	0.02500	0.02100	0.02100	1.20987
Nitrate (mg/L)		0.08496	—	0.11000	—	—	7.07000	7.07000	0.10162
pH (mg/L)		—	—	5.82000	—	—	6.16000	6.16000	5.82486
Phosphorus (mg/L)		—	—	0.03334	—	—	0.06000	0.06000	0.03372
Potassium (mg/L)		4.31917	—	0.94611	—	—	1.78000	1.78000	3.86918
Selenium (mg/L)		0.00236	0.00270	0.00117	0.00270	0.00270	0.00050	0.00050	0.00241
Silicon (mg/L)		—	—	6.93333	—	—	0.09900	0.09900	6.83572
Silver (mg/L)		0.00020	0.00011	0.00009	0.00011	0.00010	0.00005	0.00005	0.00015
Sodium (mg/L)		11.11292	—	1.38667	—	—	1.16000	1.16000	9.81035
Strontium (mg/L)		0.11640	—	0.01786	—	—	0.03200	0.03200	0.10323
Sulphate (mg/L)		31.37708	—	2.12000	—	—	68.67000	68.67000	27.58743
Sulphur (mg/L)		—	—	—	—	—	22.94000	22.94000	22.94000
Thallium (mg/L)		0.00060	0.00058	0.00027	0.00058	0.00030	0.64200	0.64200	0.00121
Tin (mg/L)		0.00198	—	0.00112	—	—	0.00050	0.00050	0.00186
Titanium (mg/L)		0.00699	—	0.02217	—	—	0.00300	0.00300	0.00898
Uranium (mg/L)		0.00803	0.11257	0.00400	0.11257	0.00500	0.00500	0.00500	0.02889
Vanadium (mg/L)		0.00205	0.00552	0.00161	0.00552	0.00552	0.00400	0.00400	0.00349
Zinc (mg/L)		0.00720	3.39940	0.01136	3.39940	0.03000	0.04000	0.04000	0.72045