Attachment 1

2019 TIA Annual Geotechnical Inspection Report (SRK, 2020)

2019 Annual Geotechnical Inspection
Tailings Impoundment Area
Hope Bay Project, Hope Bay, Nunavut

Prepared for

TMAC Resources Inc.

Prepared by

SRK Consulting (Canada) Inc.
1CT022.038.400
July 2020

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Tailings Impoundment Area
Hope Bay Project, Hope Bay, Nunavut

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File Name: Doris_TIA_2019_AGI_Report_20200703_1CT022.038_rw_PL.docx

Executive Summary

The Hope Bay Project is a gold mining and milling undertaking of TMAC Resources Inc. The Project comprises three distinct areas of known mineralization, Doris, Madrid (North and South), and Boston. Doris Mine (Phase 1) is currently being operated (as of December 2018) under Nunavut Water Board (NWB) Type A Water License 2AM-DOH1335 - Amendment No.2. This license covers the current Phase 1 and well as the Phase 2 mining developments. TMAC contracted SRK Consulting (Canada) Inc. to conduct an annual geotechnical inspection (AGI) for the Tailings Impoundment Area (TIA) in accordance with all stipulated license conditions.

The TIA currently consists of a water retaining dam, the North Dam, and a tailings retaining dam, the South Dam. A second tailings retaining dam or saddle dam, the West Dam, will be built adjacent to the South Dam when the South Dam is raised. Subaerial tailings are currently retained by the South Dam, and the Reclaim Pond is impounded by the North Dam. The North Dam was constructed during the winters of 2011 and 2012, and Phase 1 of the South Dam was constructed in one season during the winter of the 2017 to 2018 season. In Phase 2, the South Dam will be raised approximately 46m and the West Dam will be constructed. Phase 2 construction is expected to commence around 2022 with the downstream raise of the South Dam. Around the winter of 2023 construction of the West Dam is expected to start. The exact timing of the commencement of the South Dam Phase 2 raise and West Dam construction will be depending on mill processing rates and on-site development activities. An internal dike structure (referred to as the Interim Dike) was previously designed for Phase 2 but is no longer required.

Table A provides a summary of the 2019 AGI inspection components for the TIA, and the primary recommendations stemming from the site inspection and subsequent review of monitoring data. The recommendations from the previous 2018 AGI are included for reference. Based on the results of the 2019 AGI, the North Dam and South Dam are functioning as designed, and no concerns were identified regarding the ongoing performance of these structures. There are however maintenance issues that require attention, and suggestions for improvement of the performance monitoring system. The items in Table A are considered important to the ongoing performance and safety of the TIA and require attention by TMAC prior to the 2020 annual geotechnical inspection. Where appropriate, an update status of certain recommendations is provided in *red* text.

Table A: Summary of 2019 AGI Recommendations

Inspection Item	2018 Recommendations (for reference)	2019 Recommendations
General TIA Management Recommendations		
Third Party Dam Safety Review	• The North Dam hazard classification was revisited and is considered HIGH. This requires an independent third-party Dam Safety Review by 2021.	• Conduct an independent third-party Dam Safety Review for both the North and South Dams in the summer of 2021.
Tailings Operating, Maintenance and Surveillance (OMS) Manual and Emergency Response Plan (ERP)	• Ensure all staff are aware of the OMS Manual and are familiar with its contents. • Review and revise the OMS manual to ensure consistency with the recently amended Water License. • Provide necessary training in accordance with the OMS Manual.	• An update to the OMS manual is in progress by SRK and will be submitted by Q4, 2020. This update is aimed to be a notable improvement to the current OMS. This noted, additional updates are expected in Q3 and Q4 2020. The focus of the OMS updates in Q3 and Q4 will be further refinement of the Trigger Action Response Plans (TARPs). The OMS for this facility will be a 'living' document that is expected to be reviewed annually. • TMAC should ensure all staff are properly informed and trained on the contents of the OMS Manual. • *At the time of writing this report, TMAC was in the process of developing a standalone 'Hope Bay Project Dam Emergency Plan', rather than updates to the ERP, to address dam emergencies. It will incorporate inundation mapping and dam break scenarios. The standalone dam emergency plan will be released upon completion of the OMS update to ensure alignment.* An Emergency Reponses Plan exists for the site; however, this document was lacking sufficient detail for a specific emergency at the TIA, if one were to occur. In 2019 SRK visited site and held a session with site personnel to go over preliminary dam break inundation maps completed by SRK and to provide inputs into what should be included in the site ERP updates to ensure the TIA is properly covered in this document. An update to the ERP is recommended in 2020 to provide additional details for the TIA.
TIA Responsible Parties	• N/A	• TMAC must agree on the roles and responsibilities for the TIA, train and inform personnel of their duties, and operate the facility accordingly. This will be an ongoing recommendation that is expected to be repeated annually. The roles and responsibilities for the TIA will be defined in the OMS update, to be released in 2020.
Monitoring Standard Operating Procedures (SOPs)	• To avoid confusion update SOPs to reflect changes that has been agreed to since the original SOP was developed.	• Update the Monitoring SOP to include South Dam monitoring requirements. SRK is currently preparing a separate SOP for the South Dam, and one already exists for the North Dam. A draft version of the South Dam SOP was submitted to TMAC in June 2020 and a final version is expected in July 2020.

Inspection Item	2018 Recommendations (for reference)	2019 Recommendations
Compliance with Monitoring Requirements	• Improve efforts to conduct monitoring at the frequency described in the SOPs.	• Conduct monitoring in accordance with the Monitoring SOP, paying attention to those areas where conformance is not consistently met.
North Dam Inspection and Review of Monitoring Data		
Ground Temperature Cables (GTCs)	• In accordance with manufacturers recommendations, the dataloggers must be recalibrated as it has been in operation for more than five years. Internal batteries on the dataloggers must also be replaced. • A monitoring well near ND-VTS-130-DS is no longer required. See “Physical Inspection of North Dam”.	• There are no specific recommendations for the installed GTCs. However, TMAC should aim to improve performance tracking of the dataloggers at the South Dam and check to see if cables are being damaged by wildlife after spring melt in order to confirm that current cable protection is adequate.
Thermosyphons	• AFI or another qualified contractor must physically inspect thermosyphon North 2 (at the North Dam) and determine why it is not working. Appropriate repairs must be conducted. • While the contractor is on-site, have them inspect all thermosyphons, and carry out any additional maintenance they recommend.	• The 2018 recommendations were completed in 2019 and Arctic Foundations Canada (AFC) visited the site for an inspection. Additional details are provided in this 2019 AGI (see Appendix A).
CR1000 Datalogger Battery Voltage	• The external datalogger batteries should be tested and recharged or replaced annually.	• The external CR1000 datalogger batteries should continue to be monitored and recharged annually or replaced as needed.
Inclinometers	• No action required.	• The inclinometer and associated readout device should be recalibrated every 3 years as per recommended best practice. SRK was aware that TMAC sent this instrument for recalibration but due to COVID-19, the instrument calibration was unable to be performed and had to be returned from the out of country manufacturers. This recommendation should be revisited before the spring of 2021.
Survey Monitoring Points	• Backfill the erosion around ND−DSP−100.	• Backfill the erosion around survey monitoring point ND−DSP−100 at the North Dam. • Continue to carefully observe the North Dam downstream shell settlement points ND-SSP-080-3 and ND-SSP-110-3 to determine if thaw settlement of the toe is causing undue deformation.
Creep Displacement	• N/A	• None.
Walkover Surveys	• Improve efforts to conduct walkover surveys in accordance with the frequency prescribed in the SOP.	• The required weekly walkover surveys at the North Dam are not being completed in accordance with the SOP. This is an important surveillance activity as defined in the OMS Manual and needs to be complied with.
North Dam Seepage	• Continue to conduct monitoring of the North Dam toe seep in accordance with	• Continue water quality monitoring of North Dam seepage according to the methods

Inspection Item	2018 Recommendations (for reference)	2019 Recommendations
	the recommendations (see Appendix J for the 2018 TIA AGI). This includes: • Field measurements of Electrical Conductivity when Surveillance Network Program (SNP) samples are collected at TL-1; • Weekly sampling and geochemical analysis of North Dam toe seepage when present; • Annual review of North Dam toe seepage water chemistry; • Measurement of active layer thaw depth using a frost probe.	outlined in SRK (2018b) (this was completed in 2019). • Conduct at least one additional frost probe survey along the same transects in early summer and early fall, following the same procedure as in 2018 and 2019. Based on current favourable results, SRK will revisit the requirements for the frost probe surveys as part of the 2020 AGI and determine if further surveys are required beyond 2020.
AGI Physical Inspection	• N/A	• None.
South Dam Inspection and Review of Monitoring Data		
Ground Temperature Cables (GTCs) and D405 Dataloggers	• N/A	• Complete a walk over survey of the South Dam after spring melt and look for any exposed or damaged ground temperature cables. This will allow for preventative maintenance to be done if exposed cables are observed, which will help to limit the potential for damage from wildlife. • SRK to further assess, if repairs are not possible, replacement of Ground Temperature Cables SD-VTS-155-US, SD-VTS-240-US and SD-VTS-240-DS will be required. • Manually download data from each datalogger once annually or as specified by the EOR.
Survey Monitoring Points	• N/A	• None.
Physical Inspection of the South Dam and Walkover Surveys	• N/A	• Start weekly walkover surveys of the South Dam in 2020. This is an important surveillance activity. Additional details will be provided to TMAC in the South Dam SOP.
TIA-Wide Monitoring		
Tailings Deposition System	• No action required.	• TMAC should install the dedicated mine water discharge pipeline to the TIA as soon as possible to allow tailings deposition to recommence from the South Dam. It is critical that tailings deposition from South Dam recommence in order to maintain a beach length of at least 100 m at all times, for all TIA water levels. *UPDATE: this was addressed at the start of 2020 and is now complete. The Roberts Bay Discharge system is now operational.* • Saline mine water may only be discharged together with tailings from, or within, 300 m of the South Dam provided the freezing point depression is less than 0.5ºC (around 4,500 mg/L Cl maximum equivalent). If the

Inspection Item	2018 Recommendations (for reference)	2019 Recommendations
		freezing point depression exceeds 0.5ºC, saline mine water may only be discharged with tailings at other designated tailings discharge points further than 300 m from the South Dam or directly into the Reclaim Pond. The freezing point depression calculation is provided in this AGI and will be incorporated by SRK into the updated OMS Manual (update currently in progress). • The tailings discharge system must be operated in accordance with the designated tailings discharge plan. Primary spigot moves should be expected around, or shortly afterwards, spring melt and again prior to winter freeze up. • Areas along the eastern shoreline of the TIA where tailings discharge has occurred at elevations above 36.5 m need to be carefully monitored to determine if permafrost damage is occurring due to tailings flow and vegetation dieback. Should any damage be noted, appropriate proactive mitigation may be required.
Emergency Dump Catch Basins	• N/A	• Repair the Western Emergency Dump Catch Basin at the earliest opportunity to ensure liner movement does not occur and impact the as-built storage capacity of this Emergency Catch Basin.
Pipelines (Reclaim, Tailings Deposition and TIA Discharge)	• N/A	• TMAC must carefully inspect all pipelines placed directly on the tundra for signs of vegetation dieback and associated flow path channelling. Where this is occurring, the pipeline must be relocated to follow existing all-weather road shoulders, and appropriate remediation needs to be put in place where damage has occurred. Going forward, TMAC should consider abandoning the practice of placing pipelines directly onto the tundra. • The permafrost thermal erosion feature that has developed along the northern shore of the TIA was backfilled by TMAC in 2019. This area should continue to be monitored to ensure that additional thermal erosion does not result in this area.
Shoreline Erosion	• N/A	• None.
TIA Water Balance	• N/A	• It is of paramount importance that the Roberts Bay Discharge System Pipeline be completed during the summer of 2019. Further delay of this may result in reduced operations. *UPDATE: this was addressed at the start of 2020 and is **now complete**. The Roberts Bay Discharge system is now operational.*
Climate Data	• N/A	• None.

Inspection Item	2018 Recommendations (for reference)	2019 Recommendations
TIA Water Quality	• N/A	• No recommendations; however, the following comments are made below. • The water treatment plant for the TIA is required to be maintained in good operational condition so that discharge of supernatant water can occur once the Roberts Bay Discharge System Pipeline is operational, and allow treated water to be discharged in order to maintain water levels in the TIA below the full supply level. *UPDATE: as of the start of 2020 the Roberts Bay Discharge system and the connected water treatment plant is now operational.*
TIA Reclaim Water Pad / 710 Pumphouse Pad	• N/A	• Notable settlement was noted at the TIA Reclaim Jetty Pad (also referred to as the 710 Pumphouse pad). Upon visual inspection and from review of the as-built data, it looks like new ROQ material was placed off the edge of the pad in thick, end dumped lifts in order to widen the pad for the new 710 pumphouse. There are notable stability concerns with this pad as large settlements and notable cracking indicate that a failure of this pad (albeit slow) appears to be occurring. However, it should be noted that the rate of movement could increase suddenly causing a sudden failure, and this risk should not be ignored. Monitoring of this area (at least weekly during winter and daily during months with no ice cover on the lake) should be completed. It is recommended that remediation measures be completed for the pad in order to stabilize the fill and prevent further deformation. This is expected to consist of placing additional fill along the outside of the access road and pad to reduce the overall slope and provide additional confining stress at the toe of the pad (which is currently underwater). Rates of loading must be controlled and slow enough in order to avoid inducing excess pore pressures in the foundation. This means that it may take weeks to build this small additional fill and that the dumping faces should be spread out as much as possible. Material should be end dumped back from the working face and spread with an excavator with the largest reach on site (to limit loading at the crest).

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Appendices

1 Introduction

1.1 General

The Hope Bay Project is a gold mining and milling undertaking of TMAC Resources Inc. The Project is located 705 km northeast of Yellowknife and 153 km southwest of Cambridge Bay in Nunavut Territory, and is situated east of Bathurst Inlet (Figure 1). The Project comprises three distinct areas of known mineralization, Doris, Madrid (North and South), and Boston.

The Project is being executed in Phases; Phase 1 is currently carried out under an existing Type A Water Licence (Figure 2), while Phase 2 will be carried out under the two Water Licences that were approved in December 2018 (Water License 2AM-DOH1323 and 2AM-DOH1335). Phase 1 includes mining and infrastructure at Doris, while Phase 2 includes mining and infrastructure at Madrid and Boston located approximately 10 and 60 km south from Doris, respectively. The Doris Tailings Impoundment Area (TIA) (Figure 3) will ultimately contain both Phase 1 and 2 tailings.

Construction of Phase 1 infrastructure started in 2007, and underground development commenced in 2010. The North Dam which provides containment for the TIA at its northern perimeter was constructed over two winter seasons, 2011 and 2012 (Figure 3). In the fall of 2012, the Project was placed into Care and Maintenance prior to completing infrastructure development required to allow commercial production. Following an ownership change of the Project, Phase 1 was taken out of Care and Maintenance in 2015 and transitioned into commercial production in 2017. Construction of the South Dam, providing southern TIA containment was carried out between January and June of 2018 (Figure 3).

To fulfill regulatory compliance requirements for an annual geotechnical inspection (AGI) for the TIA containment dams as well as any supplementary infrastructure pertaining to the TIA operations such as pipelines and emergency catch basins, TMAC contracted SRK Consulting (Canada) Inc. to conduct the 2019 inspection. This report provides a summary of the conditions observed, a review of monitoring data, and recommendations to ensure ongoing successful performance of the tailings management system. SRK has conducted each formal AGI of the TIA since 2012 (SRK 2012a, 2013a, 2014a, 2014b, 2016a, 2017a, 2018a, 2019a).

Cam Scott, MSc, PEng, Principal Consultant, and John Kurylo, MSc, PEng, Senior Consultant with SRK, conducted the on-site geotechnical inspection between August 16 and 21, 2019. As of 2019, with the passing of Maritz Rykaart, John Kurylo has taken over the official Engineer-of-Record (EOR) for the North and South Dams (see Appendix O). Weather conditions during the inspection were rainy on August 20, becoming sunny on August 21. The detailed inspection of the dams and supporting infrastructure was carried out on foot, followed by an aerial survey of the TIA using a low altitude helicopter flyover. Kyle Conway, On-Site Environmental Superintendent with TMAC, accompanied Cam and John during the walkover inspections. Photos detailing the inspection conditions are included as photologs, and comprehensive review and analysis of the monitoring data are provided in the appendices. A post inspection meeting was held on site with key personnel from relevant departments, where SRK presented the preliminary inspection findings.

1.2 Inspection Requirements

Phase 1, including the TIA, is licensed by the Nunavut Water Board (NWB) under Type A License 2AM-DOH1323 - Amendment No. 1, dated November 4, 2016. This licence entitles TMAC to use water and dispose of mine waste associated with their operation. The following specific inspection requirements, relevant to the TIA, are stated in Part J, items 16 and 17 of the license:

16. The Licensee shall undertake a geotechnical inspection annually between July and September, by a Geotechnical Engineer. The inspection shall be conducted in accordance with the Canadian Dam Safety Guidelines where applicable and take into account all major earthworks, including the following:

a. Tailings Impoundment Area North Dam, Interim Dike and South Dam;
b. Geotechnical instrumentation and associated monitoring data;
…
d. Tailings Impoundment Area shoreline and erosion strip survey monitoring results;
…

17. The Licensee shall submit to the Board for review, within ninety (90) days of completion of the geotechnical inspection, the Geotechnical Engineer's inspection report. The report shall include a cover letter from the Licensee outlining an implementation plan addressing each of the Geotechnical Engineer's recommendations and shall include the following:

a. All quantities in cubic meters of dike seepage from the North and South Dams pumped back into the Tailings Impoundment Area;
b. As-built drawings and a summary of the mitigation works undertaken along the shoreline of the Tailings Impoundment Area in response to erosion, as stipulated in the Shoreline Adaptive Management Plan; and
c. All data and information generated from the monitoring of all project geotechnical instrumentation.

Additional inspection requirements for other components of Phase 1 are listed within the water license; these conditions are addressed in separate inspection reports which are submitted to the NWB under different covers.

Under the Phase 2 Type A Water License 2AM-DOH1335 - Amendment No. 2, dated December 7, 2018, the specific TIA inspection requirements are stated in Part I, items 9 and 10 of the license:

9. The Licensee shall undertake a geotechnical inspection of all surface infrastructure and earthworks, annually between July and September, by a Geotechnical Engineer. The inspection shall be conducted in accordance with applicable best practices including the Canadian Dam Association Guidelines for water and waste containment facilities.

10. The Licensee shall submit to the Board for review, within ninety (90) days of completion of the geotechnical inspection, a report in accordance with Part I Item 9 and/or the Annual Report. The report shall include a cover letter from the Licensee outlining an implementation plan addressing each of the Geotechnical Engineer's recommendations and shall include the following:

a. All quantities in cubic meters of dike seepage from the North, West, and South Dams pumped back into the Tailings Impoundment Area;

b. *As-built drawings and a summary of the mitigation works undertaken along the shoreline of the Tailings Impoundment Area in response to erosion; and*
c. *All data and information generated from the monitoring of all project geotechnical instrumentation.*

As both water licenses were in effect over the time since the previous inspection, and since the TIA operational strategy changes to some extent between Phase 1 and Phase 2, the 2019 AGI was completed taking into consideration both the Water Licence in effect in August 2018 (2018 Inspection) and the new Water Licence obtained in December 2018.

2 Site Conditions

2.1 Tailings Impoundment Area History

A summary of the TIA permitting, construction, and operations history is provided in Table 1.

Table 1: Summary of TIA Development History

Period	Comments
2003	Doris North Project preliminary economic assessment is completed with Tail Lake designated as the TIA, assuming subaqueous deposition and a maximum tailings quantity of about 0.4 Mt (SRK 2002a).
2002 - 2005	Geotechnical, geophysical, geohydrological and permafrost investigations of dam foundations (North, South and alternate internal locations), TIA shoreline perimeter, and TIA talik (SRK 2002b, 2003 and 2005a, 2005b and 2005c).
2005	Environmental Assessment for the Doris North Project is completed which includes rigorous alternatives assessment confirming Tail Lake as the preferred TIA.
2006	Project Certificate is issued for the Doris North Project.
2006	Application for Schedule 2 listing of Tail Lake as TIA in accordance with the Metal Mining Effluent Regulations (MMER).
2008	Tail Lake MMER Schedule 2 listing obtained.
Winter 2011 and Winter 2012	North Dam constructed (SRK 2012b).
Fall 2012	Project placed into Care and Maintenance before any tailings was ever produced.
2012 – 2015	Project in Care and Maintenance. Water within the TIA is managed in accordance with the Interim Water Management Plan (SRK 2012c) which includes pumping water from the Pollution Control Pond (PCP) to the TIA and discharging TIA water to Doris Creek.
2015 – 2016	TMAC submits application to amend the Water Licence and Project Certificate which amongst other things will result in a change from subaqueous tailings deposition to sub-aerial tailings deposition, increase the TIA capacity to 2.5 Mt, change the South Dam design to a frozen foundation dam, and construction of an Interim Dike. This amendment was approved November 4, 2016.
2017 – 2019	TMAC submits application to amend the Doris Water Licence and Project Certificate, and to obtain a new Water Licence in support of Phase 2 of the Hope Bay Project. Amongst other things, this will result in increasing the TIA capacity to 18 Mt, constructing a South Dam raise, and the Interim Dike would no longer be required. The updated Project Certificate was issued in October 2018, and the amended and new Water Licence issued December 2018.
January 2017	Start of tailings deposition in TIA.
January – June 2018	Completion of Phase 1 South Dam construction.
August 2018	Additional installation of South Dam instrumentation, and cable extensions for the ground temperature cables.
May 2019	Instrumentation upgrades and additional data logger installations at the South Dam.

2.2 Tailings Management Strategy

2.2.1 Phase 1

Phase 1 tailings are subaerially deposited in the TIA (formerly Tail Lake), which was listed on Schedule 2 of the Metal Mining Effluent Regulations (MMER) specifically for use as a tailings facility. The TIA is located south-east of the Doris mill and mine (Figure 2). Containment for the TIA is provided through a water retaining frozen core dam (North Dam), and a geosynthetic clay liner (GCL) lined frozen foundation tailings dam (South Dam). An Interim Dike near the mid-point of the TIA provides solids containment (Figure 3). Phase 1 tailings solids containment capacity is limited to 2.5 Mt.

2.2.2 Phase 2

Phase 2 tailings management increases the overall tailings solids containment capacity to approximately 18 Mt. The North Dam remains unchanged and is not planned to be raised, but the South Dam gets raised and a new West Dam (also a frozen foundation GCL lined dam) is constructed (Figure 3). Tailings deposition completely covers the Interim Dike if it has been constructed; however, construction of the Interim Dike is currently not planned. Note there is no requirement to construct the Interim Dike to accommodate Phase 2 tailings.

2.3 Tailings Storage Requirements

The planned tailings production rates and associated tailings storage requirements for the Doris TIA are summarized in Table 2. See Appendix N for additional details on the latest tailings deposition modelling analysis.

Table 2: TIA Containment Volume Design Criteria

Description	Value
Tailings Production Rate Allowances	2020 to 2023 → 2,000 tonnes per day (tpd) 2024 → up to 3,500 tpd 2025 to End of Mine Life → up to 4,000 tpd
Tailings Specific Gravity	2.85
Deposited Tailings Dry Density	1.3 t/m^3
Tailings Solids Content	35% solids (by weight) initially, increasing to 65% (somewhat dependent on if mine water inputs continue to TIA or if this water is treated and discharged directly to Roberts Bay before going to the TIA)
Total Tailings Storage Requirement: By Mass By Volume	 20.0 Mt 15.4 Mm^3
Remaining Tailings Storage Requirement: By Mass By Volume	 18.8 Mt 14.5 Mm^3
Ice Entrainment Allowance: Percentage of tailings capacity By volume	 20% 2.4 Mm^3
Tailings Beach Slope:	Between 0.5% and 1.0% (expected variability based on monitoring data and survey data)

2.4 Tailings Impoundment Area Infrastructure

2.4.1 North Dam

The North Dam forms the northern boundary of the Doris TIA within a narrow natural valley, blocking the original Tail Lake outlet to Doris Lake (Figure 3). Complete North Dam geometric design parameters and design criteria are summarized in Table 3 and Table 4 respectively. Figure 4 through Figure 6 depict pertinent details of the North Dam and its instrumentation. Photolog 1 through Photolog 3 from the 2019 inspection show photos of the upstream and downstream slopes, and the installed instrumentation.

The North Dam impounds the Reclaim Pond and was designed as a water retaining structure. The dam has a central frozen core with a secondary upstream GCL. The dam is constructed from local quarry rock and consists of processed fines for the core, 150 mm nominal sized transition material, and a run of quarry (ROQ) outer shell. To ensure maintenance of frozen foundation and frozen core conditions, the key trench of the dam is equipped with 12 horizontal thermosyphon evaporators (SRK 2007, 2012a, 2013a, 2015a).

Construction of the North Dam started in February 2011 and was completed in April 2012, over two distinct winter seasons. Complete as-built details are provided in SRK (2012b).

2.4.2 South Dam

The South Dam is located at the southern end of the former Tail Lake, on the watershed divide to Ogama Lake (Figure 3). The South Dam is designed as a frozen foundation dam consisting of a compacted rock fill dam (sourced from a local quarry) with a GCL keyed into the permafrost overburden and bedrock foundation for seepage control. Complete geometric design parameters and design criteria are summarized in Table 3 and Table 4 respectively, with Figure 7 through Figure 9 presenting pertinent details of the South Dam design. The dam is designed to retain beached tailings as opposed to water. The dam is to be constructed in two phases, incorporating a single downstream raise between Phase 1 and Phase 2.

South Dam construction began in January 2018 and Phase 1 construction was completed in June 2018. The South Dam instrumentation was mostly completed in August 2018. Photolog 4 shows the South Dam Inspection photos.

2.4.3 Interim Dike

The Interim Dike was originally designed as part of Phase 1 and consisted of a homogeneous ROQ rock fill dike, with an upstream filter zone. This was planned to be constructed within the confines of the TIA, directly on the existing lake bed sediment, without dewatering the TIA. The Interim Dike was originally intended to retain tailings solids while allowing for tailings supernatant water to pass unhindered to the Reclaim Pond (SRK 2016). However, the Interim Dike is not required as part of the Phase 2 tailings deposition plan, and since it has not been constructed, it is not expected to be constructed now that the Phase 2 Water Licence has been issued. Going forward, the Interim Dike will be removed from the 2020 AGI.

2.4.4 West Dam

The West Dam has been designed as a frozen foundation dam with a key trench and a GCL liner keyed into permafrost, similar in design to the South Dam. It is intended to retain beached tailings along low-lying ground on the western perimeter of the TIA (Figure 3). Complete geometric design parameters and design criteria are provided in Table 3 and Table 4. This dam will be constructed in a single stage using local quarry rock. This dam has not yet been constructed.

Table 3: TIA Containment Dams Geometric Design Parameters

Description	North Dam	South Dam	West Dam
Structure Type	Frozen core rock fill dam with geomembrane	Frozen foundation rock fill dam with geomembrane	Frozen foundation rock fill dam with geomembrane
Secondary Seepage Barrier	GCL		
GCL Deployment Slope	2.5H:1V	Phase 1 – 3H:1V Phase 2 – 4H:1V	3H:1V
Thermosyphons	12 sloped	None	None
Crest Centerline Length	220 m	515 m	470 m
Maximum Height	11.0 m	Phase 1 – 6.0 m Phase 2 – 14.0 m	5.0 m
Crest Elevation	37.5 masl	Phase 1 – 38.0 masl Phase 2 – 46.0 masl	46.0 masl
Core/GCL Elevation	35.0 masl	Phase 1 – 37.0 masl Phase 2 – 45.0 masl	45.0 masl
Full Supply Level (FSL)	33.5 masl	Phase 1: Water – 33.5 masl Tailings – 36.5 masl Phase 2: Water – 33.5 masl Tailings – 44.5 masl	Water – 33.5 masl Tailings – 44.5 masl
Original Tail Lake Water Level	28.3 masl		
Total Actual Freeboard (Crest to FSL)	4.0 m	Phase 1: Water – 4.5 m Tailings – 1.5 m Phase 2: Water – 12.5 m Tailings – 1.5 m	Water – 12.5 m Tailings – 1.5 m
Total Actual Minimum Freeboard (Core/GCL to FSL)	1.5 m	Phase 1: Water – 3.5 m Tailings – 0.5 m Phase 2: Water – 11.5 m Tailings – 0.5 m	Water – 11.5 m Tailings – 0.5 m
Required Normal Freeboard (CDA 2013)	Wind setup (0.07 m) + Wave runup (1.06 m) = 1.13 m		

Description	North Dam	South Dam	West Dam
Required Minimum Freeboard (CDA 2013)	Wind setup (0.06 m) + Wave runup (1.16 m) = 1.22 m Inflow Design Flood (IDF) = 2.1 m (at end of mine life when Reclaim Pond is at its minimum size)		
Thermal Protection above Frozen Core	2.5 m	n/a	n/a
Crest Width	13 m	10 m	10 m
Upstream Structure Slope	6H:1V	4H:1V	4H:1V
Downstream Structure Slope	4H:1V	2H:1V	2H:1V
Key Trench Depth	Varies (2.0 – 5.0 m)	Varies (2.0 – 4.0 m)	4.0 m
Key Trench Upstream Slope	0.5H:1V	2H:1V	2H:1V
Key Trench Downstream Slope	0.5H:1V	1H:1V	1H:1V

Table 4: TIA Containment Dams Design Criteria

Description	North Dam	South Dam	West Dam
Settlement Allowance Foundation thaw of 1 m (partial thaw) Foundation thaw of 7 m (full thaw)	1.00 m	 0.47 – 0.67 m 2.45 – 3.85 m	 0.40 – 0.60 m 2.03 – 3.43 m
Deformation Allowance (Total Strain due to Creep)	<2%	n/a	n/a
Original Design Life: Active use as water retaining structure Design base as water retaining structure Design base until breach Active use as solids retaining structure Design base as solids retaining structure	 17 years 22 years 30 years	 17 years 25 years	 17 years 25 years
Annual Exceedance Probability (AEP) for Inflow Design Flood Risk Based Standards Based	 1/2,475 (0.0004) 1/3 between 1/1,000 and the PMF(1)		
Static Stability Factor of Safety: Long-term (Drained Conditions)	1.3 during construction 1.5 during operation and closure 1.2 to 1.3 partial or rapid drawdown		
Pseudo-Static Stability Factors of Safety	1.0 during earthquake 1.2 post earthquake		
AEP for Earthquake Design Ground Motion	1/2,500 (0.0004)		
Peak Ground Acceleration (PGA)	0.060g(2)	0.036g	0.043g
Mean Annual Air Temperature Climate Change	+6.8°C up to year 2100		
Thermal Design Freezing Point Depression (Normal Conditions) Tailings Overburden Frozen core	 n/a -8ºC -2ºC	 0 to -1ºC -2ºC n/a	 0 to -1ºC -2ºC n/a

Description	North Dam	South Dam	West Dam
Thermal Design Freezing Point Depression (Upset Conditions)			
Tailings	n/a	0 to -1ºC	0 to -1ºC
Overburden	-7ºC	-2ºC	-2ºC
Frozen core	-1ºC	n/a	n/a
Seepage Allowance	78 m^3/day	50 m^3/day	<1 m^3/day

Notes:

1. Value based on experiential engineered judgement.
2. A peak ground acceleration for a ½,475 return period was not available at the time of design of the North Dam, and therefore the PGA of 0.06 g was selected based on published data for Kugluktuk. This is further described in SRK (2007).

2.4.5 Spillway

An operational spillway was originally designed for the TIA at the North Dam due to the freeboard of the North Dam being adjusted to contain the IDF, as defined in Table 4. It has not been constructed. This may be revaluated later in the mine life when the Reclaim Pond diminishes in size requiring more freeboard to contain the IDF.

Additional discussions on the timing for the spillway construction are expected to occur between TMAC and SRK in 2020. Based on the latest deposition modelling for this facility, in excess of 640,000 m^3 is required to be stored for the design storm event. Based on current plans, and assuming the Roberts Bay Discharge system continues to be operational, it is not until around the last four years of the tailings deposition when the available pond storage in the TIA starts to approach the IDF storage volume requirement. At this time, it is expected that lowering the elevation of the TIA's full supply level (FSL) (i.e. operations will need to maintain a very low pond level in the TIA) will be required to help free up as much storage space as possible for the design storm event. To mitigate against the risk of an overtopping failure (specifically at the North Dam) and ensure there is redundancy in the system (i.e. to have a passive outflow in the event pumps break down) an emergency spillway will be required to be constructed. A discharge from the spillway would only occur during an emergency event and is not planned for routine use.

The urgency behind construction of the spillway is linked to the later stages of the mine life, around 2028 or later as indicated by the results of the deposition models. However, this timeline can easily be impacted by unexpected conditions or poor management practices i.e. storing additional water in the TIA or in particular if the Roberts Bay Discharge system was to fail and be offline for an extended period of time (e.g. 6 months or more).

2.4.6 Tailings Deposition System

The tailings discharge system is designed as a single heat-traced and insulated pipeline with end-point (i.e. single spigot) discharge at predetermined locations. The tailings deposition pipeline consists of a combination of 6-inch internal diameter steel and High-Density Polyethylene (HDPE) pipelines with no redundancy. There are no double lined pipeline sections for environmental containment. The pipeline is placed directly on the ground, which consists of either engineered rockfill pads, the all-weather road shoulders, or in some areas directly on the tundra.

Actual tailings deposition started in February 2017 and tailings discharge has occurred from four locations. A plan overview of the tailings deposition history is illustrated in Figure 10. The different tailings discharge locations were in part because of deferral of South Dam construction which prevented earlier tailings deposition. Photos of the tailings deposition are shown in Photologs 5 and 6 attached.

Table 5 summarizes the deposition status as of December 2019. As previously noted, actual tailings deposition is behind what was planned (Table 2); however, increases in deposition rate have been observed over 2019 (Figure 11 and Figure 12). It should be noted that there is no evidence to suggest that there is any significant entrained ice within the deposited tailings at this point in time. The current deposition modelling and storage capacity assessment (see Appendix N) includes a 20% allowance for ice entrainment.

Table 5: Actual Tailings Deposition Between Start-up (February 2017) and December 2019

Period	Percent Solids (by Weight)	Tailings Solids (tpd)	Cumulative Tailings Solids (tonnes)	Cumulative Tailings Solids (m^3)
February 2017	39.0	212	5,936	2,120
March 2017	21.7	351	16,814	6,005
April 2017	32.5	635	35,864	12,809
May 2017	23.0	659	56,293	20,105
June 2017	41.7	662	76,153	27,198
July 2017	15.0	569	93,792	33,497
August 2017	20.8	741	116,778	41,706
September 2017	20.5	555	133,431	47,654
October 2017	19.5	733	156,139	55,764
November 2017	17.3	634	175,159	62,557
December 2017	22.0	841	201,234	71,869
January 2018	34.5	814	226,452	80,876
February 2018	33.0	966	253,489	90,532
March 2018	25.2	1,012	284,864	101,737
April 2018	39.2	1,073	317,066	113,238
May 2018	42.0	893	344,758	123,128
June 2018	16.9	818	369,285	131,888
July 2018	28.3	1,027	401,129	143,260
August 2018	44.6	1,386	444,101	158,607
September 2018	45.7	1,614	492,527	175,902
October 2018	48.6	1,851	549,905	196,395
November 2018	48.0	1,842	605,159	216,128
December 2018	44.0	1,555	653,367	233,345
January 2019	45.0	1,621	703,617	251,292
February 2019	36.7	1,696	751,094	268,248
March 2019	44.0	1,630	801,611	286,290
April 2019	45.0	1,292	840,362	300,129

Period	Percent Solids (by Weight)	Tailings Solids (tpd)	Cumulative Tailings Solids (tonnes)	Cumulative Tailings Solids (m^3)
May 2019	42.8	1,935	900,360	321,557
June 2019	50.0	1,819	954,924	341,044
July 2019	48.0	1,374	997,518	356,256
August 2019	44.0	1,784	1,052,819	376,007
September 2019	47.0	1,838	1,107,969	395,703
October 2019	41.2	1,723	1,161,396	414,784
November 2019	44.5	1,315	1,200,834	428,869
December 2019	28.0	1,091	1,234,664	440,951

2.4.7 Emergency Dump Catch Basins

Two Emergency Dump Catch Basins (EDCBs) have been constructed on either side of Doris Creek (Photolog 7). The EDCBs are lined cells constructed at a topographic low-point along the tailings and reclaim pipeline routes that allow for the pipelines to be drained during prolonged mill shutdowns or power failures to prevent pipeline freeze-up. They were designed to accommodate at least two consecutive shutdowns plus direct precipitation over the basin areas. The EDCBs were constructed in 2017. Table 6 summarizes their design and as-built containment capacities.

Table 6. EDCB Design and As-built Capacities

Component	Western EDCB	Eastern EDCB
Permitted Design Capacity	120 m^3	120 m^3
Required Design Capacity	97 m^3	85 m^3
As-Built Design Capacity	124 m^3	85 m^3

2.4.8 Reclaim Water System

Reclaim water is drawn from the TIA Reclaim Pond for re-use in the Process Plant. Reclaim water is drawn from a submerged suction line feeding a low suction head pump installed in an on-shore enclosure located at the Reclaim Pond (Figure 3). This heat-traced and insulated pipeline follows the TIA Access Road (*aka* Secondary Road) from the Reclaim Pond to the Doris mill and is placed directly on the ground (either tundra, all-weather road shoulder, or the engineered rockfill pads). There are no double-lined sections of this pipeline and there is no redundant pipeline (see attached Photologs 8 and 9).

Table 7 provides a summary of reclaim water volumes drawn from the TIA since tailings production started.

Table 7: Reclaim Water Volumes Between Start-up (February 2017) and November 2018

Date	Reclaim Volume (m^3/month)	Cumulative Reclaim Volume (m^3)
February 2017	94,080	94,080
March 2017	107,880	201,960
April 2017	100,800	302,760

Date	Reclaim Volume (m³/month)	Cumulative Reclaim Volume (m³)
May 2017	104,160	406,920
June 2017	100,800	507,720
July 2017	81,721	589,441
August 2017	96,586	686,027
September 2017	92,016	778,043
October 2017	92,181	870,224
November 2017	93,088	963,312
December 2017	93,900	1,057,212
January 2018	82,577	1,139,789
February 2018	69,744	1,209,533
March 2018	78,864	1,288,397
April 2018	74,638	1,363,035
May 2018	76,444	1,439,479
June 2018	69,120	1,508,599
July 2018	66,699	1,575,298
August 2018	71,186	1,646,484
September 2018	65,833	1,712,317
October 2018	64,395	1,776,712
November 2018	66,962	1,843,674
December 2018	65,565	1,909,239
January 2019	64,572	1,973,811
February 2019	57,207	2,031,018
March 2019	69,824	2,100,842
April 2019	60,912	2,161,754
May 2019	61,908	2,223,662
June 2019	57,603	2,281,265
July 2019	69,389	2,350,654
August 2019	79,005	2,429,659
September 2019	84,230	2,513,889
October 2019	82,918	2,596,807
November 2019	77,744	2,674,551
December 2019	76,670	2,751,221

2.4.9 TIA Water Discharge System

TIA water will be discharged to Roberts Bay once the Roberts Bay Ocean Discharge System is operational (note: operation of the system started in February 2020 and will be reported in the 2020 AGI report). The discharge pump is located adjacent to the reclaim pump and will pump water along a pipeline following the same route as the reclaim water pipeline. Historically, prior to tailings deposition, TIA water was discharged to Doris Creek (compliance monitoring station TL-2) during the open water seasons of 2014 and 2015, as summarized in Table 8.

Table 8: Historic TIA Discharge Water Volumes to Doris Creek (TL-2)

Date	Discharge to TL-2 (m^3/month)	Cumulative Discharge to TL-2 (m^3)
June 2014	104,634	104,634
July 2014	257,778	362,411
August 2014	194,405	556,816
September 2014	118,218	675,034
June 2015	3,095	678,129
July 2015	230,460	908,589
August 2015	233,603	1,142,192
September 2015	164,260	1,306,452

2.5 Tailings Impoundment Area Instrumentation

2.5.1 North Dam

Permanent performance monitoring instrumentation for the North Dam consists of:

- 11 vertical ground temperature cables (GTCs);
- 13 horizontal GTCs;
- 18 surficial survey monitoring points located throughout the downstream face of the dam;
- 14 crest survey monitoring points located along the upstream and downstream crest of the dam;
- 3 deep settlement points;
- 6 inclinometers located within the downstream face; and
- 12 single bead thermistors, measuring thermosyphon contact temperatures.

Figure 4 through Figure 6 illustrates the location of North Dam instrumentation. All GTCs are connected to dataloggers allowing continuous data collection. Slope inclinometers are recorded manually using a slope inclinometer instrument owned by TMAC. Settlement monitoring is done manually by ground survey. The North Dam Standard Operating Procedure (SOP) provides comprehensive details pertaining to this instrumentation (SRK 2018b).

2.5.2 South Dam

The active South Dam permanent performance monitoring instrumentation consists of:

- 9 horizontal GTCs;
- 12 vertical GTCs;
- 1 long GTC parallel to the top crest of the key trench

- 19 surficial survey monitoring points (crest and downstream slope);
- 12 crest survey monitoring points; and
- 3 deep settlement points.

The monitoring instrument locations are shown on Figure 7 through Figure 9.

2.5.3 Interim Dike

No monitoring is undertaken for this structure since it has not been constructed and is no longer required for Phase 2. This structure will be removed from the 2020 AGI reporting.

2.5.4 West Dam

Once constructed, this structure will have a similar monitoring plan to that of the South Dam.

2.5.5 Other TIA Instrumentation and Monitoring

Additional monitoring data collected for the TIA are summarized below:

- The water level in the TIA Reclaim Pond is monitored by an automated pressure transducer-datalogger installed at monitoring point TIA-2. The data is transmitted by a solar-powered iridium satellite transceiver to an online portal where it can be accessed remotely by TMAC and SRK. There is also a back-up datalogger installed to record pond levels should a problem occur with the primary data collection system. The secondary datalogger also records water temperature which is beneficial from a thermal review perspective.
- The primary datalogger is configured to collect a reading every 15 minutes in the summer and every 60 minutes during the winter. The data is transmitted to the online portal daily.
- On at least an annual basis, Environmental Resources Management (ERM) conducts a water level reference survey and bathymetry survey of the TIA basin. Based on communications from ERM and TMAC, the water level constant elevation was adjusted from 27.761 masl (ERM 2017) to 27.71 m on August 15, 2019 at 00:00. This was also reflected / updated in the water level transduce / datalogger readings.

Additional detail of the installed tailings monitoring system is described by ERM (2017) and SRK (2018b):

- Tailings deposition is a continuous operation and the volumes are monitored with a flowmeter and an automated data collection system;
- Reclaim water is measured using a flowmeter with an automated data collection system;
- Mine water is measured by means of a totalizer instrument, recorded manually twice daily; and
- Climate data most directly related to the TIA monitoring includes temperature and precipitation (Appendix J). The ambient air temperature shown is collected at the crest of the North Dam as part of the thermal monitoring system. Precipitation data has historically been collected from several sources including on-site meteorological stations. For the indicative

use in this report, the precipitation data shown in Appendix J is based on precipitation data from Cambridge Bay, adjusted for under catch.

2.6 Water Management

2.6.1 Water Management Plan

The TIA is used as the overall collector for all site contact water, which is either pumped or trucked to the TIA. Saline underground water (i.e., mine water) may also be pumped to the TIA if it is not discharged directly to Roberts Bay. TIA water is stored in the Reclaim Pond which is recycled for processing make-up to the extent possible. Excess water in the TIA will be discharged to Roberts Bay for ocean discharge. Prior to discharge to Roberts Bay, all water must meet MDMER limits (SRK 2017b, TMAC 2017).

There are no non-contact surface water diversions upstream of the TIA. The TIA is in an isolated catchment measuring 461 ha, and the benefits of any diversions are outweighed by the relative cost and complexity of constructing them. A schematic of the TIA water management plan is presented in Figure 13.

2.6.2 Water Balance

A site wide water and load balance, including the TIA, has been developed for the Project (SRK 2017b) and forms the basis for the Water Management Plan (TMAC 2017). A detailed operational TIA water balance has also been developed considering the relevant TIA inflows and outflows. This is used by TMAC to make day-to-day operational decisions pertaining to the TIA. This operational water balance incorporates the most recent available site measurements and then uses historical measurements and direct user inputs to predict future TIA water levels, and water quality. The direct user-inputs allow for the modelling of various scenarios to test future “what if cases”. The cases all start with a base case prediction defined as the most likely outcome based on the information known today. The current base case prediction for water levels is presented in Figure 14. TMAC has generated this prediction and it is provided as a representation of current planning. Several assumptions feed into the prediction including:

- All measured data to date (in this case, end of 2019);
- A production rate of 2,000 tpd for the remainder of the model (additional updates to the model are ongoing and this rate will be adjusted based on any changes at site);
- Doris Underground mine water was pumped to the Doris TIA at a rate ramping up from measured flows to the FEIS water load balance values up until February 2020 when it will be discharged to Robert’s Bay;
- All process water (including freshwater inputs) are sourced from the Doris TIA and are based on historical usage rates (m^3 water/ tonnes ore processed);
- Sedimentation Control Pond (SCP) water is pumped to the Doris TIA based on historical rates;
- Discharge to Robert’s Bay from the Doris TIA commences in January 2020 and each of the following years should occur at a rate of approximately 6,650 m^3/day (after pump availability considerations);

- Sewage treatment plant effluent is directed to the Doris TIA starting in January 2020 based on an average camp size of 300 people at historical usage rates (0.16 m^3/person/day); and
- Average climatic conditions for predicted years.

2.7 Dam Hazard Classification

Dam hazard classifications for the TIA containment dams were made in accordance with the Canadian Dam Safety Guidelines (CDA 2013), as well as the CDA Technical Bulletin on Application of Dam Safety Guidelines to Mining Dams (CDA 2014), as summarized in Table 9. The designated dam hazard classifications assigned to each structure is listed in Table 10 (SRK 2015, 2016b).

Table 9: Dam Hazard Classification (as defined in CDA 2013)

Dam Class	Population at Risk[1]	Incremental losses		
		Loss of Life[2]	Environmental and Cultural Values	Infrastructure and Economics
Low	None	0	• Minimal short-term loss • No long-term loss	Low economic losses; area contains limited infrastructure or services.
Significant	Temporary only	Unspecified	• No significant loss or deterioration of fish or wildlife habitat • Loss of marginal habitat only • Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes.
High	Permanent	10 or fewer	• Significant loss or deterioration of *important* fish or wildlife habitat • Restoration or compensation in kind highly possible	High economic losses affection infrastructure, public transportation, and commercial facilities.
Very high	Permanent	100 or fewer	• Significant loss or deterioration of *critical* fish or wildlife habitat • Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances).
Extreme	Permanent	More than 100	• Major loss of *critical* fish or wildlife habitat • Restoration or compensation in kind impossible	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances).

Notes:

[1] Definitions for population at risk:

None – There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary – People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent – The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

[2] Implications for loss of life:

Unspecified – The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

Table 10: Dam Hazard Classification of TIA Containment Structures

Structure	Population at Risk (PAR)	Loss of Life	Environmental and Cultural Values	Infrastructure and Economics	Overall Hazard Classification
North Dam	SIGNIFICANT	SIGNIFICANT	HIGH	LOW	HIGH
South Dam	SIGNIFICANT	SIGNIFICANT	HIGH	LOW	HIGH
Interim Dike (not constructed)	LOW	LOW	LOW	LOW	LOW
West Dam (not constructed)	SIGNIFICANT	SIGNIFICANT	HIGH	LOW	HIGH

A presentation providing a preliminary overview of the dam break inundation maps developed by SRK and site-specific considerations for the next updates of the TMAC Hope Bay Emergency Response Plan (ERP) are provided in Appendix Q.

3 TIA Management System Review Findings

3.1 Third Party Dam Safety Review

In accordance with CDA Dam Safety Guidelines (CDA 2013, 2014), including the CDA Technical Bulletin on Dam Safety Reviews (CDA 2016), independent third-party Dam Safety Reviews (DSRs) should be conducted in accordance with a frequency informed by the hazard classification of the structures. This frequency typically ranges between 5 and 10 years. It is recommended a dam with a HIGH hazard classification, such as the North Dam and South Dam, undergo a Dam Safety Review every seven years. However, the hazard classification should be reviewed periodically to ensure that conditions remain valid.

SRK reviewed the hazard rating as part of the 2019 inspection, and considering tailings deposition has started, SRK agrees that a hazard rating of HIGH is appropriate for the constructed North and South Dams. Some preliminary dam break checks were also done in 2019 to help confirm this hazard rating (Appendix Q).

Therefore, in accordance with CDA guidelines, the North and South Dams should have independent Dam Safety Reviews (DSR) every seven years. The North Dam started impounding water in 2011, which means that a DSR should have been completed in 2018. As is illustrated in Figure 14, the North Dam generally retained about 0.7 m head of water (average water level of 29.0 m) until the summer of 2016. This is about 13% of the full supply level (FSL) head based on the original Tail Lake water level of 28.3 m. After that time the water level has been consistently rising to an elevation in 2018 of 30.7 m, which constitutes a head of 2.4 m, or 46% of the FSL head of 5.2 m. In 2019 the water levels in the TIA rose further up to around 32.0m as of December 2019 which is 71% of the FSL head. This noted the Roberts Bay discharge system is now functional (as of 2020) and the system now has outputs, with overall TIA water levels now being lowered again.

Considering the dam performance to date, as well as the fact that considerable technical reanalysis of the dam was done in 2017 as part of the Phase 2 design, SRK is comfortable at this time, to defer completion of a DSR to 2021, which is 10 years after initial impoundment started.

South Dam construction was completed in 2018, which means a DSR for that structure is due in 2025; however, since a DSR is needed for the North Dam in 2021, it is recommended that the South Dam DSR be completed at the same time.

Recommendations:

- Conduct an independent third-party Dam Safety Review for both the North and South Dams in the summer of 2021.

3.2 Tailings Operating, Maintenance and Surveillance Manual

Phase 1 tailings management is carried out under a Tailings Operation, Maintenance and Surveillance (OMS) Manual prepared in 2016 (TMAC 2016). Because tailings deposition in 2017 was inconsistent and less than the planned deposition rates due to mill commissioning challenges, a thorough review of OMS Manual procedures was not undertaken in 2017, although a minor update was completed (TMAC 2017). There were however significant operational changes in 2018, including significant personnel changes, and as a result the OMS Manual became outdated. Although the OMS Manual was updated in 2017 (TMAC 2017), that update was centered around changes associated with the Phase 2 project, and the necessary operational and personnel changes were not adequately captured. Furthermore, an updated North Dam Monitoring SOP has been issued (SRK 2018b). In 2019 an update to the OMS manual was started with the involvement of site personnel. The updated OMS is planned to be submitted formally by Q4 2020 and will capture the changes from the Phase 2 project and also the updates to the North Dam and South Dam SOPs. The full document has been rewritten to further improve the usability of the document. This being noted, additional work to refine Trigger Action Response Plans (TARPs) is currently underway and is planned to be completed by Q4 2020. With completion of the construction of the South Dam in 2018, a South Dam Monitoring SOP was also required. A draft version of the South Dam SOP was submitted in June 2020 and a final version of the South Dam SOP is expected in July 2020.

Appendix P provides a presentation that was delivered to site staff in 2019 that provided an overview of the Doris TIA design, upcoming OMS updates and considerations for site staff completing the various inspections and data collection activities at the TIA.

Recommendation:

- An additional update to the OMS manual is in progress by SRK at the time of submitting this report. The updated OMS manual will be submitted by Q4, 2020. This update is aimed to be a notable improvement to the past and current OMS versions. This noted, additional OMS updates are planned (specifically refinement of the TARPs) and will be completed by Q4 2020. The OMS for this facility will be a 'living' document that is expected to be reviewed annually as part of the AGI.
- TMAC should ensure all staff are properly informed and trained on the contents of the OMS Manual.
- An ERP exists for the site; however, this document was lacking sufficient detail for the TIA. In 2019 SRK visited site and held a session with site personnel to review the preliminary dam break inundation maps developed by SRK and to provide inputs into what should be included in the site ERP updates (Appendix Q) to ensure that the TIA is properly covered in the document. It is recommended that the updated ERP be completed in 2020. At the time of writing this report, TMAC was in the process of developing a standalone 'Hope Bay Project Dam Emergency Plan', rather than updates to the ERP, to address dam emergencies. It will incorporate inundation mapping and dam break scenarios. The standalone dam emergency plan will be released upon completion of the OMS update to ensure alignment.

3.3 TIA Roles and Responsibilities

The roles and responsibilities for those involved in managing the TIA are defined in the current OMS Manual. However, due to operational challenges associated with an extended commissioning period, in addition to the South Dam construction activities, the OMS was not updated in 2019. Now that the transition period is complete, and South Dam and fully operational, updates to the 'responsible parties' section outlined in the TIA OMS are recommended. This will be documented in the next submitted revision of the TIA OMS Manual (for Q4 2020). SRK understands that the primary responsible party for the TIA is the mill, and TMAC has now implemented measures to ensure this responsibility (and associated requirements) are understood on site. This is a notable improvement from 2018.

John Kurylo, MSc, PEng, a licenced professional engineer in Nunavut Territory, and a Senior Consultant with SRK has taken over as the EOR for the TIA from the late Maritz Rykaart. This was based on the EOR succession plan for this facility. John has been heavily involved in the Project and TIA since its construction. This is the current status at the time of completing this report. All monitoring data for the North Dam and South Dam is submitted to the EOR monthly, and the EOR remains in constant communication with site staff regarding the overall operation of the TIA. TMAC has allowed free access to information and resources to allow the EOR to fulfill his duties.

Recommendation:

- The responsible parties' section of the OMS should be updated in the next revision (submitted by SRK to TMAC Q4 2020).

4 TIA Inspection and Monitoring Instrumentation Findings

4.1 Compliance with Monitoring Requirements

The North Dam monitoring frequency requirements were first outlined in the North Dam As-built Report (SRK 2012b) and subsequently finalized in the North Dam Monitoring Standard Operating Procedures (Monitoring SOP) which was updated in 2018 (SRK 2013b, 2018b). The South Dam monitoring requirements are similar to the North Dam, where applicable, and will be included in a revised Monitoring SOP that includes both dams.

Since transitioning to tailings production in 2017, routine monitoring and inspections of the North Dam have been completed by site personnel. The monitoring frequency requirements and actual monitoring frequency for the 2018/2019 monitoring period are summarized in Table 11 for the established instrumentation on the North Dam and within the TIA. The South Dam monitoring program has not yet been finalized as it is still under development at the time of the inspection; however, preliminary monitoring since construction is summarized in Table 12.

Table 11: North Dam Monitoring Requirements for the 2019 Monitoring Year(1)

Element	Item	Method	Resp.	Required Frequency	Conformance with SOP (SRK 2018b)(1)(2)	Comments
Thermal	Ground Temperature Cables	Datalogger	TMAC	Daily (automated)	Yes	• Recorded four times daily
	Thermo-syphons				Yes	• Record four times daily
	Datalogger downloads	Manual		Monthly	Yes	• Data collected monthly
Deformation	Downstream Surface Settlement	Manual	TMAC	Monthly (May to Nov.)	Yes	• Surveys received monthly
	Downstream Deep Settlement				Yes	
	Crest Settlement				Yes	
	Depressions				Yes	• No changes observed
	Inclinometers			Monthly	Yes	• Data collected monthly
Water Balance	Water Level	Datalogger Station	TMAC	Daily (automated)	Yes	• Readings every 15 min and uploaded daily
	Water Level	Manual		Monthly	Yes	• Water Level surveyed during installation of datalogger and must be surveyed once during open water season (2019)
	Seepage			Weekly when seepage is observed	Yes	• Seepage documented at the toe of North Dam during spring 2018
Visual	Walkover Survey	Manual	TMAC	Weekly (below FSL(3))	No	• 51 inspections conducted between Nov. 2018 and Dec. 2019

Element	Item	Method	Resp.	Required Frequency	Conformance with SOP (SRK 2018b)(1)(2)	Comments
				Daily (at or above FSL)		• The inspection rate is slightly below the target (60 inspections)
	Annual Geotechnical Inspection		Independent Qualified Licensed Geotechnical Engineer	Annually	Yes	• Aug. 2018 (SRK 2019a) • Aug. 2019 (This report)
Maintenance						
North Dam Thermal Datalogger	Datalogger Primary Batteries	Manually recharge	TMAC	Annually	Yes	• Recharged Jun. 2019
	Datalogger Backup Batteries	Manually replace		5-year cycle	Yes	• Replaced during datalogger recalibration
	Datalogger Recalibration	Manual			Yes	• Completed Jan. 2018
	Desiccant Packs	Manually replace		As required	Not required	• No action required
Water Level Datalogger Station (TIA-2)	Datalogger Transmission Subscription	Online		Annually	Yes	• 22% of the data service plan remains
	Physical Datalogger Station	Manually recalibrate or replace		As required	Not required	• No action required

Note(s):

(1) Data reporting period included in this report was November 1, 2018 to December 31, 2019 which is a continuation of data from the last AGI (SRK 2019a)
(2) This column lists if the monitoring frequency is compliant with the monitoring frequency requirements since the last AGI (SRK 2018a)
(3) FSL: Full Supply Level

Table 12: South Dam Preliminary Monitoring Following Construction(1)

Element	Item	Method	Resp.	Required Frequency	Conformance with Preliminary Needs	Comments
Thermal	Ground Temperature Cables	Datalogger	TMAC	Daily (automated)	No (Acceptable)	• Datalogger systems operating (partially) • Troubleshoot or repair based on recommendations
	Datalogger downloads	Manual		Monthly		
Deformation	Downstream Surface Settlement	Manual	TMAC	Monthly (May – Nov.)		• Survey monitoring points were fully established in the summer of 2019 • Surveys received for August to November
	Downstream Deep Settlement					
	Crest Settlement					
	Depressions					• No issues observed
Water Balance	Seepage	Manual	TMAC	Weekly when seepage is observed	Yes	• No seepage observed

Element	Item	Method	Resp.	Required Frequency	Conformance with Preliminary Needs	Comments
Visual	Walkover Survey	Manual	TMAC	Weekly (below FSL(2)) Daily (at or above FSL)	No (Acceptable during transition period)	• Formal documentation of the South Dam inspections should be completed in a similar fashion to the North Dam
	Annual Geotechnical Inspection		Independent Qualified Licensed Geotechnical Engineer	Annually	Yes	• August 2019 (This report)
Maintenance						
South Dam Thermal Datalogger	Datalogger Primary Batteries	Manually recharge	TMAC	Not yet established	Not applicable during transition period	• The maintenance requirements will be provided in the updated TIA monitoring SOP
	Datalogger Backup Batteries	Manually replace				
	Datalogger Recalibration	Manual				
	Desiccant Packs	Manually replace				

Note(s):

(1) Data reporting period included in this report was November 1, 2018 to December 31, 2019 which is a continuation of data from the last AGI (SRK 2019a)

(2) FSL: Full Supply Level

Recommendations:

- Formalize the South Dam Monitoring SOP with detailed monitoring requirements. The draft version was submitted in June 2020, and the final version will be submitted in July 2020.
- Provide an updated North Dam SOP. This would be done to highlight the change in EOR and review to make sure no additional updates are required.
- Conduct monitoring in accordance with the Monitoring SOP, paying attention to those areas where conformance is not consistently met.

4.2 North Dam Inspection and Monitoring

4.2.1 Ground Temperature Cables

To monitor long-term temperature of the frozen core and the dam foundation, a total of twenty-four GTCs were installed during the North Dam construction (SRK 2012b). Of the twenty-four installed GTCs, twenty-two are still functional. Since September 2012, GTC data for the North Dam is recorded every six hours by two Campbell Scientific CR1000 dataloggers (Photolog 3). Data is downloaded from the dataloggers by TMAC personnel using compact flash memory cards.

The frequency of datalogger downloads and the recorded temperature data is presented in Appendix B. In general, the data logger and GTC system is performing well. Only one isolated error event was observed in the 2018/19 monitoring period on June 12, 2019 as noted in Appendix B. The complete status of all North Dam GTCs is summarized in Table 13.

Table 13: North Dam Ground Temperature Cable Status

GTC ID	Status	Comments
ND-VTS-040-KT	Active	Fully operational, except for recalibration January 1 to March 3, 2018
ND-HTS-040-31.5	Active	Fully operational, except for recalibration January 1 to March 3, 2018
ND-HTS-040-33.5	Active	Cable disconnected from datalogger October 10, 2013 to May 13, 2014
		Connection to datalogger more permanently repaired July 2014
		Disconnected for recalibration January 1 to March 3, 2018
ND-VTS-060-US	Inactive	Irreparably damaged between April 27 and August 8, 2012
ND-VTS-060-DS	Active	Fully operational, except for recalibration January 1 to March 3, 2018
ND-VTS-060-KT	Active	Spliced during construction. Fully operational, except for recalibration January 1 to March 3, 2018
ND-HTS-060-28.8	Active	Bead 7 - No readings February 11, 2012 to December 8, 2013
		Bead 7 - No readings since April 21, 2014
		Bead 7 - Readings between November 1, 2014 and April 19, 2015
		Bead 7 - Readings between October 2015 and April 2016
		Bead 7 - Readings between October 2016 and June 2017
		Bead 7 – Readings between September 2017 and May 2018 (excluding recalibration period), resuming at the end of October 2018. Occasional erratic readings continue (since fall 2016) and are attributed to instrument errors.
		Bead 9 - No readings October 10, 2013 to May 20, 2014 and July 2014 onward
		Disconnected for recalibration January 1 to March 3, 2018
ND-HTS-060-31.0	Active	Fully operational, except for recalibration January 1 to March 3, 2018
ND-HTS-060-33.5	Active	Fully operational, except for recalibration January 1 to March 3, 2018
ND-VTS-085-US	Active	Erratic data at most beads (excluding Beads 3, 6 and 9) between June 2016 and May 2017 with lower amplitude spikes between December 2016 and May 2017
		Erratic data subsided since May 2017
		Disconnected for recalibration January 1 to March 3, 2018
ND-VTS-085-DS	Active	Erratic data at most beads (excluding Beads 3, 6 and 9) between June 2016 and May 2017 with lower amplitude spikes between December 2016 and May 2017
		Erratic data subsided since May 2017
		Disconnected for recalibration January 1 to March 3, 2018
ND-VTS-085-KT	Active	Erratic data at most beads (excluding Beads 3, 6 and 9) between June 2016 and May 2017 with lower amplitude spikes between December 2016 and May 2017
		Erratic data subsided since May 2017
		Disconnected for recalibration January 1 to March 3, 2018
ND-HTS-085-25.3	Active	Fully operational, except for recalibration January 1 to March 3, 2018
ND-HTS-085-29.4	Active	Fully operational, except for recalibration January 1 to March 3, 2018
ND-HTS-085-33.5	Inactive	Irreparably damaged during construction
ND-VTS-130-US	Active	Bead 9 – Readings erratic for periods since June 2016 (temperature dropping randomly to less than -15ºC)
		Disconnected for recalibration January 1 to March 3, 2018

GTC ID	Status	Comments
ND-VTS-130-DS	Active	Small magnitude temperature spikes during summer months between 2013 and 2017 (Bead 3, 7, 8, 9, 11), no spikes observed in 2018
		Beads 3 – 8 were offline after the connector at the datalogger housing was damaged on September 24, 2017. Repaired and reconnected on March 11, 2018 following datalogger recalibration
		Disconnected for recalibration January 1 to March 3, 2018. Beads 3 to 8 were disconnected and repaired between September 24, 2017 and March 3, 2018 (due to damaged cable connection)
ND-VTS-130-KT	Active	Fully operational, except for recalibration January 1 to March 3, 2018
ND-HTS-130-28.8	Active	All beads were offline after the connector at the datalogger housing was damaged on September 24, 2017. Repaired and reconnected on March 4, 2018 following datalogger recalibration
		Disconnected for recalibration January 1 to March 3, 2018
		Low temperature spikes and intermittent logging from Bead 2 in Summer 2018 and 2019
ND-HTS-130-31.0	Active	Fully operational, except for recalibration January 1 to March 3, 2018
ND-HTS-130-33.5	Active	Fully operational, except for cable repair and recalibration September 24, 2017 to March 3, 2018
ND-VTS-175-KT	Active	Spliced during construction
		Incorrectly connected to datalogger as ND-HTS-175-33.5 from August 9, 2012 to June 16, 2014
		Beads 9, 10 and 11 - No readings August 9, 2012 to June 16, 2014
		Disconnected for recalibration January 1 to March 3, 2018
ND-HTS-175-32.5	Active	Fully operational, except for recalibration January 1 to March 3, 2018
ND-HTS-175-33.5	Active	Spliced during construction
		Incorrectly connected to datalogger as ND-HTS-175-KT, from August 9, 2012 to June 16, 2014
		Disconnected for recalibration January 1 to March 3, 2018

Source: J:\01_SITES\Hope.Bay\!Project_Data (Not Job Specific)\06_NorthDamMonitoringData\[SiteMonitoringSummary.xlsx]ThermisorStatus

The North Dam GTCs were installed to ensure the dam core and key foundation section remain below the design temperatures of −2˚C and −8˚C, respectively under normal operating conditions. Under upset conditions these temperatures increase to −1˚C and −7˚C. In addition, ground temperature data along with thermosyphon monitoring data can be used to determine if the thermosyphons are functioning correctly. Observations related to a review of the data presented in Appendix B are summarized in Table 14.

Table 14: Summary of Core and Key Trench Ground Temperature Cable Observations

Zone	Horizontal GTCs	Vertical GTCs	Observation
Design Temperature	**−2˚C**	**−8˚C**	• **The minimum criteria required to ensure Dam is performing in accordance with design specifications**
Station 0+040	Meets	Meets	• Performing as expected with substantive safety buffer and slight trend suggesting ongoing cooling
Station 0+060	Meets	Meets	• Performing as expected with substantive safety buffer and slight trend suggesting ongoing cooling • In conjunction with the 2019 seepage review (SRK 2020), no evidence of seepage was noted at this station
Station 0+085	Meets	Meets	• Generally performing as expected with substantive safety buffer and slight trend suggesting ongoing cooling in the core, foundation and downstream portions of the dam • A rise in the temperature of the upstream-most beads of ND-HTS-085-29.4 (Bead 7, 8, 9, 10) and ND-HTS-085-25.3 (Bead 9 to 15) was observed. This is attributed to the elevated RCP water levels in 2019 and are in line with the expected thermal response. • Seasonal variability in temperature continues to be observed and the temperatures remain below 0C. Ground warming is expected in this area. • In conjunction with the 2019 seepage review (SRK 2020), no evidence of seepage was noted at this station
Station 0+130	Meets	Meets	• Generally performing as expected with substantive safety buffer and stable or a slight cooling trend • Short term temperature spikes are noted for all but the uppermost 2 beads of ND−VTS−130−DS in 2017 (and every year prior). In 2018, no temperature spikes were noted. Between 2013 and 2017, the temperature spikes were observed between May and November with the largest amplitudes in 2013 and 2016 (Appendix B.13) • Erratic reading attributed to instrumentation error are noted in both ND-HTS-130-28.8 (Bead 2) and ND-VTS-130-US (Bead 9) in 2018. Previously erratic readings were only observed in ND-VTS-130-US • A slight rise in the upstream-most beads of ND-HTS-130-28.8 (Bead 10) and ND-HTS-130-31.0 (Bead 8) was observed. This is attributed to the elevated RCP water levels in 2019 and in line with the expected thermal response. • In conjunction with the 2019 seepage review (SRK 2020), no evidence of seepage was noted at this station
Station 0+175	Meets	Meets	• Generally performing as expected with substantive safety buffer and stable or a slight cooling trend • The annual maximum of the uppermost two beads remain slightly above the design temperature at -7˚C

Recommendations

- None.

4.2.2 Thermosyphons

Passive thermosyphons assist in cooling the North Dam key trench foundation. They function when the ambient air temperature is colder than the ground temperature where the thermosyphon is located. This happens because of phase change of the carbon dioxide gas with which the thermosyphon is filled. Therefore, during the winter months the cold ambient air temperature is used to draw heat from the foundation, but during the summer period the thermosyphons remain dormant.

Thermosyphon temperature monitoring for the North Dam has been automated. Single bead thermistors connected to the datalogger system are attached to each thermosyphon evaporator pipe below the ground surface, and insulation has been placed around the thermistor beads to ensure the evaporator pipe temperature, and not the ambient air temperature, is measured (SRK 2012b). Additionally, air temperatures are recorded at the dataloggers every six hours. This data is downloaded as part of the monthly thermal datalogger downloads.

To monitor the performance of the thermosyphons, thermosyphon evaporator pipe contact temperatures and air temperatures are plotted against time. During the winter months, when the thermosyphons are working, the thermosyphon pipe temperature should be roughly 5˚C warmer than the air temperature. If the thermosyphon pipe temperature during the winter months is approximately the same as the air temperature, it indicates that the thermosyphon is not working correctly.

Thermistor data indicates all the south and north thermosyphons are functioning except for North 2 (Appendix C). Since 2012, the measured pipe temperature of North 2 was only slightly higher than the measured air temperature, which indicates a malfunction. Ground temperature readings near the North 2 thermosyphon pipe support the conclusion that the North 2 thermosyphon is not working correctly.

During the 2014 North Dam AGI, thermosyphon North 2 was inspected in detail to determine the cause of the elevated temperature readings. No damage or reason for the malfunction was observed (SRK 2014b). Previously, SRK recommended that Arctic Foundations of Canada Inc. (AFC) be contracted to investigate further and repair the thermosyphon. An initial inspection was conducted by AFC on April 10 and 11, 2017. No issues were identified at the time; however, monitoring data indicated North 2 continued to malfunction.

To address the issue, the best course of action was decided to discharge and recharge the thermosyphon. To do so in the most efficient manner, Mike Watt (AFC) travelled to site to inspect and discharge the North 2 thermosyphon on June 5 and 6, 2019 after the thermosyphon had gone dormant. The recharge and testing were completed between November 19 and 21, 2019. During this time AFC conducted testing and recharged the North 2 thermosyphon. After recharge, AFC periodically tested the system but North 2 was not observed to be operating correctly. The thermosyphon was partially discharged to reinitiate function in a blocked thermosyphon evaporator scenario (Appendix A).

Following the recharge, initial inspection of the thermosyphons and monitoring data indicate North 2 continues to remain essentially dormant (Appendix C). TMAC has exhausted the practical repair options for the thermosyphon at this point, and performance monitoring will continue. AFC recommended re-modelling the North Dam, taking into account the non-functional North 2 thermosyphon. This was already completed as part of past studies on extending the life of the North Dam. The result of this modelling shows that under conservative boundary conditions (typically higher thermal inputs or temperatures), the North Dam performance will not be adversely impacted by a non-functional North 2 thermosyphon; however, the design redundancy is slightly reduced. Based on these checks there is no major concerns at this time from the loss of the North 2 thermosyphon.

Any additional measures will be taken as necessary based on the observed performance of the overall dam.

The thermosyphon radiator steel foundations are in good condition. The thermosyphons themselves do not show any physical damage; however, there is rust and peeling paint at the weld between the evaporator pipe and the twin radiators on most of the thermosyphons. AFC was not concerned about this surface rust during their inspection.

Recommendations:

- None

4.2.3 CR1000 External Datalogger Battery Voltage

Each CR1000 data logger is powered by an external lead acid battery. Battery voltage is an important indicator of datalogger performance. If the battery voltage drops below 12 V, it is operating outside of the optimal range. At or below 9.6 V, voltage is outside of the operating range and the recorded readings could be incorrect, or the datalogger will shut down and readings would not be recorded at all. The dataloggers record the minimum battery voltage four times daily. A graph of battery voltage versus time is provided in Appendix D.

The batteries have been recharged on multiple occasions since the North Dam was commissioned. At no time has the voltage dropped low enough to cause any concerns with data integrity. The batteries should continue to be monitored to ensure they maintain their charge through the winter months.

Recommendations:

- The external CR1000 datalogger batteries should continue to be monitored and recharged annually or replaced as needed.

4.2.4 Inclinometers

Six inclinometers were installed within the downstream face of the North Dam. These inclinometers are used along with the survey monitoring points to monitor deformation within the dam and dam foundation. Inclinometer readings are taken by TMAC site personnel. As discussed in Section 3.1, inclinometer readings were collected intermittently prior to May 2014. Readings were collected monthly during the 2018/2019 monitoring period.

Inclinometer measurements are provided in Appendix E. Data quality for the surveys has generally been good. The inclinometer profiles show only negligible displacements in the dam foundation, and small displacements over the portion of the inclinometer above the natural ground surface as summarized in Table 15. Inclinometer ND-IN-120-3 is the only inclinometer that suggests a trend of downslope movement. All other inclinometers are showing virtually no movement, or the movement is oscillating seasonally which likely means there is some movement of the inclinometer tube itself, as opposed to actual deformation of the dam or foundation.

Table 15: Summary of Inclinometer Measurement Observations (Sep. 2012 through Dec. 2019)

Inclinometer	Maximum Overall Deformation			Maximum Foundation Deformation (m)	Observations
	Magnitude (m)	Location – Depth Below Dam Shell (m)	Location – Height Above Foundation (m)		
ND-IN-070-1	0.025	1.0	8.5	0.002	• Deformation essentially constant since 2015
ND-IN-070-2	0.029	2.5	6.5	0.019	• Seasonal oscillation, and overall trend suggest slight increase in deformation over time
ND-IN-070-3	0.013	4	3.5	0.013	• Deformation essentially constant since 2015
ND-IN-120-1	0.012	0.5	6.5	0.004	• Deformation essentially constant since May 2016
ND-IN-120-2	0.008	0.5	5.5	0.005	• Deformation essentially constant since November 2017. Upper deformation oscillating somewhat
ND-IN-120-3	0.021	1.0	2.2	0.002	• General trend of movement towards the south and downstream of the dam

Previous recommendations were made to send the inclinometer for re-calibration every three years. Although these do not have specified re-calibration intervals, the instruments are sensitive, and issues identified in February 2019 indicate one reason for this. TMAC sent the instrument to the manufacturer, in the United States, for recalibration in March 2020. Unfortunately, due to the global COVID-19 pandemic, this calibration was unable to be performed and was sent back to site for use in the spring and summer 2020 monitoring program.

Recommendations:

- Inclinometer re-calibration should be re-attempted before spring 2021.

4.2.5 Survey Monitoring Points

A series of 14 crest survey monitoring points, 3 deep survey monitoring points, and 18 surficial survey points were installed in the North Dam upon completion. These survey monitoring points were installed to monitor for any surface movement of the downstream face and deep settlement of the downstream foundation of the dam.

Survey monitoring of the North Dam occurred for all eight of eight occurrences between November 2018 and December 2019. The survey data should be collected monthly between May and November. Complete survey data is presented in Appendix F.

The overall vertical and horizontal displacement since completion of construction based on these readings are summarized in Table 16. Deep settlement and crest displacement have been very small and of similar magnitude, and has essentially been unchanged since September 2013, confirming that the measured displacement to date is all directly related to the period immediately following construction.

Downstream dam shell settlement follows the same general trends as the deep and crest settlement points; however, the total displacement magnitude is about twice as much. There is also an increasing trend in displacement in two points (ND-SSP-155-2 and ND-SSP-110-3) since June 2016. The measured vertical displacement of these points suggests no displacement change, but the horizontal displacement is increasing, which results in the overall increased displacement trend. Both these points are located near the downstream toe of the dam, and this increased displacement is likely a result of increased active layer thaw beneath the shallow rockfill toe of the dam. The displacement is not of immediate concern, but it should be carefully monitored going forward.

Table 16. Summary of Survey Monitoring Observations (May 2012 through December 2019)

Location	No. of Stations	Vertical Displacement (m)			Horizontal Displacement (m)		
		Min.	Max.	Avg.	Min.	Max.	Avg.
Deep settlement points (DSP)	3	0.02	0.04	0.03	0.01	0.08	0.05
Crest settlement points (SMP)	14	0.03	0.08	0.05	0.02	0.10	0.05
Downstream dam shell settlement points (SSP)	18	0.03	0.22	0.11	0.0	0.29	0.07

Recommendations:

- Continue to carefully monitor the downstream dam shell settlement points ND-SSP-080-3 and ND-SSP-110-3 to further assess if thaw settlement of the toe is causing undue deformation.
- Continue to watch for ongoing erosion around settlement monitoring point ND-DSP-100.

4.2.6 Creep Displacement

North Dam displacements as recorded by the inclinometers and survey points are expected to be caused primarily because of creep of the saline ice-rich permafrost foundation soils. Table 17 summarizes the predicted deformation as determined through rigorous numerical creep deformation modeling (SRK 2017c), as well as the allowable design values. Figure 15 presents a plot comparing predicted vertical displacement against measured vertical displacement along the crest of the dam near Station 1+20. This graph clearly demonstrates that the current displacement is less than predicted.

Table 17. Predicted North Dam Deformation Displacement

Period	Location	Max. Shear Strain Rate (year-1)	Max. Shear Strain (m/m)	Displacement (m)	
				Max. Horizontal	Max. Vertical
Overall allowable design values	**Core**	**3.2E+02**	**2%**	**-**	**1.0**
10 years post construction	Core crest	-	-	-	0.2
	Core	5.0E-08	5.0E-02	0.4	0.6
	Foundation	1.0E-07	~1.0E-01	0.4	0.6
30 years post construction	Core crest	-	-	-	1.0
	Core	2.0E-08	1.0E-01	0.8	1.0
	Foundation	4.0E-08	~2.0E-02	0.6	1.0

Recommendations:

- None.

4.2.7 Walkover Surveys

Walkover surveys of the North Dam are required weekly when tailings deposition is occurring, and when the TIA water level is below the FSL. During the 2018/2019 monitoring period between November 2018 and December 2019, 51 walkover surveys were completed, and the associated reports and photos are included in Appendix G.

The walkover survey reports and tracks all changes to the dam surface, visible damage to instrumentation, signs of erosion or seepage, or any other surface anomalies. To date, the primary observations of note from the walkover surveys include:

- Surface depressions in the upstream and downstream slopes of the dam;
- Minor cracking on the turn-around pad on the upstream side;
- Rust on the thermosyphons (Section 4.2.2);
- Erosion near the thermosyphons (Section 4.2.2); and
- Ponded or flowing water at the downstream toe of the dam (Section 4.2.8).

The surface depressions are located on the upstream and downstream faces of the dam. Six depressions have historically been classified as significant depressions requiring monitoring (D1, D2, D3, U1, U2 and U3), as illustrated in Appendix H. The Monitoring SOP requires a GPS location, photographs and estimated dimensions/extents of these large surface depressions on a continuous basis to track if they are increasing in size. No monitoring of the depressions was completed during this monitoring year. Based on the AGI physical inspection (see Photolog 1 and 2), SRK is satisfied that there were no substantial changes to these surface depressions since the 2017 AGI, and this observation is confirmed by the settlement data.

Some surficial cracking has been noted in past walk over inspections (more in 2018) near the upstream face of the North Dam (now below the water level in the TIA). A review of this area was completed and determined that this cracking was primarily on additional fill that was placed over steepened during care and maintenance to access temporary pumps. This fill was placed on top of the North Dam upstream slope and is not expected to be reflective of the underlying dam conditions. In addition, this temporary access route is no longer being used on site and is currently decommissioned. Review of the thermal monitoring data also confirms that any upstream foundation thawing rates are still below the original design criteria and predictions.

Recommendations:

- Ensure that the required weekly walkover surveys are being completed in accordance with the SOP. This is an important surveillance activity as defined in the OMS Manual and needs to be complied with. In 2019 notable improvements were made in the frequency of the walk over surveys completed, however there are still room for additional improvement on frequency and documentation. SRK and TMAC to continue to work together on this and South Dam walkover surveys to be included in 2020.

4.2.8 North Dam Seepage

Since completion of the North Dam construction there has been evidence of surface water flow along the downstream toe of the dam. This flow has historically been reviewed by SRK, and a rigorous thermal assessment and water quality review was conducted in 2017 to establish whether the flow was in any way indicative of North Dam seepage (SRK 2018a). The evaluation concluded that North Dam seepage was unlikely but could not be definitively excluded. It was recommended that flow measurements be obtained, systematic water quality sampling be undertaken, and frost probe data be collected.

A V-notch weir was installed at this location in July 2017, as illustrated in Figure 4 and flow and water quality sampling were carried out in accordance with the newly established Monitoring SOP (SRK 2018b). SRK's review of the 2019 seepage water quality data (Appendix K) confirms that currently there is strong evidence to suggest that the origin of the seepage water is not from the TIA. Although this 'seepage' is not expected to be from the TIA impoundment, additional data collection could allow for a more rigorous determination going forward if things were to change. Based on this the implemented seepage monitoring program is planned to be continued on site.

As part of the seepage monitoring, flow through the V-notch weir varied between 0 and 2.5 l/s and was only present between late June and September (approximately 85 days). The flow was variable, and generally correlates with rainfall which suggests that a consistent baseflow seepage from the TIA is unlikely.

Two frost probe surveys were conducted along seven transects downstream of the North Dam. The data collected identifies variation in the seasonal active layer thaw depth between July and November, typically varying by 0.2 – 0.6 m. The greatest variation was observed near the previously identified flow path locations along the NE downstream toe where the maximum thaw depth was 0.7 m. This data is consistent with the settlement data indicating maximum dam deformation at the toe of the dam.

Based on all data reviewed in relation to the North Dam seep, there is currently no anomalous data to suggest that TIA water is seeping from the North Dam.

Recommendations:

- Continue water quality and flow monitoring of North Dam seepage according to the methods outlined in SRK (2018b).
- Conduct at least one additional frost probe survey along the same transects in early summer to early fall 2020, following the same procedure as in 2019. Data from this frost probe survey should be reviewed in 2020 to determine if these surveys are required beyond 2020.

4.2.9 Physical Inspection of the North Dam

As part of the 2019 AGI a walkover survey of the North Dam was completed. No general issues of concern were observed. The attached Photolog (Photolog 1 to 3) provides a general overview of conditions on the North Dam.

Recommendations:

- None.

4.3 South Dam Inspection and Monitoring

4.3.1 Ground Temperature Cables

To monitor long-term temperature of the frozen foundation dam, a total of twenty-seven GTCs were installed during South Dam construction (SRK 2018c). The GTCs are connected to Beaded Stream Dataloggers (D405) to allow continuous data capture; however, some issues in data capture and transmission have been encountered and required SRK to undergo detailed review and ongoing monitoring by SRK and TMAC site staff. Due to these commissioning challenges, a detailed review of monitoring data is provided in Appendix L, in additional to the plots seen in Appendix B. Table 18 provides a summary of the GTC status during the 2019 AGI inspection. Note that not all of the installed cables are operational (due to various issues typically linked to cable damage from construction and/or wildlife). Wherever possible, repairs were completed on site by the mill instrumentation electrician to bring as many cables as possible back online, and additional measures were put in place to improve protection of the cables.

The design criteria for the dam requires a ground temperature of less than -2^{o}C at the upstream base of the key trench (Figure 9). Based on the data review, the ground temperatures generally meet the design requirements and the dam is performing as expected.

Table 18: South Dam Ground Temperature Cable Status Summary

GTC ID	Station ID	Status	# of Sensors (Functional / As-built)	Comment
SD-VTS-065-KT	0+65	Active	11 / 11	• Damaged following construction (repaired)
SD-HTS-065-US	0+65	Active	5 / 5	• Damaged following construction (repaired)
SD-VTS-155-KT	1+55	Active	11 / 11	
SD-HTS-155-US	1+55	Active	5 / 5	
SD-VTS-155-US	1+55	Inactive	1 / 11	• Sensor 1 functional, ended on 11/8/2019
SD-VTS-155-DS	1+55	Active	11 / 11	
SD-HTS-155-KT	1+55	Inactive	0 / 11	• Damaged during construction (irreparable)
SD-HTS-240-KT	2+40	Active	11 / 11	
SD-VTS-240-KT	2+40	Active	11 / 11	
SD-HTS-240-US	2+40	Active	7 / 7	
SD-VTS-240-US	2+40	Inactive	0 / 11	• Measurements ended on 10/10/2019
SD-VTS-240-DS	2+40	Inactive	0 / 11	• Measurements ended on 10/22/2019
SD-VTS-365-KT	3+65	Inactive	0 / 11	• Damaged following construction (irreparable)
SD-HTS-365-KT	3+65	Active	11 / 11	• Damaged following construction (repaired)
SD-HTS-365-US	3+65	Active	11 / 11	
SD-VTS-365-US	3+65	Active	11 / 11	
SD-VTS-365-DS	3+65	Active	11 / 11	
SD-VTS-US1	3+65	Active	2 / 13	• Installed in suspected ground ice wedge near upstream toe • Sensors 1 and 2 active
SD-VTS-US2	3+65	Active	1 / 15	• Installed in suspected ground ice wedge near upstream toe • Sensor 1 active
SD-VTS-460-KT	4+60	Active	11 / 11	
SD-HTS-460-KT	4+60	Active	11 / 11	
SD-VTS-460-US	4+60	Active	11 / 11	• Damaged following construction (repaired)
SD-VTS-460-DS	4+60	Active	11 / 11	
SD-HTS-460-US	4+60	Inactive	0 / 5	• Damaged following construction (irreparable)
SD-VTS-510-KT	5+10	Active	11 / 11	
SD-HTS-510-US	5+10	Active	5 / 5	• Damaged following construction (repaired)
SD-HTS-B1-KT	NA	Active	20 / 20	

Notes:

1. Number of functional GTC sensors on 3/1/2020

GTCs provide thermal monitoring of the dam to ensure conditions remain within the intended design for safe operation and containment. SRK is currently assessing if replacement of the following GTCs will be required to ensure the monitoring system integrity is upheld; SD-VTS-155-US; SD-VTS-240-US; SD-VTS-240-DS. Prior to any GTC replacement, the surface cable lead and connection with the data loggers should be inspected for damage and repaired, where possible. The upstream toe at section 2+40 is currently outside of the tailings beach which would allow for replacement of SD-VTS-240-US prior to being covered by tailings.

Recommendations:

- Inspect the surface cable lead and connection with the data loggers for damage or similar issues and repair where possible. SRK to further assess, if the repairs are not possible, replacement of SD-VTS-155-US, SD-VTS-240-US and SD-VTS-240-DS will be required.
- Manually download data from each datalogger once annually or as specified by the EOR.

4.3.2 Survey Monitoring Points

A series of 12 crest survey monitoring points, 3 deep settlement points, and 26 surficial survey monitoring points are proposed for the South Dam. Survey monitoring points were installed in August 2019 and monitoring surveys occurred in August through November. Going forward, survey data should be collected monthly between May and November. Complete survey data is presented in Appendix F.

The overall vertical and horizontal displacement since August 2019 indicates limited displacements. In all instruments, vertical displacements were less than 0.05 m and horizontal displacements less than 0.05 m except for SD-FMP-04 (0.13 m). Continued monitoring will provide a greater understanding of the dam’s performance. At this point the limited displacements observed are not of concern.

Recommendation:

- Complete survey monitoring monthly from May to November.

4.3.3 Physical Inspection of the South Dam

As part of the AGI a walkover survey of the South Dam was completed. As dam construction had just been completed, there were no issues of concern to note. Photolog 4 provides a general overview of the South Dam conditions at the time of the AGI.

Recommendations:

- None.

4.4 Tailings Deposition System

Table 5, Figure 10, and Figure 11 provide a summary of tailings deposition in the TIA to date. Generally, the tailings deposition rates to date have been lower than the original planned tonnages. The solids content during this time has also been variable. There has generally been a constant increase from about 15% solids by weight in July 2017 to approximately 48% solids by weight by November 2018. In 2019 tailings solids contents were typically between 40 and 50% (except for February and December 2019 where solids contents were lower).

Tailings deposition has occurred as single point discharge from approximately 5 separate locations in 2019; two locations along the eastern shoreline of the TIA, two locations from the South Dam, and one winter location just downstream of the developing South Dam tailings beach. At the time of the 2019 AGI tailings discharge from the South Dam was underway and beach development had pushed supernatant water greater than the specified 100m offset from the upstream dam crest. Tailings deposition will need to continue from the South Dam in accordance with the tailings deposition plan (Figure 12 and Appendix N).

In accordance with the site water management plan, saline mine water can be discharged directly to Roberts Bay, or directed to the TIA via a dedicated pipeline. The marine outfall pipeline was constructed in 2019 but was not commissioned until Q1 2020. SRK has advised against discharging saline mine water with tailings into the TIA, especially when beaching from the South Dam, because the saline pore water will depress the freezing point of the tailings. This could compromise the performance of the South Dam or the long-term freeze-back of the tailings. Based on this risk, saline water should be directed away from the TIA whenever possible. This noted, if saline water must be directed to the TIA then it should be done at a spigot location that is at least 300 m away from the South Dam crest so that the freeze back of the tailings at the South Dam beach is not impacted.

In 2019, tailings samples were collected from the South Dam beach and geochemical laboratory testing was completed to assess the pore water salinity. A review of the tailings pore water salinity and freezing point depression analysis is presented in Appendix M.

As noted in the 2018 AGI, TMAC has advised that, on occasion, they may dispose of propylene glycol from aircraft de-icing activities into the TIA. Small volumes of glycol will not affect the TIA water chemistry, but glycol does have a depressed freezing point and therefore discharging glycol with the tailings solids can only be done under the following conditions:

- Glycol must be discharged directly into the Reclaim Pond, at least 300 m away from any dams, and at least 10 m from any exposed shoreline;
- The maximum discharge rate of glycol is 30 m^3 per 6 months;
- All glycol disposal into the TIA must be recorded with the product details, disposal volume, location of discharge and date; and
- The EOR must be informed of all glycol discharges to the TIA.

Recommendations:

- TMAC should install the dedicated mine water discharge pipeline to the TIA as soon as possible to allow tailings deposition to recommence from the South Dam. It is critical that tailings deposition from the South Dam occur in order to maintain a beach of at least 100 m at all times, for all TIA water levels. *UPDATE: this was addressed at the start of 2020 and is now complete. The Roberts Bay Discharge system is now operational.*

- Saline mine water may only be discharged together with tailings from, or within, 300 m of the South Dam provided the freezing point depression is less than 0.5ºC (around 4,500 mg/L Cl maximum equivalent). If the freezing point depression exceeds 0.5ºC, saline mine water may be discharged with tailings at other designated tailings discharge points or directly into the Reclaim Pond. The freezing point depression calculation provided in this AGI (Appendix M) will be incorporated by SRK into the updated OMS Manual (update currently in progress).
- Tailings discharge must be done in accordance with the designated tailings discharge plan. Primary spigot moves should be expected around or immediately after spring melt and again prior to winter freeze up. This approach will help to achieve the required beach development, promote beach freeze back, and minimize ice entrainment in the tailings.
- Areas along the eastern shoreline of the TIA where tailings discharge has occurred at elevations above 36.5 m, although mainly over exposed bedrock, should be carefully monitored to determine if permafrost damage is occurring due to vegetation dieback. Should any damage be noted, appropriate proactive mitigation may be required.

4.5 Emergency Dump Catch Basins

The Eastern Dump Catch Basin is in good condition as shown in Photolog 7. The Western Dump Catch Basin was however not constructed in accordance with the Design Drawings and Technical Specifications and may not perform as intended. Currently it looks like this structure has the required containment volume, but some liner slippage has been noted and repairs are suggested. SRK has therefore advised that this structure be repaired at the earliest opportunity. TMAC has agreed to do this reconstruction at the earliest opportunity on site / when practical.

Recommendations:

- Repair the Western Emergency Dump Catch Basin at the earliest opportunity.

4.6 Pipelines (Reclaim, Tailings Deposition and TIA Discharge)

Pipelines are placed directly on the ground, which could be either rockfill pads, road shoulders or directly on the tundra. There are signs of vegetation dieback because of pipelines placed directly on the tundra along the northern shore of the TIA upstream of the Reclaim Pump Station. This is becoming a preferred flow path for surface runoff which could ultimately lead to rapid surface erosion and subsequent thermal erosion of permafrost.

Notable settlement was noted at the TIA Reclaim Jetty Pad (also referred to as the 710 Pumphouse pad). Upon visual inspection and from review of the as-built data it looks like new ROQ material was placed off the edge of the pad in thick, end dumped lifts in order to widen the pad for the new 710 pumphouse. There are notable stability concerns with this pad as large settlements and notable cracking indicate that a failure of this pad (albeit slow) appears to be occurring. However, it should be noted that the rate of movement could increase suddenly, causing a sudden failure, and this risk should not be ignored. Monitoring of this area (at least weekly during winter and daily during months with no ice cover on the lake) should be completed. It is recommended that remediation measures be completed for the pad area in order to stabilize the fill and prevent further deformation. This is expected to consist of placing additional fill along the outside of the access road and pad to reduce the overall slope and provide additional confining stress at the toe of the pad (which is currently underwater). Rates of loading must be controlled and slow enough to avoid inducing excess pore pressures in the foundation. This means that it may take weeks to build this small additional fill and that the dumping faces should be spread out as much as possible. Material should be end dumped back from the working face and spread with an excavator with the largest reach on site (to limit loading at the crest).

Recommendations:

- TMAC must carefully inspect all pipelines placed directly on the tundra for signs of vegetation dieback and associated development of erosion and channeling. Where this is occurring, the pipeline must be relocated to follow existing all-weather road shoulders, and appropriate remediation needs to be put in place where damage has occurred. Although SRK previously approved the placement of insulated pipelines directly on the tundra, inspection observations suggest TMAC should avoid placement of any pipelines on the tundra where possible and relocate any un-insulated pipes on the tundra.
- The thermal erosion feature that was backfilled in 2019 should continue to be monitored to ensure that ongoing thermal erosion of this area does not occur and to confirm that the thermal erosion has slowed.
- Monitoring instruments should be installed at the TIA Reclaim Jetty Pad (710 Pumphouse pad) and additional safety considerations put into place when personnel are working at or around this area. *UPDATE: since the time of the 2019 inspection these measures have been installed on site (installed start of Q2 2020).*
- Remediation construction activities should be carried out on the TIA Reclaim Jetty Pad in 2020 to improve the stability of this pad, specifically on the most recently constructed, most northern portion of the pad (where additional fill was placed in 2019).

4.7 Shoreline Erosion

The pre-mining water level in the pond is 28.3 m. Since the start of commercial production, the water level has risen to 30.7 m, which is 2.4 m above the original lake water level. Therefore, a large section of shoreline has been flooded which has resulted in vegetation stress. At this time, there are no visible signs of shoreline erosion, and therefore no additional monitoring is required.

Recommendations:

- None.

4.8 TIA Operational Water Level Targets

The TIA operational water balance can be used to predict water levels in the TIA going forward. The Roberts Bay Discharge System began discharging from the TIA to Roberts Bay in February 2020. As a result, the Reclaim Pond water levels decreased from 32.0 m (around January 2020) down to 31.1 m in May 2020, which is near the target level for this stage of the operation. SRK has previously provided recommendations on target maximum operational water levels in the TIA (SRK 2019). These same recommendations currently hold. The current recommendation is tied to two key time periods:

- May 31, 2020 (Pre-freshet): 31.5 masl
- September 30, 2020 (Pre-freeze-up): 31.0 masl

In addition to the Reclaim Pond water level targets, the South Dam beach length must be maintained to a minimum of 100 m. See the 2019 TIA target water levels memo (provided in Appendix I) for additional details.

Recommendations:

- Continue pumping to reduce the water levels in the pond to at or below the target maximum elevations.
- Continue to monitor the South Dam beach length to maintain at least 100 meters separation between the Dam and Reclaim Pond.

4.9 Climate Data

For reference, precipitation and temperature data, as described in Section 2.5.5, is provided in Appendix J.

Recommendations:

- None.

4.10 TIA Water Quality

TIA Water quality is monitored at compliance station TL-1 at the Reclaim Water pump station. Ongoing review of water quality trends and a comparison to MDMER limits has been completed each year. To date, the only parameter that has exceeded MDMER limits is total suspended solids (TSS) for both the maximum authorized monthly mean concentration and the maximum authorized concentration in a grab sample.

A comprehensive analysis of the reasons for the high TSS concentrations has been completed (SRK 2019). The high TSS is a result of an algae bloom event that typically occurs each year during the summer months. In order to maintain operational flexibility and continue to discharge water to Robert’s Bay during the summer, it has been concluded that a water treatment plant is required to remove TSS prior to discharge.

Recommendations:

- TMAC must commission a water treatment plant to be able to treat for TSS and provide flexibility for water discharge during the annual anticipated algae bloom. If the plant is not constructed ahead of the anticipated algae bloom in 2020, no discharge will occur when elevated TSS is measured in the TIA.

5 Recommendations and Conclusions

Based on the results of the 2019 AGI, the Doris TIA and associated structures (primarily the North Dam and South Dam) are functioning as designed. Some issues were observed during the physical inspection and some anomalies were identified during the monitoring data review; however, these are either within expected performance or determined to be of no concern to dam performance. Improvements to the overall tailings management system (e.g. SOP and OMS Manual updates) were also identified, and these are currently being actioned by TMAC with support from SRK where required. Table 19 presents a summary of the recommendations listed throughout this report.

Table 19: Summary of Recommendations

Inspection Item	2018 Recommendations (for reference)	2019 Recommendations
General TIA Management Recommendations		
Third Party Dam Safety Review	• The North Dam hazard classification was revisited and is considered HIGH. This requires an independent third-party Dam Safety Review by 2021.	• Conduct an independent third-party Dam Safety Review for both the North and South Dams in the summer of 2021.
Tailings Operating, Maintenance and Surveillance (OMS) Manual and Emergency Response Plan (ERP)	• Ensure all staff are aware of the OMS Manual and are familiar with its contents. • Review and revise the OMS manual to ensure consistency with the recently amended Water License. • Provide necessary training in accordance with the OMS Manual.	• An update to the OMS manual is in progress by SRK and will be submitted by Q4, 2020. This update is aimed to be a notable improvement to the current OMS. This noted, additional updates are expected in Q3 and Q4 2020. The focus of the OMS updates in Q3 and Q4 will be further refinement of the Trigger Action Response Plans (TARPs). The OMS for this facility will be a 'living' document that is expected to be reviewed annually. • TMAC should ensure all staff are properly informed and trained on the contents of the OMS Manual. • *At the time of writing this report, TMAC was in the process of developing a standalone 'Hope Bay Project Dam Emergency Plan', rather than updates to the ERP, to address dam emergencies. It will incorporate inundation mapping and dam break scenarios. The standalone dam emergency plan will be released upon completion of the OMS update to ensure alignment.* An Emergency Reponses Plan exists for the site; however, this document was lacking sufficient detail for an emergency at the TIA. In 2019 SRK visited site and held a session with site personnel to go over preliminary dam break inundation maps completed by SRK and to provide inputs into what should be included in the site ERP updates to ensure the TIA is properly covered in this document. An update to the ERP is recommended in 2020 to provide additional details for the TIA.
TIA Responsible Parties	• N/A	• TMAC must agree on the roles and responsibilities for the TIA, train and inform personnel of their duties, and operate the

Inspection Item	2018 Recommendations (for reference)	2019 Recommendations
		facility accordingly. This will be an ongoing recommendation that is expected to be repeated annually. The roles and responsibilities for the TIA will be defined in the OMS update, to be released in 2020.
Monitoring Standard Operating Procedures (SOPs)	• To avoid confusion update SOPs to reflect changes that has been agreed to since the original SOP was developed.	• Update the Monitoring SOP to include South Dam monitoring requirements. SRK is currently preparing a separate SOP for the South Dam, and one already exists for the North Dam. A draft version of the South Dam SOP was submitted to TMAC in June 2020 and a final version is expected in July 2020.
Compliance with Monitoring Requirements	• Improve efforts to conduct monitoring at the frequency described in the SOPs.	• Conduct monitoring in accordance with the Monitoring SOP, paying attention to those areas where conformance is not consistently met.
North Dam Inspection and Review of Monitoring Data		
Ground Temperature Cables (GTCs)	• In accordance with manufacturers recommendations, the dataloggers must be recalibrated as it has been in operation for more than five years. Internal batteries on the dataloggers must also be replaced. • A monitoring well near ND-VTS-130-DS is no longer required. See “Physical Inspection of North Dam”.	• There are no specific recommendations for the installed GTCs. However, TMAC should aim to improve performance tracking of the dataloggers at the South Dam and check to see if cables are being damaged by wildlife after spring melt in order to confirm that current cable protection is adequate.
Thermosyphons	• AFI or another qualified contractor must physically inspect thermosyphon North 2 (at the North Dam) and determine why it is not working. Appropriate repairs must be conducted. • While the contractor is on-site, have them inspect all thermosyphons, and carry out any additional maintenance they recommend.	• The 2018 recommendations were completed in 2019 and Arctic Foundations Canada (AFC) visited the site for an inspection. Additional details are provided in this 2019 AGI (see Appendix A).
CR1000 Datalogger Battery Voltage	• The external datalogger batteries should be tested and recharged or replaced annually.	• The external CR1000 datalogger batteries should continue to be monitored and recharged annually or replaced as needed.
Inclinometers	• No action required.	• The inclinometer and associated readout device should be recalibrated every 3 years as per recommended best practice. SRK was aware that TMAC sent this instrument for recalibration but due to COVID-19, the instrument calibration was unable to be performed and had to be returned from the out of country manufacturers. This recommendation should be revisited before the spring of 2021.
Survey Monitoring Points	• Backfill the erosion around ND−DSP−100.	• Backfill the erosion around survey monitoring point ND−DSP−100 at the North Dam. • Continue to carefully observe the North Dam downstream shell settlement points ND-SSP-080-3 and ND-SSP-110-3 to

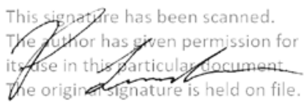
Inspection Item	2018 Recommendations (for reference)	2019 Recommendations
		determine if thaw settlement of the toe is causing undue deformation.
Creep Displacement	• N/A	• None.
Walkover Surveys	• Improve efforts to conduct walkover surveys in accordance with the frequency prescribed in the SOP.	• The required weekly walkover surveys at the North Dam are not being completed in accordance with the SOP. This is an important surveillance activity as defined in the OMS Manual and needs to be complied with.
North Dam Seepage	• Continue to conduct monitoring of the North Dam toe seep in accordance with the recommendations (see Appendix J for the 2018 TIA AGI). This includes: • Field measurements of Electrical Conductivity when Surveillance Network Program (SNP) samples are collected at TL-1; • Weekly sampling and geochemical analysis of North Dam toe seepage when present; • Annual review of North Dam toe seepage water chemistry; • Measurement of active layer thaw depth using a frost probe.	• Continue water quality monitoring of North Dam seepage according to the methods outlined in SRK (2018b) (this was completed in 2019). • Conduct at least one additional frost probe survey along the same transects in early summer and early fall, following the same procedure as in 2018 and 2019. Based on current favourable results, SRK will revisit the requirements for the frost probe surveys as part of the 2020 AGI and determine if further surveys are required beyond 2020.
AGI Physical Inspection	• N/A	• None.
South Dam Inspection and Review of Monitoring Data		
Ground Temperature Cables (GTCs) and D405 Dataloggers	• N/A	• Complete a walk over survey of the South Dam after spring melt and look for any exposed or damaged ground temperature cables. This will allow for preventative maintenance to be done if exposed cables are observed, which will help to limit the potential for damage from wildlife. • SRK to further assess, if repairs are not possible, if replacement of Ground Temperature Cables SD-VTS-155-US, SD-VTS-240-US and SD-VTS-240-DS will be required. • Manually download data from each datalogger once annually or as specified by the EOR.
Survey Monitoring Points	• N/A	• None.
Physical Inspection of the South Dam and Walkover Surveys	• N/A	• Start weekly walkover surveys of the South Dam in 2020. This is an important surveillance activity. Additional details will be provided to TMAC in the South Dam SOP.
TIA-Wide Monitoring		
Tailings Deposition System	• No action required.	• TMAC should install the dedicated mine water discharge pipeline to the TIA as soon as possible to allow tailings deposition to recommence from the South Dam. It is critical that tailings deposition from South

Inspection Item	2018 Recommendations (for reference)	2019 Recommendations
		Dam recommence in order to maintain a beach length of at least 100 m at all times, for all TIA water levels. *UPDATE: this was addressed at the start of 2020 and is now complete. The Roberts Bay Discharge system is now operational.* • Saline mine water may only be discharged together with tailings from, or within, 300 m of the South Dam provided the freezing point depression is less than 0.5ºC (around 4,500 mg/L Cl maximum equivalent). If the freezing point depression exceeds 0.5ºC, saline mine water may only be discharged with tailings at other designated tailings discharge points further than 300 m from the South Dam or directly into the Reclaim Pond. The freezing point depression calculation is provided in this AGI and will be incorporated by SRK into the updated OMS Manual (update currently in progress). • The tailings discharge system must be operated in accordance with the designated tailings discharge plan. Primary spigot moves should be expected around, or shortly afterwards, spring melt and again prior to winter freeze up. • Areas along the eastern shoreline of the TIA where tailings discharge has occurred at elevations above 36.5 m need to be carefully monitored to determine if permafrost damage is occurring due to tailings flow and vegetation dieback. Should any damage be noted, appropriate proactive mitigation may be required.
Emergency Dump Catch Basins	• N/A	• Repair the Western Emergency Dump Catch Basin at the earliest opportunity to ensure liner movement does not occur and impact the as-built storage capacity of this Emergency Catch Basin.
Pipelines (Reclaim, Tailings Deposition and TIA Discharge)	• N/A	• TMAC must carefully inspect all pipelines placed directly on the tundra for signs of vegetation dieback and associated flow path channelling. Where this is occurring, the pipeline must be relocated to follow existing all-weather road shoulders, and appropriate remediation needs to be put in place where damage has occurred. Going forward, TMAC should consider abandoning the practice of placing pipelines directly onto the tundra. • The permafrost thermal erosion feature that has developed along the northern shore of the TIA was backfilled by TMAC in 2019. This area should continue to be monitored to ensure that additional thermal erosion does not result in this area.
Shoreline Erosion	• N/A	• None.

Inspection Item	2018 Recommendations (for reference)	2019 Recommendations
TIA Water Balance	• N/A	• It is of paramount importance that the Roberts Bay Discharge System Pipeline be completed during the summer of 2019. Further delay of this may result in reduced operations. *UPDATE: this was addressed at the start of 2020 and is **now complete**. The Roberts Bay Discharge system is now operational.*
Climate Data	• N/A	• None.
TIA Water Quality	• N/A	• No recommendations; however, the following comments are made below. • The water treatment plant for the TIA is required to be maintained in good operational condition so that discharge of supernatant water can occur once the Roberts Bay Discharge System Pipeline is operational, and allow treated water to be discharged in order to maintain water levels in the TIA below the full supply level. *UPDATE: as of the start of 2020 the Roberts Bay Discharge system and the connected water treatment plant is now operational.*
TIA Reclaim Water Pad / 710 Pumphouse Pad	• N/A	• Notable settlement was noted at the TIA Reclaim Jetty Pad (also referred to as the 710 Pumphouse pad). Upon visual inspection and from review of the as-built data, it looks like new ROQ material was placed off the edge of the pad in thick, end dumped lifts in order to widen the pad for the new 710 pumphouse. There are notable stability concerns with this pad as large settlements and notable cracking indicate that a failure of this pad (albeit slow) appears to be occurring. However, it should be noted that the rate of movement could increase suddenly causing a sudden failure, and this risk should not be ignored. Monitoring of this area (at least weekly during winter and daily during months with no ice cover on the lake) should be completed. It is recommended that remediation measures be completed for the pad in order to stabilize the fill and prevent further deformation. This is expected to consist of placing additional fill along the outside of the access road and pad to reduce the overall slope and provide additional confining stress at the toe of the pad (which is currently underwater). Rates of loading must be controlled and slow enough in order to avoid inducing excess pore pressures in the foundation. This means that it may take weeks to build this small additional fill and that the dumping faces should be spread out as much as possible. Material should be end dumped back from the working face and spread with

Inspection Item	2018 Recommendations (for reference)	2019 Recommendations
		an excavator with the largest reach on site (to limit loading at the crest).

This final report, 2019 Annual Geotechnical Inspection, Tailings Impoundment Area, Hope Bay Project, Hope Bay, Nunavut was prepared by:



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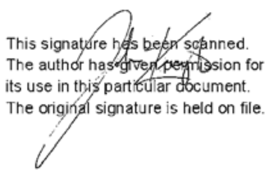

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All data used as source material plus the text, tables, figures, and appendices of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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

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