HOPE BAY PROJECT

DORIS AQUATIC EFFECTS MONITORING PLAN

August 2016

PLAIN LANGUAGE SUMMARY

This Aquatic Effects Monitoring Plan (AEMP; the Plan) describes what TMAC will do to confirm that freshwater and freshwater life near the Doris Mine are not affected by the mine.

The Plan describes how information will be collected in the freshwater environment and how this information will be studied to determine if the mining activities are affecting the freshwater environment. If there is the potential that the mining activities may change the freshwater environment, this document explains the methods TMAC will use to stop or reduce these changes.

REVISION RECORD

Date	Section	Summary of Changes	Author	Approver
February 2010	All	Original. Approved Plan under 2AM-DOH1323	Rescan	HBML
June 2016	Throughout	Update to TMAC as current licensee for the Hope Bay region. Changes to document to account for revised mine plan of discharging groundwater and TIA water to the marine environment instead of the freshwater environment.	TMAC (ERM)	TMAC
August 2016	Throughout	Revisions to Plan based on Working Group engagements and Party submissions.	TMAC	TMAC

GLOSSARY AND ACRONYMS

Term	Definition
AEMP	Aquatic Effects Monitoring Plan
CCME	Canadian Ministers of the Environment
DFO	Department of Fisheries and Oceans
DOE	Department of Environment
ECCC	Environment and Climate Change Canada
GN	Government of Nunavut
HBML	Hope Bay Mining Ltd.
INAC	Indigenous and Northern Affairs Canada
KIA	Kitikmeot Inuit Association
MMER	Metal Mining Effluent Regulations
NIRB	Nunavut Impact Review Board
NWB	Nunavut Water Board
SSWQO	Site-Specific Water Quality Objective
TIA	Tailings Impoundment Area

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1. INTRODUCTION

This Doris Aquatic Effects Monitoring Plan (the Plan) has been prepared by TMAC Resources Inc. (TMAC) in accordance with the requirements of the Doris North Project Type A Water Licence No. 2AM-DOH1323 (the Water Licence) issued by the Nunavut Water Board (NWB) on August 16, 2013. This Plan is an updated version of the AEMP submitted in June 2016 (TMAC 2016A), which itself was an update to the original AEMP for the Doris North Project (the Project; Rescan 2010). This Plan supports the amendment of the current Project Certificate (Project Certificate No. 003) and Water Licence as the operational mine effluent discharge point has been relocated from the freshwater environment (Doris Creek) to the marine environment (Roberts Bay; TMAC 2015). Previous versions of the AEMP for the Doris North Project will be superseded by this Plan following issuance of the amended licence.

This Plan presents the revised freshwater aquatic monitoring to be carried out during the construction and operation of the amended Project. The Plan focuses on pathways of potential effects in Doris Lake since most mine infrastructure is adjacent to the lake and therefore this waterbody has the greatest potential to receive non-point source inputs such as runoff and dustfall. Also, the combination of water withdrawal for mine processes and potential water loss into the underground mine has the potential to reduce the water level of the lake (SRK 2015).

This Plan considers information discussed during consultations with interested Parties, including the NWB, Environment and Climate Change Canada (ECCC), the Nunavut Impact Review Board (NIRB), the Kitikmeot Inuit Association (KIA), Indigenous and Northern Affairs Canada (INAC), and the Department of Fisheries and Oceans Canada (DFO). It also considers guidance outlined in *Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories: Overview Report* (INAC 2009) as well as lessons learned through the implementation of the original AEMP. The Plan uses monitoring data collected under Schedule J of the Water Licence to evaluate potential mine effects and includes a Response Framework that provides a mechanism to adaptively manage potential mine-effects identified through the Plan.

This Plan is intended primarily for use by TMAC and its contractors to ensure that best practices are employed throughout all freshwater monitoring activities associated with the construction and operation of the Doris North Project, thus ensuring water licence conditions are met and minimal potential downstream environmental effects occur. This Plan has been developed to reflect the amended Project and has been shaped in anticipation of an amended water licence. Should the amended water licence deviate substantially and materially from this Plan, a revised Plan will be submitted three months following the issuance of the amended water licence.

1.1. LICENCING REQUIREMENTS

Under the current Water Licence, the following is required:

- Part K, Item 7. The Licensee shall submit to the Board for review, six (6) months prior to Operations, a revised Doris North Gold Mine Project: Aquatic Effects Monitoring Plan (AEMP) that has been developed in consultation with Environment Canada. The revised AEMP shall consider modifications and advances in schedule which are consistent with the objectives and requirements with the MMER.

In compliance with Part K, item 7, TMAC has engaged interested Parties in a Working Group to discuss aquatic effects and review monitoring programs. This Working Group is comprised of members from the

Parties mentioned above, including Environment and Climate Change Canada. A proposal outlining the Plan was submitted to the Working Group on March 10, 2016 and the group convened in Edmonton, Alberta on March 15, 2016 to discuss the proposal. TMAC also engaged with the Inuit Environmental Advisory Committee (IEAC) on March 14, 2016 to review proposed aquatic monitoring programs related to the Doris North Project. The IEAC was established under the 2015 Hope Bay Inuit Impact and Benefit Agreement (IIBA) between TMAC and the KIA, and provides advice on potential environmental effects and mitigation measures resulting from TMAC operations in the Hope Bay area, including the Doris Mine. Based on these engagements, a revised Aquatic Effects Monitoring Plan was submitted to the Working Group on June 1, 2016. This document was discussed on June 6, 2016 with the Working Group. As a result of this discussion, as well as comments from Working Group parties subsequent to that meeting, the current Plan is being issued.

The requirements of the Metal Mining Effluent Regulations (MMER) are not considered within this Plan, as all mine and groundwater will be discharged to the marine environment under the amended Project.

1.2. OBJECTIVES

The purpose of this Plan is to assess the potential effects of Doris Mine activities on the freshwater environment, as well as comply with the requirements set forth in the Water Licence and commitments made during the Project amendment process. The objectives of the Plan are aligned with the definition of the AEMP outlined in the current Water Licence (Part M, Schedule A) and follow those objectives put forth in *Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories: Overview Report* (INAC 2009).

The main objectives of the Plan are to:

- detect potential short and long-term effects in Doris Lake resulting from activities of the Doris Mine;
- evaluate the accuracy of effects assessments made in TMAC's Revisions to TMAC Resources Inc. Amendment Application No. 1 of Project Certificate No. 003 and Water Licence 2AM-DOH1323 (TMAC 2015; submitted to the NIRB and the NWB in June 2015);
- assess the efficacy of mitigation measures applied to Doris Mine activities;
- develop a management framework that provides a mechanism to respond to potential mine-related effects in Doris Lake; and
- use that management framework to identify additional mitigation measures that will avert or reduce mine-related effects in Doris Lake.

This Plan is designed to address these objectives by measuring the receiving environment in the short-term (on an annual basis) and the long-term (during construction and operation). The sampling design allows for changes in the receiving environment to be detected, which determines whether mitigation measures are being effective. If potential effects are detected in the freshwater environment, TMAC management will be notified, and additional mitigation measures will be considered through a Response Framework. Together, these measures form an effective strategy to achieve environmental protection in the Doris North Project area ensuring no adverse effects occur in the freshwater environment.

1.3. Relevant Legislation and Guidance

Table 1.3-1 provides a summary of federal and territorial regulations governing this Plan and associated guidelines. Additional regulations and standards govern other TMAC plans that are designed to manage sources of potential contaminants to the freshwater environment, including the Water Management Plan (TMAC 2016b), the Spill Contingency Management Plan (TMAC 2016c), and the Air Quality Monitoring Plan (TMAC 2016d).

Table 1.3-1. Regulations and Guidelines Pertinent to the Aquatic Effects Monitoring Plan

Regulation	Year	Governing Body	Relevance
Nunavut Waters Regulations	2013	NWB	License for mining and milling undertaking to use water and deposit of waste in relation to the construction, operation, closure and reclamation.
Environmental Rights Act	2011	Government of Nunavut (Department of Environment, Environmental Protection division)	Grants all residents the ability to launch an investigation
Guideline	**Year**	**Issued by**	**Relevance**
Canadian Environmental Quality Guidelines	1999 – as amended to date	Canadian Council of Ministers of the Environment (CCME)	Provides guidance on water quality for the protection of aquatic life; both freshwater and marine

1.4. Plan Management and Execution

The Plan is reviewed annually and updated as necessary. Personnel responsible for implementing and updating the AEMP are identified in Table 1.4-1.

Table 1.4-1. Roles and Responsibilities

Role	Responsibility
VP Environmental Affairs	• Overall responsibility for and implementation of this management plan; • Provide the on-site resources to operate and maintain the monitoring program in accordance with this AEMP; • Provide input on modifications to design and operational procedures to improve operational performance.
Environmental Manager	• Review and update this AEMP as required; • Ensure Environmental staff are trained in monitoring and quality assurance and quality control procedures; • Support implementation of this monitoring plan;
Environmental Coordinator	• Conduct regular inspections of the monitoring stations and audits of the maintenance records; • Assess whether water quality samples have met applicable regulatory standards and guidelines; • Report issues, irregularities, and non-compliances with sampling program to the Environmental Compliance Manager; • Ensure sampling gear is safe and operational; • Maintain water quality records and all associated required reporting; • Audit of water quality records and all associated required reporting.

2. RATIONALE FOR REVISED AEMP DESIGN

This Plan reflects the proposed changes to the Doris Mine, which have been documented and assessed in TMAC's Project Certificate and Type A Water License Amendment Application, *Revisions to TMAC Resources Inc. Amendment Application No. 1 of Project Certificate No. 003 and Water Licence 2AM-DOH1323* (TMAC 2015) submitted to the NIRB and the NWB in June 2015. These changes result from the eventual expansion of the underground mine into the talik under Doris Lake, which will increase the operating mine life from two years to six years.

2.1. CHANGES TO DORIS MINE PLAN AND AEMP

Under the existing Doris North Project Certificate and Water Licence, all mine and intercepted groundwater reports to the Tailings Impoundment Area (TIA), which is in turn discharged to Doris Creek, a fish-bearing stream that flows from Doris Lake and eventually into Roberts Bay. The original AEMP was constructed largely to assess the aquatic effects related to this TIA discharge, with four freshwater monitoring sites located downstream of the discharge. Only one impact site, Doris Lake, was monitored for potential non-point source effects associated with dust and runoff (Rescan 2010) as this lake is adjacent to most of the Doris Mine infrastructure.

The revised mine plan now includes the expansion of the mine into the Doris Lake talik that will result in saline groundwater entering the underground workings. Because this water is saline, TMAC will combine the groundwater with effluent from the TIA and discharge both waste streams directly to Roberts Bay. This is considered to be both operationally efficient and protective of the freshwater environment as it removes the potential for freshwater effects resulting from point source discharge. The potential for the non-point source inputs of dust and runoff remains.

Mining activities also have the potential to drawdown Doris Lake water level due to the permitted water withdrawal for Project use and the recharge of mine-intercepted groundwater with Doris Lake water (SRK 2015). As a result, Doris Lake has been retained in this Plan to monitor for potential effects related to water quality (dust and runoff) and water quantity (water use, groundwater recharge). Reference Lake B will also be sampled on a three-year interval to ensure unanticipated effects are not occurring. The other TIA discharge-related sites from the original AEMP will no longer be monitored because the TIA water will not be discharged to the freshwater environment.

2.2. POTENTIAL INPUTS

The following Doris Mine infrastructure is near Doris Lake and has the potential to contribute dust and runoff during the construction and operations phases:

- Doris Camp;
- Wastewater treatment plant;
- Fuel storage and fuelling stations;
- Rock crusher;
- Road construction and use;
- Quarries, waste rock, and ore storage and camp pads;
- Sediment and pollution control ponds;

- Explosives storage and use;
- Mine Access Portal;
- Mill and processing plant; and
- Tailings deposition.

2.3. Mitigation of Potential Effects

TMAC has several management and monitoring plans in place to mitigate potential effects to the freshwater environment due to mine activities (Table 2.3-1). To date, the water and air management practices outlined in the various plans have been effective in mitigating effects to the freshwater environment surrounding the Doris Mine. No effects to water, sediment, or aquatic life have been detected in any of the waterbodies monitored under the original AEMP. This indicates that there has been no measurable influence of construction and site activities on the surrounding freshwater environment during what has been the most intensive construction period of the Doris Mine, including the development of: the underground portal, quarries, roads, airstrip, camp, pads, collection ponds, tank farms, laydown areas, TIA north dam, and the accumulation of waste rock and ore.

The efficacy of the mitigation measures pertaining to aquatic effects contained within these management plans are evaluated through this Plan and its Response Framework. These management plans are updated continually to reflect improvements to mitigation measures identified through the Plan process.

Table 2.3-1. TMAC Documents and Programs Related to the Aquatic Effects Monitoring Plan

Document Title	Relevance
Water Management Plan	Management of contact water from the site, TIA and underground
Air Quality Management Plan	Management of dust and air-borne emissions
Groundwater Management Plan	Management and minimization of groundwater inflow to the mine
Waste Rock and Ore Management Plan	Management of waste rock and ore contact water
Domestic Wastewater Treatment Management Plan	Management of treated domestic wastewater effluent
Hope Bay Spill Contingency Plan	Spill response procedures to minimize spill effects
Tailings Impoundment Area Operations, Maintenance, and Surveillance Manual (Tailings Management Plan)	Management of TIA effluent
Quality Assurance and Quality Control Plan	Approved sampling practices
Hazardous Waste Management Plan	Describes proper handling, storage and disposal procedures for hazardous wastes
Non-Hazardous Waste Management Plan	Describes proper handling, storage and disposal procedures for non-hazardous wastes

2.4. Potential Effects and AEMP Monitoring Components

The implemented management and mitigation measures outlined in the above plans reduce the potential for, and scale of, effects to the freshwater environment. However, potential remains for Doris

Mine activities to affect the Doris Lake aquatic habitat through dust deposition, runoff, and water drawdown. These potential Project contributions have the ability to affect different aquatic components in Doris Lake and this has determined the aquatic components that will be monitored in this Plan.

Water Quantity

The potential for drawdown of Doris Lake water due to Doris Mine activities will occur directly from the permitted withdrawal of the lake water for mine-related purposes and indirectly due to lake water moving into the groundwater, replacing talik water that has seeped into the underground mine. Lowered lake levels may reduce the available habitat for fish, and may destroy the incubating eggs of fall spawning species of fish (Lake Trout, Round Whitefish and Cisco) because ice may penetrate deeper into the lake than under natural conditions (TMAC 2015). Drawdown could also reduce the hydrograph downstream in Doris Creek, the number of stream flow days, and delay the onset of freshet (TMAC 2015). These changes may affect fisheries by reducing the amount and duration of habitat availability during the open-water season.

To quantify these effects, Doris Lake water levels and ice thickness will be monitored because they contribute to the depth that ice penetrates in the lake, and therefore set the maximum depth that over-wintering fish eggs would naturally survive in the lake (the depth at which they are not frozen or physically damaged). The natural maximum depth that ice can penetrate into Doris Lake, and therefore the safe threshold for over-wintering incubating fish eggs, is 2.74 m from the lake surface (Figure 2.4-1; TMAC 2015). This is because the winter drawdown of Doris Lake water level has varied naturally by an average of -0.54 m and by a maximum of -0.74 m (11 years of baseline data), while April ice thickness has naturally varied from 1.9 to 2.0 m. Because mining activities may drawdown Doris Lake levels by as much as 0.23 m (SRK 2015), this could lead to ice penetrating below the natural maxima of 2.74 m during years when ice thickness and drawdown levels are near natural peaks. If this occurs beyond the extent of natural variation, egg mortality may ensue in Doris Lake, or flow changes in Doris Creek, which could result in an adverse effects to fisheries. If such effects are likely, an offsetting plan would need to be developed and approved under the *Fisheries Act* (1985) prior to the impact occurring.

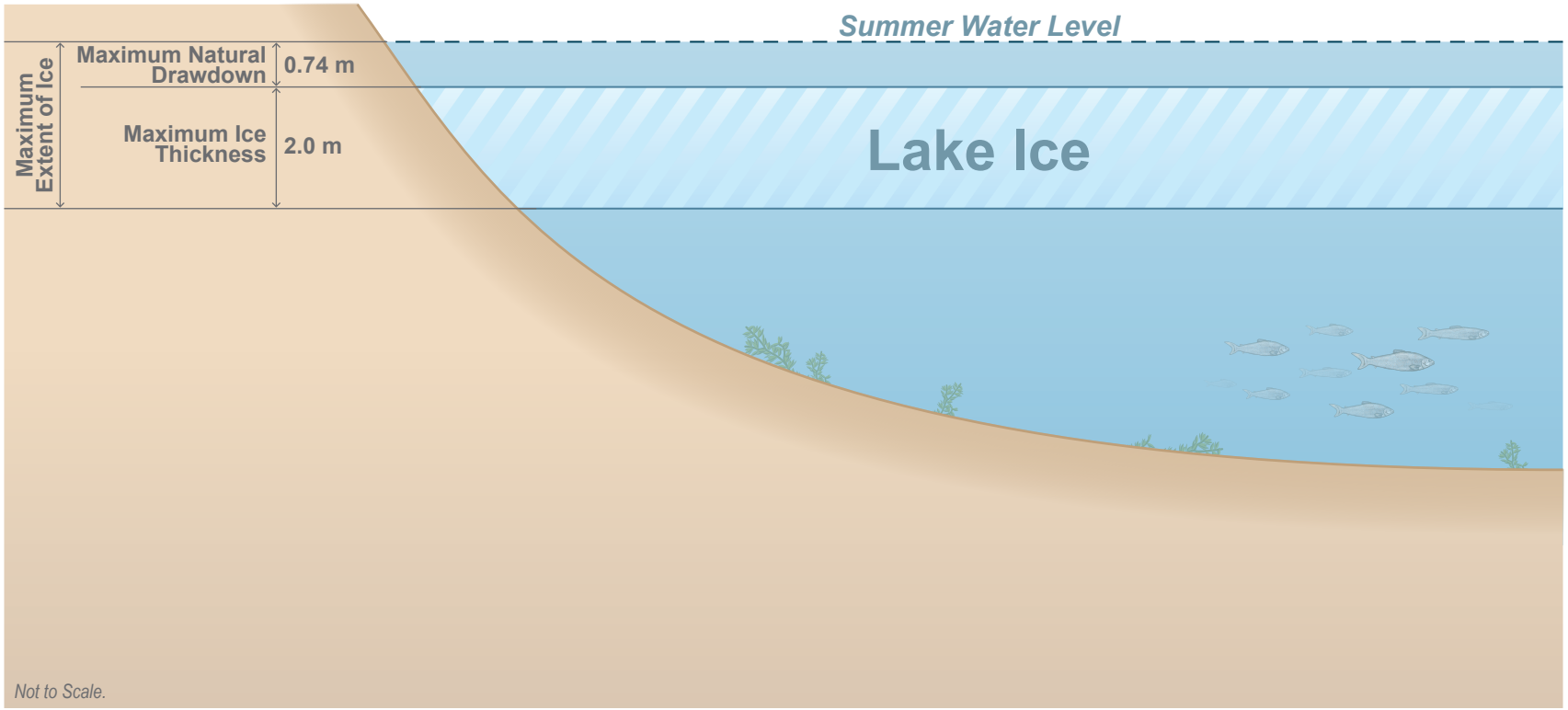
Water Quality

Dust deposition and runoff are indirect sources of potential contaminants to Doris Lake and their effects are most likely to be first measured in the lake water. If concentrations of particular water quality parameters increase above a certain level, they could affect aquatic life in the lake. Given this, water quality will continue to be monitored in Doris Lake under this Plan and will be evaluated against CCME guidelines for the protection of aquatic life and assessed to determine if concentrations are increasing in the lake due to mine activities.

Water quality monitoring samples collected under the Water Licence monitoring program and from the north-central section of the Lake will be used to evaluate potential mine effects to Doris Lake. This differs from the original AEMP where samples were only collected in the north-central section of the lake. Reasons for this revision are explained in Section 3.1.

Figure 2.4-1

Schematic of Natural Water Level Drawdown and Ice Thickness on Doris Lake



Phytoplankton Biomass

Dust deposition and runoff may contribute nutrients to Doris Lake, and if particular nutrients (e.g., nitrogen and phosphorus) naturally limit primary production in Doris Lake, additional sources could lead to increased primary production in the lake. Phytoplankton are the dominant primary producers in lakes, and phytoplankton biomass levels are estimated using the main photosynthetic pigment, chlorophyll *a*. Chlorophyll a concentrations in Doris Lake will be monitored annually (August) to evaluate potential mine effects to Doris Lake through nutrient inputs.

Benthos

Dust deposition and runoff may contribute particulate matter and potential contaminants to the water and sediments of Doris Lake and this could affect the health of benthic invertebrates (benthos) that are in contact with these environments. Benthos will be monitored on a three-year cycle in Doris Lake and at a reference site to determine if potential changes to water and sediment quality are affecting the biota of Doris Lake.

Sediment Quality

Dust deposition and runoff may contribute particulate matter and potential contaminants to Doris Lake and these constituents may settle to the sediments where they could affect aquatic life in the lake if concentrations increase above a certain level. Sediment quality will therefore be monitored in Doris Lake every 3 years under this Plan and will be evaluated against CCME guidelines for the protection of aquatic life and assessed to determine if concentrations are increasing in the lake due to mine activities.

3. MONITORING

This Chapter describes the study area, monitoring schedule, sampling methods, analysis and determination of environmental effects, and the quality assurance and quality control (QA/QC) procedures used to ensure the sample and data accuracy necessary to fulfil the objectives outlined in Section 1.2.

3.1. STUDY DESIGN

Study Area

Aquatic effects monitoring will be focused on Doris Lake (Figure 3.1-1), the waterbody adjacent to most of the Doris Mine infrastructure, and the associated talik in which mining will occur. Doris Lake has been monitored under the original AEMP since 2010, with data being used to assess potential non-point source aquatic effects related to the Project. Doris Lake monitoring will continue to evaluate non-point source Project inputs as in the original AEMP and will be used to assess any Project-related water drawdown.

Periodic monitoring will also occur at a reference lake. This will provide information on regional changes that may be occurring in the aquatic environment. The reference lake used in the original AEMP will continue to serve as the reference lake in this AEMP and has been continuously sampled since 2010.

Monitoring Sites

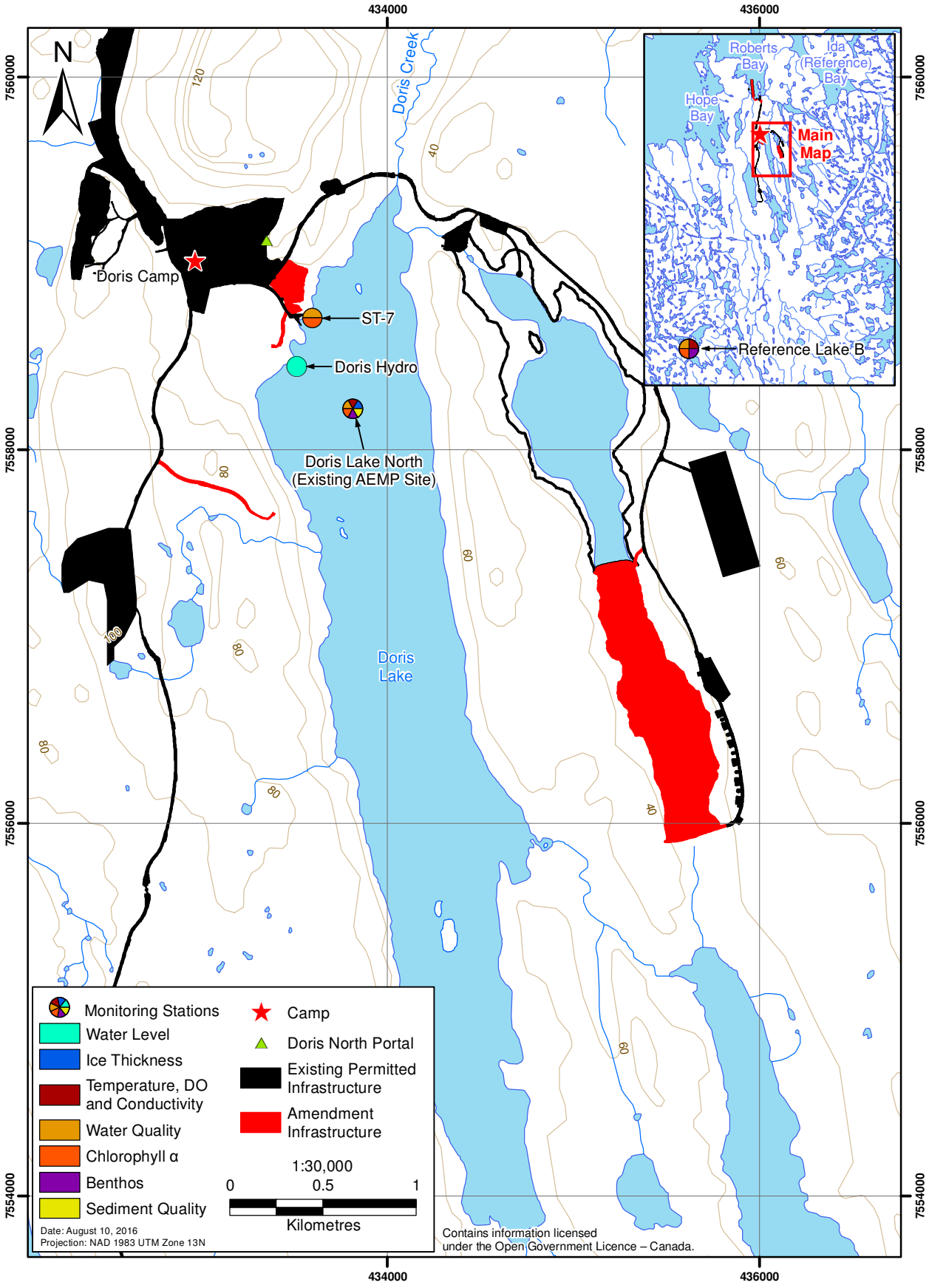
Monitoring will occur in Doris Lake as well as at a reference lake (Figure 3.1-1). Doris Lake will be monitored in three locations; ST-7, Doris Hydro, and Doris Lake North. ST-7 is the water uptake point in Doris Lake and has been monitored for water quality at a monthly interval under the Water Licence since late 2008. Doris Hydro is a hydrometric monitoring site on the northwestern shore of Doris Lake. Water levels have been monitored at this location since 2004 as part of the Doris North Hydrology Compliance Program (e.g., ERM Rescan 2014). Doris Lake North is the deep basin of the lake, and has been monitored for several environmental components since 2010 under the original AEMP.

Water quality sampling at ST-7 has been adopted and emphasized in this Plan, which differs from the original AEMP where water quality sampling occurred at two sites in the main basin of the lake. There are two main reasons for this; first, the ST-7 samples have been collected at a monthly rate since late 2008, and therefore provide a robust, largely continuous dataset that has spanned all seasons during the baseline, construction, and care and maintenance project phases, and will continue to do so through the mining process. In contrast, water sampling under the original AEMP occurred at the Doris Lake North and Doris Lake South sites four times per year and often less during the earlier baseline phase. Second, the ST-7 sampling station in Doris Lake is closer to the mine infrastructure than the existing Doris Lake sampling sites (Figure 3.1-1) making it more sensitive to Project-related influences. The ST-7 station is the water uptake point in Doris Lake where water is drawn from approximately 30 m south of Doris Lake's northern margin. The original AEMP sites were in the centre of Doris Lake where the mine influence could be less detectable due to dilution.

Under this Plan, the Doris Lake North station will continue to be sampled for water quality, temperature, dissolved oxygen, conductivity, and ice thickness measurements, as well as benthic invertebrates and surficial sediments. This sampling will be used to confirm Project effects are not occurring in the lake.

Sampling will also be conducted at a reference lake to quantify natural changes to the aquatic environment over time. Reference Lake B was chosen under the original AEMP as the closest comparable lake to Doris Lake outside of potential Project influence but within a reasonable sampling distance (Rescan 2010). Reference Lake B has been sampled four times a year since 2010 under the original AEMP, and will continue to serve as the reference lake for this AEMP.

Figure 3.1-1
AEMP Monitoring Stations



Monitoring Schedule

Aquatic effects monitoring will continue to be conducted annually throughout the construction and operations phases. The Plan will be re-evaluated three months prior to closure to determine the appropriate closure monitoring, if any, under this program. Should the site re-enter a phase of care and maintenance, the program will be carried out once every third year using any data collected from ST-7 during months of water use, with a minimum of twice per year. The monitoring schedule can be modified, if needed, in consultation with interested Parties.

The sampling frequency for each of the Plan's environmental components is outlined in Table 3.1-1. The water level in Doris Lake will be continuously monitored and data downloaded monthly. Ice thickness, temperature, dissolved oxygen, and conductivity will be measured in Doris Lake each April. Water quality samples will be collected monthly at ST-7 and sampling will comply with the monitoring requirements under the Water Licence. Phytoplankton biomass (as chlorophyll a) samples will be collected from ST-7 annually in August. Additional temperature, dissolved oxygen, and conductivity profiling, water and chlorophyll *a* sampling, and benthic invertebrate sampling will occur at Doris Lake North and Reference Lake B every 3 years in August. Sediment sampling will be conducted at Doris Lake North concurrent with benthos sampling.

Table 3.1-1. Sampling Details

Monitoring Parameter	Location and Frequency				Sampling Device
	ST-7	Doris Hydro	Doris Lake North	Reference Lake B	
Water level	-	Continuous (download monthly)	-	-	Transducer and data logger
Ice thickness	-	-	Annually (April)	-	Manual measurement
Temperature, dissolved oxygen and conductivity	-	-	Annually (April); Once every 3 years (August)	once every 3 years (August)	Temperature-DO-conductivity meter
Water Quality (Physical, nutrients, total metals)	Monthly	-	once every 3 years (August)	once every 3 years (August)	Grab samples or discrete sampler
Phytoplankton Biomass (as chl *a*)	Annually (August)	-	once every 3 years (August)	once every 3 years (August)	Grab sample
Benthic Invertebrates	-	-	once every 3 years (August)	once every 3 years (August)	Ekman Grab (500 µm sieve)
Sediment Quality	-	-	once every 3 years (August)	-	Ekman Grab

3.2. MONITORING COMPONENTS

Water Level and Ice Thickness

Doris Lake water levels and ice thickness will be measured to determine the maximum depth ice penetrates into Doris Lake. Maximum ice penetration occurs when the maximum ice thickness coincides with the maximum winter water level drawdown.

Methods

Doris Lake water levels, and hence drawdown, will be measured continuously throughout the year at the Doris Lake Hydrometric Station (Figure 3.1-1). A pressure transducer paired with a data logger is currently deployed in northwestern Doris Lake at a depth of approximately 5 m to avoid ice damage and to allow data to be collected throughout the year. Data are recorded in 10-minute intervals and are downloaded monthly. The methodology of the Doris Lake Hydrometric Station and associated data analysis are provided in the *Doris North Project 2013 Hydrology Compliance Monitoring Report* (ERM Rescan 2014).

Ice thickness monitoring will occur once each year in April. This timing was selected to ensure consistency with the baseline under-ice data that were used to measure the natural variability of ice thickness on Doris Lake (Section 2.4). The measurement will be taken through an augered hole and the thickness recorded using a metred rod. Lake bottom depth will also be measured using a depth sounder or weighted and metered line.

Effects Analysis

An effect due to lake drawdown will occur when:

1. Mining in the talik under Doris Lake takes place and seepage into the underground is confirmed; and
2. The summed measurements of ice thickness and winter drawdown are greater than the threshold of -2.74 m.

To avoid violating the *Fisheries Act* (1985), advance preparation and DFO approval of an appropriate offsetting plan under Section 35(2) of the *Act* will be needed prior to any exceedance beyond the threshold of -2.74 m. To avoid exceeding the threshold, and thus avoid adverse effects to fish, water drawdown and ice thickness in Doris Lake will be monitored and adaptively managed under the Response Framework (Section 5).

Quality Assurance and Quality Control (QA/QC)

The collection and analysis of water level data at the Doris Lake Hydrometric Station will follow procedures outlined in ERM Rescan (2014). A number of procedures are used, both in the field and in the office, to assess and assure data quality obtained from the hydrometric station. Field QA/QC procedures include following accepted water level surveying procedures and using stable benchmarks (such as bedrock).

Field crews are trained to ensure the methods used for measuring ice thickness are consistent to ensure comparability of data.

Water Quality

Methods

Monthly discrete water samples will be collected at Station ST-7 by members of TMAC's Environment staff as dictated in the Water Licence and following procedures outlined in the *Hope Bay Mining Ltd.'s Quality Assurance and Quality Control Plan for Water Licence 2AM-DOH0713, 2BB-BOS1217, 2BE-HOP1222 (*HBML 2012*)*. Samples will be collected in one of three ways at this station: directly from the uptake line when it is in use, from the shoreline when the uptake line is not active during the open-water season, and under ice when the uptake line is not active during winter. When collecting samples from the uptake line, the valve will be opened for at least 1 minute before taking the sample to ensure the water is representative of the discharge stream. Shoreline samples will be collected by taking care not to disturb the sediments or entrain surface debris. Under-ice samples will be collected through an augured hole, with the water collected using a 2 m sampling pole with a sample bottle attached.

Sampling of water quality at Doris Lake North and Reference Lake B will occur from a boat, and water will be collected from 1 m depth with the use of a clean discrete water sampler.

All water samples will be collected using laboratory-approved clean sampling bottles, with personnel using powder-free nitrile gloves. Following collection, samples will be preserved with the appropriate chemicals and properly labelled and stored. All samples will be sent to an accredited analytical laboratory within the appropriate holding times and will be analyzed for the water quality parameters outlined in Table 3.2-1 (except temperature and dissolved oxygen).

Table 3.2-1. Freshwater Water Quality Parameters

Physico-chemical	Total Metals
Conductivity	Arsenic (As) [a,b]
Sodium	Boron (B) [b]
Calcium	Cadmium (Cd) [b]
Chloride	Chromium (Cr) [b]
Sulphate	Copper (Cu) [a,b]
Alkalinity [c]	Iron (Fe) [a,b]
Hardness [c]	Lead (Pb) [a,b]
pH [a,b]	Mercury (Hg) [b]
Total Suspended Solids [a,b]	Molybdenum (Mo) [b]
Turbidity [b]	Nickel (Ni) [a,b]
Temperature [b]	Selenium (Se) [b]
Dissolved Oxygen [b]	Silver (Ag) [b]
Water Depth	Thallium (Tl) [b]
Nutrients	Uranium (U) [b]
Ammonia [a,b]	Zinc (Zn) [a,b]
Nitrate [a,b]	
Nitrite [a,b]	
Total Phosphate [a,b]	
Orthophosphate [a]	

[a] *Parameters monitored at ST-7 under the current Water Licence.*

[b] *Parameters with CCME water quality guidelines for the protection of aquatic life.*

[c] *Co-factors for the determination of site-specific environmental quality benchmarks.*

Dissolved oxygen, temperature, and conductivity will be measured during winter by augering a hole through the ice and using a calibrated temperature-conductivity-dissolved oxygen meter. The profile will extend from the surface to approximately 1 m above the sediment surface, with values recorded every 1 m. Summer water column profiling will be conducted in a similar manner, but from a boat. All data will be recorded onto field sheets with the applicable meta-data such as date, time, personnel, weather, calibration data, and ice thickness measurements.

Analysis of Effects

Water quality parameters collected on a monthly schedule will be evaluated for potential Project-related effects using a before-after statistical approach given the long-term, continuous dataset for Station ST-7. This analysis will be a two-step, tiered process that evaluates those water quality parameters with CCME guidelines (CCME 2016). The first step will be comparing monthly results for each CCME parameter against historical data to identify whether concentrations are within their expected range based on natural variability, or have exceeded a CCME guideline concentration. Empirical distributions will be developed for each CCME water quality parameter using historical water quality data. These distributions will be used to assess whether the monthly water quality data collected during the construction and operations phases (i.e., 'after' data) fits within historical patterns (i.e., 'before' data). Natural variability will be defined as those concentrations that fall below the 75th percentile of the historical data, except pH, where natural variability will be defined within the upper and lower 75th percentiles.

If monthly water quality concentrations are greater than their 75th percentile concentration in three samples collected over a six-month period, or increase above a CCME guideline concentration, the parameter will be analyzed for differences in means between the 'after' year and the historical 'before' years using mixed model regression techniques. This analysis will be used to determine if the shorter term increases are contributing to longer term changes in the water quality of Doris Lake.

Water quality data collected from 2015 and prior will be used as the 'before' data since there have been no indications of changes to Doris Lake water quality due to Project activities over the course of the original AEMP (ERM 2016).

Those parameters without CCME guidelines, such as water hardness, sodium, and sulphate, will be reported in appendices with summary information, and the data used where necessary to support the evaluation of effects.

Water quality data collected every 3 years from the Doris Lake North site will corroborate water data collected at the ST-7 site and will support the interpretation of the sediment quality and benthos data collected in Doris Lake concurrently every 3 years. Data collected from Reference Lake B will indicate if any potential changes to water quality in Doris Lake could be occurring on a regional scale.

Quality Assurance and Quality Control (QA/QC)

The collection of water quality samples will follow the procedures outlined in the approved *Hope Bay Mining Ltd.'s Quality Assurance and Quality Control Plan for Water Licence 2AM-DOH0713, 2BB-BOS1217, 2BE-HOP1222* (HBML 2012). This plan was developed following the *QA/QC Guidelines for use by Class "A" and "B" Licencees in Meeting Surveillance Network Program Requirements and for*

Submission of a QA/QC Plan (INAC 1996), which was designed to promote best practices in environmental management.

Quality assurance measures will include Environmental staff being trained to carry out the sampling and fully understanding the QA/QC procedures; using certified laboratories for analyses; and using lab-approved clean bottles, high quality preservatives, and distilled water. On-site quality control measures will include the use of chain-of-custody (CoCs) forms to track shipped samples and collecting travel blanks, field blanks, and replicate samples to assess potential sources of contamination and variability in the sampling program. The travel and field blanks are designed to identify sources of contamination during the collection and transportation of water samples, while replicate samples identify potential *in situ* variability within the sampling environment.

Rigorous quality assurance and control measures will be followed at the analytical laboratory, and will include identifying holding time exceedances and using split samples and spiked samples (using certified standards) to track laboratory precision and process recoverability.

Phytoplankton Biomass (as chlorophyll *a*)

Methods

Sampling for chlorophyll *a* will occur as described for water quality sampling. Water collected in foil-wrapped bottles, filtered, the volume of water filtered recorded, and the filter frozen and sent to a laboratory for analysis of chlorophyll *a*. Three replicate samples will be collected.

Analysis of Effects

Chlorophyll *a* concentrations will be compared to historical (2015 and earlier) concentrations to verify if they fall within the 95th percentile of that observed historically.

Quality Assurance and Quality Control (QA/QC)

The QA/QC program for chlorophyll *a* sampling will include collecting the water in a foil-wrapped bottle (to prevent further photosynthesis), keeping the filtered sample frozen at all times prior to analysis, collecting replicate samples, and use of chain of custody forms to track samples.

Benthos

Methods

Benthos will be collected at the Doris Lake North site using an Ekman Grab. At each site, five samples will be collected, each of which will be comprised of a composite of 3 subsamples. Benthos will be sieved to 500 µm, preserved, and sent to a taxonomist for identification and enumeration.

Analysis of Effects

The benthos endpoints of total density, richness, and diversity (both Simpson's and Bray-Curtis) will be evaluated using a before-after control-impact (BACI) statistical approach. Benthos data collected from 2015 and prior will be used as the 'before' data since there have been no indications of changes to Doris Lake benthos due to Project activities over the course of the original AEMP (ERM 2016).

Quality Assurance and Quality Control (QA/QC)

The QA/QC program for benthos sampling will include the collection of replicates to account for within-site variability and the use of chain of custody forms to track samples.

A re-sorting of randomly selected sample residues will be conducted by the taxonomist on a minimum of 10% of the benthos samples to determine the level of sorting efficiency. The criterion for an acceptable sorting will be that more than 90% of the total number of organisms will be recovered from the initial sort. The number of organisms initially recovered from the sample will be expressed as a percentage of the total number after the re-sort (total of initial and re-sort count). Any sample not meeting the 90% removal criterion will be re-sorted a third time.

Sediment Quality

Methods

Surficial sediment quality samples will be collected at the Doris Lake North site using an Ekman grab sampler. Three replicate samples will be collected in August every three years concurrent with benthos sampling. Each replicate sediment sample will be carefully transferred onto a tray, and the top 2 to 3 cm of sediment will be removed and homogenized in a plastic bowl using a plastic spoon and placed into two containers: one for particle size, and one for sediment chemistry. Samples will be kept cool and sent to an accredited laboratory for analysis of particle size, arsenic, cadmium, chromium, copper, lead, mercury and zinc.

Analysis of Effects

Sediment quality metals will be evaluated for potential Project-related effects using a before-after statistical approach, with each CCME parameter being analyzed for differences in means between the 'after' year and the historical 'before' years.

Sediment quality data collected from 2015 and prior will be used as the 'before' data since there have been no indications of changes to Doris Lake sediment quality due to Project activities over the course of the original AEMP (ERM 2016).

Quality Assurance and Quality Control (QA/QC)

The QA/QC program for sediment quality sampling will include the collection of replicates to account for within-site variability and the use of chain of custody forms to track samples. Rigorous quality assurance and control measures will be followed at the analytical laboratory, and will include identifying holding time exceedances and using split samples and spiked samples (using certified standards) to track laboratory precision and process recoverability.

4. REPORTING

The results of the Plan will be reported annually to the NWB during construction and operations. If adverse trends are detected, the results will be communicated to TMAC management (Section 1.4) and the appropriate management actions will be carried out through the Response Framework (Section 5).

5. RESPONSE FRAMEWORK

5.1. BACKGROUND

Potential effects in Doris Lake will be adaptively managed through the implementation of a Response Framework, which will be developed to link results of the Plan to management actions so significant adverse effects arising from mine operation are avoided in Doris Lake. The Response Framework is based on two sources: the *Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories: Overview Report* (INAC 2009), and the *Guidelines for Adaptive Management — a Response Framework for Aquatic Effects Monitoring DRAFT* (WLWB 2010). The Response Framework is founded on the concept of "action level", which is "*a predetermined change, to a monitored parameter or other qualitative or quantitative measure, that requires the Licensee to take appropriate actions*…" (WLWB 2010). The Response Framework, therefore, is the "*systematic approach to responding when the results of a monitoring program indicate that an action level has been reached*".

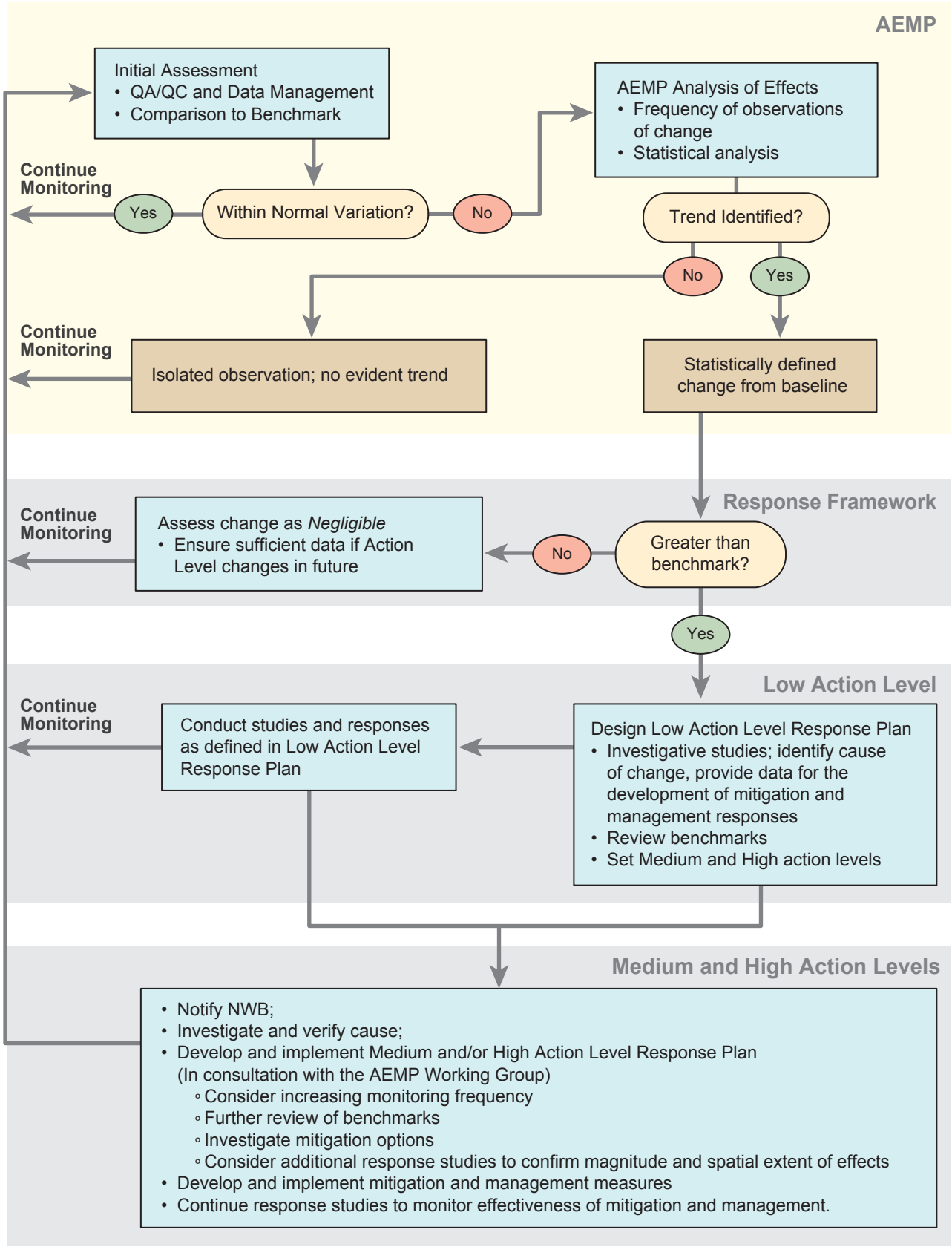
5.2. OBJECTIVES AND APPROACH

The overarching objective of the Response Framework will be to ensure the protection of the aquatic receiving environment in Doris Lake and connected waterbodies. The Response Framework will act as an early-warning system with defined action levels that initiate monitoring and/or management actions within an adequate timeframe to ensure that significant adverse effects do not occur. The system will consist of the following components:

- Appropriate benchmarks and action levels such that mine-related environmental effects are investigated, and if necessary, mitigated, prior to any significant environmental effect occurring;
- Definition of the process by which mine-related environmental effects are assessed against defined action levels;
- Procedure for reporting exceedances of action levels, and defining the process by which the Response Framework is reviewed and amended;
- Development of Response Plans and mitigation actions that may be implemented if action levels are exceeded; and
- Procedures for submitting Response Plans, outlining the type of information that are included in Response Plans, defining how the results of Response Plan actions are reported, and defining the process for reviewing and amending the Response Plans.

The Response Framework will be a defined process that compares the results of the Plan to the pre-determined trigger(s) of the action levels. Action levels are a set of tiered monitoring and/or management actions linked to increasing magnitude of effects to the aquatic environment. This Response Framework will consist of three action levels: Low, Medium, and High (Figure 5.2-1). These action levels will correspond to an indication of increasing magnitudes of effects on the aquatic environment and an increasing risk of adverse significant effects (i.e., the significance threshold).

Figure 5.2-1
Doris AEMP Response Framework



5.3. SIGNIFICANCE THRESHOLDS

A significance threshold is defined as a level of change in any monitored variable that results in a significant adverse effect. For each component of the aquatic effects monitoring (i.e., water quality and under-ice drawdown), the significance thresholds will be:

- The water of Doris Lake is not safe for fish and aquatic organisms that support the aquatic ecosystem and the growth of fish; and
- Drawdown of Doris Lake water levels results in serious harm to fish.

These significance thresholds are adverse conditions to be avoided and therefore represent the overall objectives of the Plan.

5.4. ACTION LEVELS

The Response Framework will have three tiers of action levels: Low, Medium, and High. Variation in monitored components within the normal range, as defined by the data collected in Doris Lake to date, will be considered negligible and will not trigger the Low action level (Figure 5.2-1). Each action level will include the following:

- a description of the variable;
- a definition and rationale for the action level trigger(s), including a consideration of the predictions and conclusions of the effects assessment (TMAC 2015) and aquatics effects monitoring results to date; and
- a description of how exceedances of action levels will be assessed.

The Low action levels will be defined initially for each monitored component based on baseline data, CCME water quality guidelines, and the assessment of potential effects (TMAC 2015). Moderate and High action levels will developed in Response Plans that result from the exceedance of Low action levels, as recommended by WLWB (2010).

The triggers for the action levels will combine the results of the monitoring data with benchmarks based on water quality guidelines and the predictions of the environmental assessment (TMAC 2015).

Water Level and Ice Thickness

The benchmark for ice thickness and Doris Lake water level will be based on the combined maximum ice thickness and natural under-ice drawdown in Doris Lake (Figure 2.4-1; TMAC 2015). Based on the analysis of natural variation in lake levels and the predicted changes in Doris Lake volume, no significant effects to fish habitat were predicted if the maximum extent of ice penetrates 2.74 m below the fall lake surface level, when fish are spawning in the lake (-2.74 m). The benchmark for water level and ice thickness, therefore, is -2.74 m.

The following will be considered for Low action level triggers for Doris Lake under-ice liquid water level:

- identification that the water level has passed its median baseline natural drawdown and thickness of ice baseline ice thickness (2.42 m); and
- there is a corresponding intrusion of groundwater into the mine.

Further, should groundwater pumping exceed 3,000 m^3/day for a prolonged period, specifically 200,000 m^3/quarter, the NWB will be notified and the analyses and assessment described in this AEMP will be carried out and reported quarterly.

Water Quality

For water quality, the benchmarks will be the CCME water quality guideline concentrations for the protection of aquatic life (CCME 2016). The CCME water quality guidelines are designed to be protective of all aquatic life including the earliest life stages. Water quality benchmarks are available for the parameters in Table 5.4-1.

For water quality, the following trigger conditions will be considered for the Low action levels:

- identification of a statistically significant increase when comparing the "before" and "after" periods in the AEMP effects analysis (Section 3.2) for that water quality variable; and
- exceeding the 75% percentage of a CCME water quality benchmark; and
- absence of a similar difference at the reference location (in reference site monitoring years).

Table 5.4-1. Freshwater Water Quality Parameters for Response Framework Benchmarks

Physico-chemical	Total Metals
pH	Aluminum (Al)
Total Suspended Solids	Arsenic (As)
Turbidity	Boron (B)
Temperature	Cadmium (Cd)
Dissolved Oxygen	Chromium (Cr)
	Copper (Cu)
	Iron (Fe)
Nutrients	Lead (Pb)
Ammonia	Mercury (Hg)
Nitrate	Molybdenum (Mo)
Nitrite	Nickel (Ni)
Total Phosphate	Selenium (Se)
	Silver (Ag)
	Thallium (Tl)
	Uranium (U)
	Zinc (Zn)

Phytoplankton Biomass (chlorophyll *a*)

The benchmark for Doris Lake phytoplankton biomass will be based on baseline chlorophyll *a* concentrations. The following will be considered for Low action level triggers for Doris Lake chlorophyll *a* concentrations:

- identification of a significant difference in the "before" and "after" periods in the AEMP effects analysis (Section 3.2) for chlorophyll *a.*

Benthos

The benchmarks for benthos will be based on baseline total density, richness, and diversity. The following will be considered for Low action level triggers for Doris Lake benthos:

- identification of a significant difference in the “before” and “after” periods in the AEMP effects analysis (Section 3.2) for that benthos metric; and
- absence of a similar difference at the reference location.

Sediment Quality

For sediment quality, the benchmarks will be the CCME sediment quality guideline concentrations for the protection of aquatic life (CCME 2016).

For sediment quality, the following trigger conditions will be considered for the Low action levels:

- identification of a significant increase when comparing the “before” and “after” periods in the AEMP effects analysis (Section 3.2); and
- exceedance of the 75th percentage of the corresponding CCME sediment quality benchmark.

5.5. RESPONSE PLANS

If an action level is exceeded, a Response Plan will be developed that contains the following components:

- general description of the monitoring component or variable;
- determination of the action level exceedance;
- likely cause(s) of the exceedance;
- ecological consequences of the exceedance;
- proposed monitoring and management responses;
- definition of the next action level tier(s); and
- a proposed schedule for responses and any additional reporting.

These response plans will be developed to suit the variable, the probable causes of the exceedance, the feasibility and expected effectiveness of management responses, and the potential risks of exceeding the significance thresholds.

Low Action Levels

For Low action levels, the Response Plan will include the setting of Medium and High action levels. In some cases, the definition of the High action level may be deferred if specific and appropriate rationale is provided (e.g., additional research is required). Monitoring and management response actions for a Low action level response plan will be largely investigative, and may include the following:

- an investigation to verify the source(s) of observed change;
- a comparison to predictions made in the effects assessment (TMAC 2015);
- the confirmation of ecological relevance;
- increased monitoring frequency;
- the planning or initiation of an issue-specific information collection program or study to define the magnitude, spatial extent, and reversibility of the effect;

- a review of the water or sediment quality benchmark or development of a site-specific objective; or
- the identification of possible mitigation options.

If a likely cause can be identified, management responses for a Low action level may include updates to Best Management Practices or Standard Operating Procedures to improve the mitigation or avoidance of the mine-related effect on Doris Lake.

Review Medium and High Action Levels

The management response actions in Medium or High action level Response Plans will usually involve greater intervention to reflect the increased risk of exceedance of significance thresholds. These plans will incorporate options identified during investigations when the Low action level is exceeded. Additional monitoring and management responses in Medium and High action level Response Plans may include the following:

- an investigation to verify the causes(s) of change;
- notification of the NWB;
- investigation of mitigation options;
- increased monitoring frequency;
- further review of the water or sediment quality benchmarks or development of site-specific objectives;
- review and revision of facility water use and groundwater management practices to reduce water take from Doris Lake;
- notification of DFO, for potential fisheries offsetting;
- selecting, planning for, and implementing a mitigation option such as modification of management plans, modification of water and air quality management practices, or design and construction of mitigation structures or facilities; or
- an assessment of the effectiveness of implemented mitigation options as part of the Response Plans for the specific variable in question.

Mitigation actions that could be selected for review and improvement include those outlined in the site management plans listed in Table 2.3-1.

5.6. Cyclical Monitoring and Reporting Process

The environmental monitoring data collected through the aquatic effect monitoring will be fed into the Response Framework for assessment against action levels. The assessment will be conducted annually as part of the AEMP. If an action level exceedance is observed, a Response Plan will be prepared and submitted to the NWB along with the annual AEMP report.

The Response Framework will be reviewed on an annual basis and any new components (variables, benchmarks and action levels) or changes tracked in the AEMP Report.

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